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Abykenova D.B.[1], *Zhanaidarov B.B.[2], Assainova A.Zh.[3], Abildinova G.M.[4]
[1,2,3] *Pavlodar Pedagogical University named after Alkey Margulan*
[4] *L.N. Gumilyov Eurasian National University*
[1,2,3] *Kazakhstan, Pavlodar*
[4] *Kazakhstan, Astana*
[1]*ORCID 0000-0002-0980-8722*
[2]*ORCID 0009-0001-2511-2944*
[3]*ORCID 0000-0003-0909-9767*
[4]*ORCID 0000-0001-9054-6549*
**batyrkhan97@gmail.com*

INTEGRATION OF ARTIFICIAL INTELLIGENCE IN EDUCATION THROUGH THE TPACK FRAMEWORK

Annotation

The article examines a range of issues related to the specifics of introducing artificial intelligence (AI) into the educational process based on the TPACK model. The study has a comprehensive character and aims to identify the opportunities and limitations of using AI in education, as well as to analyze the features of its integration through the TPACK model.

The research includes a review of contemporary studies dedicated to the application of AI and the TPACK model in the educational sphere. AI is rapidly being implemented in education in various parts of the world. The advantages of using AI are identified, and some necessary conclusions that should be considered when centralizing it in the educational environment are outlined. The article discusses some application specifics within the context of each component of the TPACK model. Examples of successful implementation of AI in educational practice are presented.

The survey results made it possible to identify both the opportunities and the challenges associated with integrating AI into the educational process through the TPACK model. In particular, it was found that students demonstrate a higher level of awareness of AI's potential compared to teachers, whereas the latter show greater confidence in their professional knowledge. Partial readiness for the use of AI in educational practice was also revealed, as well as key barriers and respondents' confidence in AI's effectiveness when properly implemented in the future.

The article proposes a program for implementing artificial intelligence in education through the lens of the TPACK model. The results of the experiment confirmed the hypothesis regarding the positive impact of AI on academic performance, motivation, and quality of learning among students in the experimental group, which indicates the feasibility of integrating AI into the educational process under the conditions of the TPACK model.

Practical recommendations have been developed for educational technology developers, suggesting close collaboration with teachers at the stage of creating and implementing such solutions.

Keywords: artificial intelligence, education, TPACK model, educational content, AI integration, AI tools, content knowledge.

Introduction. The relevance of the study lies in the fact that, under modern conditions, society faces the need to adapt to the rapid changes taking place in the field of digital and other information technologies. It is important to note that the education system is also involved in these processes. The integration of artificial intelligence (AI) is increasingly becoming one of the keyways to improve the educational process. This is due to the fact that, on the one hand, AI has the potential to enhance learning efficiency, optimize various pedagogical processes — including the development of educational materials, the creation of individualized learning plans, monitoring academic performance, and providing feedback, among others. At the same time, on the other hand, the introduction of AI into the educational sphere is associated with a number of risks. These risks include the potential for excessive human dependence on technology, which may lead to a decline in students' critical thinking, a loss of meaningful social and emotional interaction between teachers and students, as well as the emergence of other negative consequences.

Therefore, for the successful and correct implementation of AI-based technologies in education, it is necessary to consider not only ethical and technical aspects but also pedagogical conditions. At the same time, it is important to remember that the content of academic disciplines varies, and each discipline requires its own approach. For this reason, the TPACK model (an abbreviation of

Technological Pedagogical Content Knowledge) is currently being proposed as an important tool for analyzing and designing the integration of AI intended for use within the education system.

This topic is highly relevant and actively discussed, especially in recent years. Numerous scholars, both from Kazakhstan and abroad, are exploring the opportunities and challenges associated with the use of AI in the education system. Most often, their research focuses on issues such as the significance of AI in automating routine and everyday tasks faced by teachers, personalized learning, and the development of intelligent systems that can be used in educational institutions for various decision-making processes.

It is worth noting that most research is focused either on the problems that AI implementation may cause, or on the technical aspects of its integration, as well as on specific pedagogical approaches in the field of AI. At the same time, the comprehensive impact of AI technologies on the educational process as a whole is rarely considered. Furthermore, the issues of AI implementation through the lens of the TPACK model remain understudied, especially in the context of the Kazakhstani education system.

