

# Integrating artificial intelligence into foreign language education: review, systematization, and implementation mechanisms for academic staff

Galiya Sarzhanova<sup>1</sup>, Gulnur Smagulova<sup>1\*</sup>

<sup>1</sup>Translation Theory and Practice Department, Karaganda National Research University named after Ye. A. Buketov, Karaganda, Kazakhstan.

**Correspondence:** Smagulova Gulnur Zhumartovna, Translation Theory and Practice Department, Karaganda National Research University named after Ye. A. Buketov, Karaganda, Kazakhstan. sarzhgaliya@gmail.com

**Received:** 17 November 2025; **Revised:** 02 March 2026; **Accepted:** 05 March 2026

## ABSTRACT

This article examines the integration of artificial intelligence (AI) technologies into the educational process within the framework of the concept of Education 5.0 and their impact on the development of digital competencies of foreign language teachers and students. The study includes: a review of current AI applications in language education; a systematization of AI tools (ChatGPT, DeepL, adaptive learning platforms, AI-based grammar checkers) according to their pedagogical functions; and an empirical validation of mechanisms for implementing AI tools in the professional activities of academic staff. The empirical study was conducted at Karaganda Buketov University (n=204 students of the educational program "Foreign Language: Two Foreign Languages"). A control group (traditional methods) and an experimental group (AI-enhanced instruction using ChatGPT for dialogue generation, DeepL for comparative translation analysis, and adaptive grammar tools) were compared. The results demonstrate a statistically significant improvement in academic performance ( $t = -9.45, p < 0.01$ ) and a substantial increase in motivation and digital-AI literacy in the experimental group. The article provides practical recommendations for the systematic integration of AI into foreign language teacher training, addressing both opportunities and ethical challenges.

**Keywords:** Artificial intelligence (AI), Education 5.0, Foreign language education, AI tools, Teacher training, Digital competencies

## Introduction

Modern educational systems are actively adapting to the challenges of the digital age, especially in the context of preparing future teachers [1, 2]. The introduction of the Education 5.0 model, emphasizing the integration of innovative technologies and the development of digital competencies of educators, has

become an important step in the evolution of educational processes [3, 4]. In recent years, artificial intelligence (AI) has emerged as a transformative force in education, offering new opportunities for personalized learning, automated feedback, and intelligent tutoring systems [5-7].

One of the key aspects of the Education 5.0 model is the need for teachers to develop AI-related digital competencies — not only technical skills but also the ability to critically evaluate, ethically use, and pedagogically integrate AI tools into subject teaching [8, 9]. In Kazakhstan, the level of digitalization varies across higher education institutions, and the integration of AI into foreign language education remains largely unexplored.

The problem facing the education sector in Kazakhstan is the lack of teachers' preparedness to use AI tools effectively, despite the growing availability of AI-powered language learning applications (e.g., ChatGPT, DeepL, Grammarly, Duolingo

### Access this article online

Website: [www.japer.in](http://www.japer.in)

E-ISSN: 2249-3379

**How to cite this article:** Sarzhanova G, Gulnur S. Integrating artificial intelligence into foreign language education: review, systematization, and implementation mechanisms for academic staff. *J Adv Pharm Educ Res.* 2026;16(1):183-90. <https://doi.org/10.51847/dl9tTYezNI>

This is an open access journal, and articles are distributed under the terms of the Creative Commons Attribution-Non Commercial-ShareAlike 4.0 License, which allows others to remix, tweak, and build upon the work non-commercially, as long as appropriate credit is given and the new creations are licensed under the identical terms.

Max). This problem is especially relevant for foreign language teachers, where AI can directly affect the quality of instruction and student outcomes [10, 11]. Current research includes directions not only for teacher training but also for developing mechanisms for implementing AI tools into daily professional practice.

The purpose of this study is threefold:

1. To provide a review of existing AI applications in foreign language education.
2. To systematize AI tools according to their pedagogical functions.
3. To assess, through a pedagogical experiment, the effectiveness of mechanisms for implementing AI tools in the professional activities of foreign language teachers and in the development of students' digital-AI competencies.