The core problem of this research is the lack of sufficiently developed methodological approaches for effectively leveraging AI in education—approaches that consider the evolving conditions of modern pedagogy and the specific requirements of different academic disciplines. To establish a sound methodological foundation for integrating AI into modern education, a more rigorous evaluation of existing practical AI models is necessary, coupled with heightened attention to the technological and pedagogical knowledge of the specific educational context and content.

The aim of this article is to provide a theoretical review of scientific research on the problem of integrating AI into educational processes through the lens of the TPACK model. We have defined the following research questions:

What opportunities and challenges arise from integrating AI into education through the TPACK model framework?

What practical recommendations can be developed for teachers on the effective use of AI within the TPACK framework?

Methods and materials. To find answers to the research questions, a study was conducted in Kazakhstan at M. Utemisov West Kazakhstan University and Pavlodar Pedagogical University named after A. Margulan. Between October and December 2024, theoretical and field research was carried out, aimed at developing practical recommendations for teachers on the effective use of AI within the TPACK framework, which are applicable across various levels of education.

The method employed was a theoretical review of scientific research from the Google Scholar database, focusing on publications from 2020 to 2024. The theoretical review was conducted in five stages: formulation of the research question or search objective, definition of the search strategy, selection of relevant scientific publications, data analysis, and synthesis. The search query used was the phrase: “TPACK AI”.

The research methods employed were:

— Theoretical methods: literary analysis of sourced publications on the use of AI and the TPACK model in education;

— Practical methods: studying the possibilities and limitations of the TPACK model in relation to AI integration, including surveys, observation, and pedagogical experiments;

— Statistical methods: descriptive statistics methods (calculation of absolute and relative frequencies, mean values) were used to process and calculate the results, as well as comparative analysis of groups using the Mann-Whitney test (for independent samples) and the Wilcoxon test (for comparing indicators before and after the experiment). The level of statistical significance was set at $p \leq 0.05$. Data processing was carried out using IBM SPSS Statistics 26.0;

— Analytical methods: generalization and drawing conclusions;

— Modeling methods: used in the development of the Program and Practical Recommendations.

Sample Description. The study included two categories of participants: students and teachers from pedagogical universities. The total sample size was 200 people: 120 students and 80 teachers.

The student sample was formed from 2nd-year to 4th-year students majoring in "Pedagogy and Methodology of Primary Education," "Computer Science," and "Foreign Language" at Pavlodar Pedagogical University named after A. Margulan and M. Utemisov West Kazakhstan University. Among the student participants, 78 were women (65%) and 42 men (35%). The teacher sample included teachers and methodologists from the aforementioned universities with 3 to 25 years of teaching experience; of these, 58 were women (72.5%) and 22 men (27.5%). The criteria for selecting participants were: affiliation with a pedagogical university, direct participation in the educational process, and voluntary consent to participate in the study.

The sample description indicates that the study covers teachers and students, and that pedagogical universities are the participant selection criteria.

Data collection tools include questionnaires and participant testing.

The survey questions for students, teachers, and methodologists at pedagogical universities assess awareness: Do you know about artificial intelligence?

Attitudes toward artificial intelligence: What is your attitude toward the idea of using artificial intelligence in education?

Readiness to use AI: Are you prepared to use AI-based tools in your future and professional development?

AI application: In your opinion, which aspects of education could be improved by using AI?

Barriers to AI use: In your opinion, what are the main challenges associated with the implementation of AI in education?

Attitudes toward use: Have you used AI-based tools in the educational process?

AI effectiveness: Do you agree that using AI in education will make education more effective?

Future attitudes towards the use of AI in education: Do you agree that AI will be widely used in education?

Research procedure of the experiment. The experiment involved two groups: Experimental group: students who were provided access to AI-based tools; Control group: students who did not have access to AI-based tools.

The evaluation criteria were defined based on quantitative data collected across three main parameters: academic performance, level of engagement, and quality of knowledge acquisition. To assess these indicators, academic performance results were used along with test questions measuring engagement and quality of learning. The experiment was conducted over the course of one semester.

Statistical processing of the experimental data included calculating arithmetic means and standard deviations for each criterion in both groups. To test the statistical significance of differences between the experimental and control groups, the student's t-test for independent samples (for normal distribution) or its nonparametric equivalent, the Mann–Whitney test, was used. Differences were considered statistically significant at $p \leq 0.05$.

Results and Discussion. A review of existing research on the use of artificial intelligence in educational processes reveals that AI in education constitutes modern computer technologies based on the creation of intelligent systems. These systems possess the ability to operate according to specific principles that can mimic human behavior [1], [2], [3].

The implementation of artificial intelligence in education is progressing rapidly across all countries. Many researchers report that AI is becoming accessible to both teachers and students, particularly in higher education institutions [4], [5].

A review of existing studies on the use of artificial intelligence in educational processes revealed that AI in education represents a set of modern computer technologies based on the development of intelligent systems. These systems are capable of operating according to predefined principles, which allows them to imitate human behavior [6], [7], [8]. Such studies provide valuable insights for teachers on how Artificial Intelligence in Education (AIEd) can be applied within teaching and learning.

When considering the opportunities and main challenges of AI, the key problems of implementing artificial intelligence in education in Kazakhstan are identified as the

underdevelopment of digital infrastructure, the need for better professional training of personnel, and the mandatory enforcement of ethical standards regarding the integration of AIEd [9], [10], [11].

The TPACK model (Technological Pedagogical Content Knowledge) represents a conceptual framework that integrates three key components of knowledge: technological, pedagogical, and content knowledge. Each of these plays a unique role in shaping an effective educational process. Technological knowledge encompasses an understanding of modern technologies, tools, and methods of their application in the educational environment. This knowledge enables teachers to integrate innovative technologies, including artificial intelligence, in order to enhance the effectiveness of the learning process and stimulate student engagement. Pedagogical knowledge includes both theoretical and practical understanding of teaching methods, didactics, learning psychology, and other aspects of the educational process. This component helps adapt content and teaching methods to the individual needs of students, thereby ensuring the personalization of the learning experience.

Deep and meaningful knowledge is widely used in subject areas such as physics, mathematics, biology, chemistry, and other disciplines. In line with established standards and core educational content, it allows teachers to convey the necessary knowledge. The use of AIEd provides access to educational materials and enables a high level of curricula [12], [13].

Examples of successful use of AIEd include: Massive Open Online Course (MOOC) platforms: Coursera, Udacity, edX, Quizlet; Virtual laboratories and simulations: PhET Virtual Lab, VR Chemistry Simulations; Personalized learning pathways: Khan Academy, Adaptive Learning Systems such as Knewton Learn; Intelligent assistants and tutors: ChatGPT, Google Classroom Assistant, Canva; Teacher training programs: Microsoft Educator Center, IBM SkillsBuild; Online testing and knowledge assessment: Yandex.Textbook (Яндекс.Учебник), Moodle, Google Forms Quiz; E-portfolios and certifications: ePortfolio, Badges; Blended learning models: Google Classroom, Khan Academy, MIT OpenCourseWare [14], [15], [16].

All these examples demonstrate that AI has already been successfully implemented in educational practice. They ensure the personalization of the learning process, enhance teaching effectiveness, and improve the quality of education.

Main results of practical research. Table 1 presents the results of the survey on the perceptions of teachers and students regarding the use of AI and the identified challenges within the education system. The survey was conducted among 120 students and 80 teachers.

Table 1: Survey results

Question	Answer option	Students		Teachers	
		Quantity	Percentage	Quantity	Percentage
Level of awareness	I know well	50	41,67%	68	85%
	Have a general idea	60	50%	12	15%
	Heard, but not sure	10	8,33%	0	0%
	They don't know anything	0	0%	0	0%
Attitude towards AI	Very positive	70	58,33%	22	27,50%
	Positive	30	25%	24	30%
	Neutral	20	16,67%	14	17,50%
	Negative	0	0%	20	25%
Ready to use	Fully prepared	70	58,83%	26	32,5%
	More yes than no	25	20,83%	26	32,5%
	I’m not sure	20	16,67%	8	10%
	More no than yes	5	4,17%	10	12,5%
	Absolutely not prepared	0	0%	10	12,5%
Usefulness of AI	Personalization	75	62,5%	44	55%
	Automation	24	20%	18	22,5%
	Feedback	15	12,5%	12	15%
	Motivation	6	5%	6	7,5%
Barriers	Resources	27	22,5%	17	21,25%
	Teachers skills	32	26,67%	14	17,5%
	Ethical questions	19	15,83%	25	31,25%

	Cost	42	35%	24	30%
Experience of use	Regularly	32	26,67%	18	22,5%
	Sometimes	68	56,67%	62	77,5%
	Never	20	16,67%	0	0%
AI efficiency	Strongly agree	87	72,5%	76	95%
	Somewhat agree	22	18,33%	4	5%
	Neutral	11	9,17%	0	0%
	Somewhat disagree	0	0%	0	0%
Future of AI	Widely	90	75%	54	67,5%
	Limited	30	25%	26	32,5%
	A temporary trend	0	0%	0	0%
	Negatively affects	0	0%	0	0%

Source: developed by the authors based on data from author-designed questionnaires

The results of the comparative analysis presented in percentages demonstrate that 41,67% of students have a good understanding of the concept of AI, 50% have only a general idea of it, and 8,33% had heard about it but were not confident in their knowledge. None of the students indicated being entirely unfamiliar with the concept. Among teachers, 85% reported being well acquainted with AI, while 15% reported having only a general understanding. No teachers stated that they were entirely unaware of the concept.

With regard to attitudes, 58,33% of students expressed a very positive view of AI, 25% held a positive attitude, and 16,67% were neutral. Nearly half of the students were highly enthusiastic, while about a quarter showed a positive but more cautious perspective, recognizing certain limitations. Approximately one-sixth of the students were neutral or skeptical, and around one-quarter voiced concerns that AI might negatively affect the learning process.

27.5% of teachers have a very positive attitude toward artificial intelligence, 30% have a positive attitude toward AI, 17.5% are neutral toward AI, and 25% are negative. Thus, there is a small proportion of skeptics among teachers who doubt the usefulness or fear the negative consequences of AI. Only a few believe that artificial intelligence is dangerous or useless.

58.3% of students are completely ready to use AI; 20.83% responded that they are more likely to use it than not; 16.67% responded that they have never used AI; 4.17% responded that they are more likely to use AI than not. The survey results indicate that half of the students are completely ready to use AI in their teaching activities.

32,5% of teachers are completely open to using AI; 32,5% are more likely to use it than not; 10% of teachers find it difficult to answer the question; 12,5% are more likely to be unwilling than willing to use it; and 12,5% of teachers are completely unwilling to use AI. The study's analysis shows that half of teachers are strongly prepared to use artificial intelligence in their professional work, while others are either unwilling or uninterested in using it.

When asked about the usefulness of artificial intelligence, students noted the importance of individualization (62,5%); automation of various manual tasks (20%); increased feedback (12,5%); and increased motivation (5%).

Teachers' opinions align closely with those of students. Among them, 55% highlighted the importance of personalization, 22,5% expected the automation of manual tasks, 15% foresaw improvements in feedback, and 7,5% emphasized increased motivation.

The barriers identified by students were distributed as follows: 22,5% pointed to a lack of access to necessary equipment for using AI, 26,67% to insufficient skills among teachers, 15,83% expressed doubts about the ethics of AI use, and 35% to a lack of financial resources. For teachers, the barriers were identified as 21,25% citing insufficient equipment, 17,5% insufficient skills, 31,25% doubting the ethics of AI use, and 30% a shortage of financial resources.

The primary problem for students is the lack of necessary skills and insufficient technical equipment. In some cases, students face problems accessing the required resources and learning tools. Doubts regarding the ethics and permissibility of using artificial intelligence are noted among a small portion of students.

In contrast, the main barriers for teachers lie in their insufficient experience with AI and the absence of necessary skills. Many teachers also complain about a lack of time to master new technologies and the insufficient technical equipment in schools.

26,67% of students reported that they regularly use artificial intelligence, 56,67% stated that they use it occasionally, and 16,67% admitted that they have never used it. Among teachers, 22,5% regularly rely on AI, while 77,5% indicated that they use it from time to time.

When asked about the effectiveness of artificial intelligence, 72,5% of students expressed complete agreement with its benefits, and 18,33% were more inclined to agree than disagree. Teachers showed an even higher level of confidence: 95% fully agreed with the effectiveness of AI, while the remaining 5% rather agreed than disagreed.

Looking into the future, 75% of students believe that artificial intelligence will be used universally, while 25% expect it to be applied only in a more limited way. Among teachers, 67,5% anticipate widespread adoption of AI, whereas 32,5% foresee its use in more restricted contexts.

The experimental group demonstrated a significant increase in assignment completion success, from 60% to 85% (an increase of 25 percentage points). This increase is statistically significant ($p < 0.01$, Mann-Whitney test for independent samples, compared to a 7% increase in the control group). The effect size was Cohen's $d = 1.42$, demonstrating a strong practical effect of AI tools on student academic performance.

Engagement in the experimental group increased from 65 to 90 points (38.5%). This increase is statistically significant ($p < 0.01$, Mann-Whitney test), while in the control group the increase was only 10.9% (from 64 to 70 points). The effect size was Cohen's $d = 1.31$, which also demonstrates a strong practical effect and confirms that AI promotes greater student engagement and participation in the learning process.

The experimental group's learning performance increased from 70 to 88 points (25.7%). This increase is statistically significant ($p < 0.05$, Mann-Whitney test) compared to the control group's gain of only 5.9% (from 68 to 72 points). The effect size was Cohen's $d = 0.98$, demonstrating a moderate-to-strong practical effect, indicating a deeper understanding of the learning material thanks to the use of AI.

The obtained data allow us to draw the following conclusions. Students are generally more aware of the possibilities of artificial intelligence compared to teachers; however, teachers demonstrate a significantly higher level of confidence in their knowledge. Students' attitudes toward AI are more positive than those of teachers, which may indicate a greater openness among students to new technologies. Students also show a higher willingness to use AI, which may be associated with fewer fears and barriers. Both groups agree that the most valuable aspects of AI implementation lie in personalization and automation. The main barriers for both students and teachers are related to ethical issues and the financial costs of integrating artificial intelligence into the educational process.

The experience of using AI among students and teachers is quite similar, with "occasional use" prevailing in both cases. Most of the surveyed students, as well as slightly more than half of the teachers, expressed confidence in the effectiveness of AI and expect its widespread implementation in the future.

As part of the pedagogical experiment, a program of educational activities was developed for students of pedagogical universities, aimed at integrating artificial intelligence into education through the lens of the TPACK model. Table 2 presents specific activities, indicating their objectives, content, and expected outcomes.

Table 2. Program of educational activities for pedagogical university students aimed at integrating AIEd through the TPACK Lens

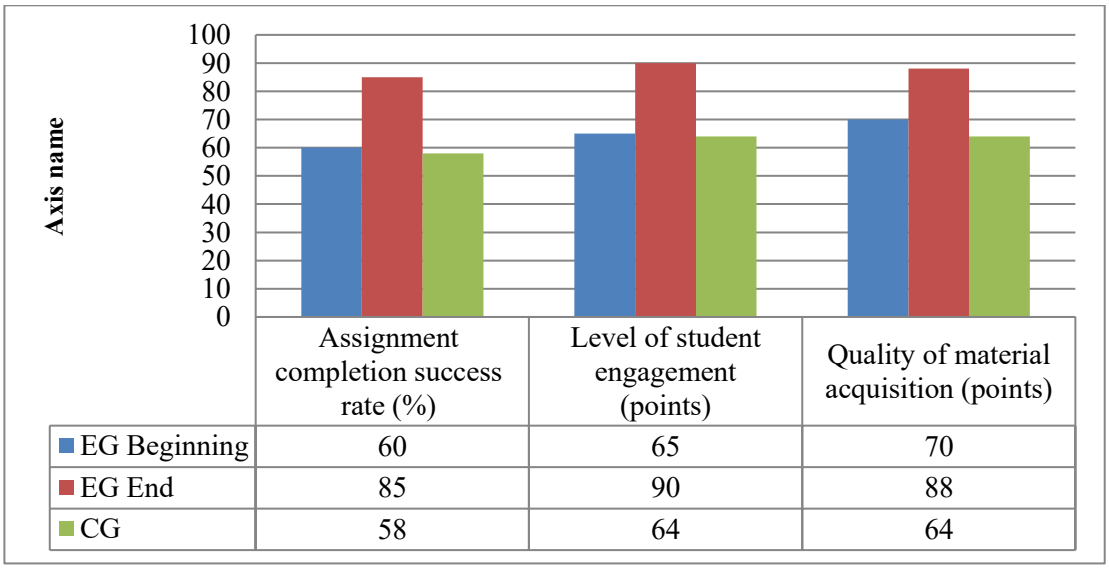
№	Name	Goal	Content	Result
1	Introduction to Artificial Intelligence.	To familiarize students with the fundamentals of artificial intelligence	Lectures and seminars on the fundamentals of artificial intelligence, its tools, and	Study of the key concepts of artificial intelligence and its potential in education.

		and its application in education.	methods of application in the educational process.	
2	Educational workshop on the use of AI tools.	Teach students to use specific AI tools for learning.	Practical training sessions on working with AI platforms (e.g., ChatGPT, adaptive learning systems).	Acquisition of skills in applying AI tools for creating educational materials.
3	Designing a lesson with AIEd Integration.	Develop skills in lesson design with AIEd integration.	Group work on creating lessons using AIEd, with discussion of the TPACK framework.	Developing a lesson project that integrates technology, pedagogy, and content.
4	Research on the impact of AIEd on learning.	Conduct research on the impact of AIEd on the learning process.	Conduct a survey, analyze data on the impact of AIEd on academic performance and engagement.	Gain experience in conducting research and data analysis.
5	Development of adaptive learning materials.	Teach students to develop adaptive materials using AIEd.	Practical classes on creating adaptive tests and assignments using AIEd.	Creation of adaptive materials that consider individual characteristics of students.
6	Presentation of AIEd implementation projects.	Develop skills in presenting and arguing for AIEd implementation.	Students present their projects, discussing the advantages and disadvantages of AIEd implementation.	Development of public speaking and critical thinking skills.
7	Discussion of ethical aspects of AIEd use.	Introduce students to ethical issues of using AIEd.	Discussions on possible risks and ethical dilemmas in using AIEd in teaching.	Understanding the importance of ethical aspects and are ready to consider them in the future

Source: developed by the authors

The Program includes the following activities: introduction to artificial intelligence; an educational workshop on the use of AI tools; designing a lesson using AIEd; researching the impact of AIEd on learning; developing adaptive learning materials; presenting projects on AIEd implementation; discussing ethical aspects of AIEd use; and others.

A preliminary assessment was conducted based on three main criteria: assignment completion success rate (in %); student engagement level (in points); and quality of material acquisition (in points). Following the pilot implementation of the program, a control assessment was conducted based on the same indicators. The results of the comparative analysis are presented in Figure 1.



	Assignment completion success rate (%)	Level of student engagement (points)	Quality of material acquisition (points)
EG Beginning	60	65	70
EG End	85	90	88
CG	58	64	64

Figure 1. Results of the comparative analysis (participants of the experimental and control groups at the beginning and end of the experiment)

Source: developed by the authors based on data from author-designed questionnaires and observations

Students in the experimental group showed a significant increase in assignment completion rate, from 60% to 85%, demonstrating the positive impact of AIEd on learning outcomes. The study results support the hypothesis of a beneficial impact of AIEd on the learning process. In the control group, the increase was only 7% (from 58% to 65%), indicating a less pronounced improvement without the use of AIEd.

The engagement level in the experimental group ranged from 65 to 90 points (38.5%), indicating increased interest and activity among participants when using AIEd. In the control group, engagement increased by only 6 points (from 64 to 70) (10.9%), confirming a low level of engagement with AIEd.

In the experimental group, the quality of material acquisition increased from 70 to 88 points (25.7%), indicating a deeper understanding of the learning material thanks to the use of AIEd. In the control group, the quality of material acquisition increased by only 4 points (from 68 to 72) (5.9%), indicating a less effective learning process.

The data obtained from the questionnaire survey are comparable with the results of other studies, particularly research conducted by SberUniversity (СберУниверситет) and the GeekBrains platform [17]. These studies emphasize that some teachers express concerns about the potential loss of individualized approaches in the educational process, as well as possible breaches of confidentiality. Among the opinions expressed, there are apprehensions that the application of AIEd may reduce the level of personal interaction with students, which in turn could lead to the erosion of trust-based relationships.

The skeptical views of teachers are often due to insufficient confidence in their AI-related skills. Furthermore, a significant portion of respondents note a lack of necessary equipment for the effective use of technologies in the educational process and emphasize the high financial costs associated with implementing AIEd.

Teachers also expressed concerns about the security of student data and the potential impact on traditional teaching methods. Furthermore, many teachers reported difficulties in acquiring the necessary digital skills and emphasised the need for targeted professional development courses and workshops. Another frequently cited concern is that over reliance on AI as a primary teaching tool may weaken the teacher’s guiding role in the learning process. Some participants also highlighted the potential risks of students accessing and using advanced AI systems independently without the approval of university administration or faculty. Most teachers agree that the use of AIEd can improve productivity and effectiveness of learning. Some teachers note the need to integrate artificial intelligence technology with traditional teaching methods. AI is primarily seen as a tool for improving workflow and reducing unnecessary workload, not as a complete replacement for traditional teaching methods.

All of this highlights the significance of the obtained results for theory and practice in the field of AI integration into education through the lens of the TPACK model. Practical recommendations have been developed for developers of educational technologies related to the use of AIEd and the TPACK model, and they are presented in Figure 2.

These recommendations highlight the importance of user friendly educational tools, prioritising pedagogical principles, and carefully considering ethical issues and the safety of the use of AI in educational environments. They also highlight the importance of continuous feedback and iterative improvement, as well as institutional support for innovation. Ultimately, these recommendations aim to promote the effective and responsible integration of AI into learning through close collaboration between teachers and educational technology developers.

Collaboration between teachers, taking into account pedagogical technologies, educational content, and AI-based technologies, will enable the creation of a balanced approach to integrating technology into the educational process using the TRACK model.

Future research can build on these findings and promote the integration of AIEd and the development of scientific research. Moreover, they have the potential to improve the quality of the educational process, provided that all drawbacks are taken into account.

Figure 2. Practical recommendations for the use of AIEd through the TPACK framework
Source: developed by the authors

Conclusion. The study holds significant importance for both theory and practice. Based on the survey, it was found that most university students and teachers perceive AI as a modern tool that is already being partially used in education. At the same time, they recognize the importance of its integration but highlight considerable barriers and concerns. This explains the reserved positions of some survey participants.

The scientific novelty of this study can be summarized in following key aspects:

First, within the context of the Kazakhstan education system, this study comprehensively analyzes the integration of AIED through the TPACK framework.

Second, the study provides empirical data on the impact of AI tools on student performance, participation, and learning outcomes.

Third, the study develops and tests a structured educational program aimed at integrating AI into future teacher training.

Finally, the study offers practical suggestions to teachers and educational technology developers on how to effectively and responsibly apply AIEd.

The primary obstacles to deeper AIEd integration into the educational process are identified as insufficient skills and lack of adequate resources for effective use of AIEd. In addition, both students and teachers express concerns about possible negative consequences, particularly regarding ethics and security, as well as potential declines in learning effectiveness and critical thinking. Despite these concerns, many teachers and students consider AIEd integration feasible, as they see its potential,

especially in optimizing many elements of the educational process and reducing routine tasks that distract teachers from their core mission of educating students.

The proposed Program is aimed at integrating AIEd through the TPACK framework. It includes specific educational activities for students of pedagogical universities, with clearly defined goals, content, and expected outcomes.

The research results obtained during the experiment confirm the hypothesis of the positive impact of AIEd use on students' academic performance, motivation, and quality of knowledge acquisition. The experimental group demonstrated better results across all three parameters compared to the improvements observed in the control group, which indicates the feasibility of integrating AIEd under the conditions of TPACK.

The developed practical recommendations are intended to help educational technology developers, in close collaboration with teachers, design programs that will enable more effective use of artificial intelligence in their pedagogical work. These recommendations emphasize the need to consider modern pedagogical approaches as well as the specifics of educational content in general and individual academic disciplines in particular when implementing AIEd.

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Абыкенова Д.Б.[1], *Жанайдаров Б.Б.[2], Асаинова А.Ж.[3], Абильдинова Г.М.[4]
[1,2,3] Әлкей Марғұлан атындағы Павлодар педагогикалық университеті
[4]Л.Н.Гумилев атындағы Еуразия ұлттық университеті
[1,2,3] Қазақстан, Павлодар
[4]Қазақстан, Астана

ЖАСАНДЫ ИНТЕЛЛЕКТІНІ БІЛІМ БЕРУДЕ TPACK ПРИЗМАСЫ АРҚЫЛЫ ЕНГІЗУ

Аңдатпа

Мақалада TPACK моделіне негізделген жасанды интеллектіні (ЖИ) білім беру үдерісіне енгізудің ерекшеліктеріне байланысты бірқатар мәселелер қарастырылады. Зерттеу кешенді сипатқа ие және білім беруде ЖИ қолданудың мүмкіндіктері мен шектеулерін айқындауға, сондай-ақ оны TPACK моделі арқылы интеграциялау ерекшеліктерін талдауға бағытталған.

Жұмыс аясында білім беру саласында ЖИ мен TPACK моделін қолдануға арналған заманауи зерттеулерге шолу жасалды. Әлемнің түкпір-түкпірінде білім беру саласында жасанды интеллект қарқынды жүзеге асырылуда. Жасанды интеллектті пайдаланудың артықшылықтары белгіленді, оны білім беру ортасында орталықтандыру кезінде ескеру қажет кейбір қажетті тұжырымдар атап өтілді. Мақалада TPACK моделінің әр компонентінің контекстінде қолданудың кейбір ерекшеліктері көрсетілген. Білім беру тәжірибесінде ЖИ сәтті қолданудың мысалдары келтірілді.

Сауалнама нәтижелері ЖИ-ді TPACK моделі арқылы білім беру үдерісіне интеграциялауға байланысты мүмкіндіктер мен проблемаларды анықтауға мүмкіндік берді. Атап айтқанда, студенттердің ЖИ мүмкіндіктері туралы хабардарлығы педагогтарға қарағанда жоғары екені, ал педагогтардың кәсіби білімдеріне деген сенімділігі көбірек екені белгілі болды. Сондай-ақ ЖИ-ді білім беру тәжірибесінде қолдануға ішінара дайындық, негізгі кедергілер және болашақта оны дұрыс енгізген жағдайда тиімділігіне деген сенім анықталды.

Мақалада TPACK моделі тұрғысынан жасанды интеллектіні білім беру жүйесіне енгізу бағдарламасы ұсынылды. Эксперимент нәтижелері ЖИ қолданудың студенттердің үлгеріміне, мотивациясына және материалды меңгеру сапасына оң әсер ететіні туралы гипотезаны растады, бұл TPACK моделі жағдайында ЖИ-ді білім беру үдерісіне интеграциялаудың мақсатқа сай екенін дәлелдейді.

Оқыту технологияларын әзірлеушілерге арналған практикалық ұсынымдар дайындалып, мұндай шешімдерді құру және енгізу кезеңінде педагогтармен тығыз ынтымақтастық орнату қажеттілігі көрсетілді.

Түйінді сөздер: жасанды интеллект, білім беру, TPACK моделі, білім беру контенті, жасанды интеллектті интеграциялау, жасанды интеллект құралдары, мазмұнды білу.

Абыкенова Д.Б.[1], *Жанайдаров Б.Б.[2], Асаинова А.Ж.[3], Абильдинова Г.М.[4]
[1,2,3] *Павлодарский пелагогический университет имени Әлкей Марғұлан*
[4] *Евразийский национальный университет имени Л.Н. Гумилева*
[1,2,3] *Казахстан, Павлодар*
[4] *Казахстан, Астана*

ВНЕДРЕНИЕ ИСКУССТВЕННОГО ИНТЕЛЛЕКТА В ОБРАЗОВАНИЕ ЧЕРЕЗ ПРИЗМУ TPACK

Аннотация

В статье рассматривается комплекс вопросов, связанных с особенностями внедрения искусственного интеллекта (ИИ) в образовательный процесс на основе модели TPACK. Исследование носит комплексный характер и направлено на выявление возможностей и ограничений использования ИИ в образовании, а также на анализ особенностей его интеграции посредством модели TPACK.

В рамках работы проведен обзор современных исследований, посвященных применению ИИ и модели TPACK в образовательной сфере. ИИ быстро внедряется в образование в различных частях мира. Выявлены преимущества использования ИИ и изложены некоторые необходимые выводы, которые следует учитывать при его централизации в образовательной среде. В статье раскрыты некоторые особенности его применения в контексте каждого из компонентов модели TPACK. Представлены примеры успешного использования ИИ в образовательной практике.

Результаты опроса позволили выявить возможности и проблемы, связанные с интеграцией ИИ в образовательный процесс через модель TPACK. В частности, установлено, что студенты демонстрируют более высокий уровень осведомленности о возможностях ИИ по сравнению с педагогами, тогда как последние показывают более высокий уровень уверенности в своих профессиональных знаниях. Также выявлена частичная готовность к использованию ИИ в образовательной практике, основные барьеры, а также уверенность респондентов в эффективности ИИ при его правильном внедрении в будущем.

В статье предложена программа внедрения ИИ в образование через призму модели TPACK. Результаты эксперимента подтвердили гипотезу о положительном влиянии использования ИИ на успеваемость, мотивацию и качество усвоения материала студентами экспериментальной группы, что свидетельствует о целесообразности интеграции ИИ в образовательный процесс с учетом условий модели TPACK.

Разработаны практические рекомендации для разработчиков образовательных технологий, предполагающие тесное сотрудничество с педагогами на этапе создания и внедрения подобных решений.

Ключевые слова: искусственный интеллект, образование, модель TPACK, образовательный контент, интеграция ИИ, инструменты искусственного интеллекта, знание контента.

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