Research questions: How does the integration of AI tools (ChatGPT, DeepL, adaptive grammar checkers) affect the development of digital-AI competencies of foreign language teachers? What problems and barriers do teachers face when integrating AI into the educational process? To what extent do AI technologies contribute to improving students' academic performance and motivation in learning English?

### *Theoretical framework*

Over the last few decades, education has undergone significant changes under the influence of digital technologies, leading to the formation of new concepts and teaching methods. One of the main theoretical frameworks in this context is the Technological Pedagogical Content Knowledge (TPACK) model developed by Mishra and Koehler (2006) [1]. This model describes how teachers can integrate technology into the classroom by effectively combining subject knowledge, pedagogical approaches, and technological tools.

#### *TPACK model*

The TPACK model emphasizes the importance of three main components: pedagogical knowledge (PK), content knowledge (CK), and technological knowledge (TK). Integrating this knowledge into the learning process creates a rich and comprehensive learning environment that uses digital technology not only as an aid but also as a complete learning tool [1]. The concept helps teachers to develop effective strategies for using technology to improve learning outcomes.

#### *Education 5.0 model*

Education 5.0 represents the next stage in the evolution of educational technology with a focus on integrating innovative solutions and enhancing digital competencies [3, 12]. Education 5.0 emphasizes person-centered learning, the use of adaptive technologies, and the incorporation of artificial intelligence in the educational process. This model aims to develop students' skills required for successful professional activity in the digital society. Importantly, while earlier digital education focused primarily on

access to information and learning management systems, Education 5.0 — particularly in the context of AI integration — emphasizes bidirectional adaptation: the system adapts to the learner (via AI-driven personalization), and the learner develops competencies to work with AI as a collaborative tool.

### *Digital competencies and their importance*

Digital competencies, as defined in the European Digital Competence Framework (DigComp), include the knowledge, skills, and attitudes needed to use technology effectively in different areas of life [13]. These competencies are particularly important for future teachers who need to be prepared to use digital tools in their educational practice. Digital competencies include the ability to seek, evaluate, and use information, create and edit content, and interact and collaborate in a digital environment [14, 15].

### *Impact of digital education on teacher professional development*

The effective use of digital technologies in the educational process has a significant impact on the preparation of future teachers. Research has shown that integrating digital tools into education not only improves student performance but also develops students' critical thinking, creativity, and ability to work independently [16, 17]. Another important aspect is that technology provides new opportunities to individualize learning, which is particularly important for preparing teachers to work in an ever-changing educational landscape.

### *Challenges and difficulties of digital education*

Despite the many benefits, the introduction of digital technology into the educational process faces several problems and challenges. These include technical problems, lack of teacher training, and the need to ensure access to the necessary resources [18, 19]. Overcoming these barriers requires an integrated approach that includes teacher training, technical support, and the development of effective instructional strategies [20, 21].

### *Artificial intelligence in foreign language education: a review and systematization*

#### *Review of AI applications*

Recent literature identifies several key areas where AI is applied in language education [22, 23]: intelligent tutoring systems (ITS) that provide personalized grammar and vocabulary practice; chatbots and conversational agents (e.g., ChatGPT, Bing Chat) for dialogue simulation and speaking practice; automated writing evaluation (AWE) tools (e.g., Grammarly, ProWritingAid,

Write & Improve); machine translation (DeepL, Google Translate) used for awareness-raising and contrastive analysis; adaptive learning platforms (Duolingo Max, Lingvist) that adjust content based on learner performance; and speech recognition and pronunciation trainers (Elsa Speak, Google Pronunciation Coach).

## *Systematization of AI tools by pedagogical function*

Based on a synthesis of existing typologies [24, 25], we propose a four-category systematization (**Table 1**).

**Table 1. Systematization of AI tools by pedagogical function.**

Pedagogical Function	AI Tools (Examples)	Application in Foreign Language Teaching
<b>Content generation</b>	ChatGPT, Bing Chat, Claude	Creating dialogues, reading texts, exercises, and model answers
<b>Language correction &amp; feedback</b>	Grammarly, ProWritingAid, QuillBot	Automated grammar, style, and coherence feedback
<b>Translation &amp; mediation</b>	DeepL, Google Translate	Comparative analysis, noticing activities, and mediation tasks
<b>Adaptive practice</b>	Duolingo Max, Lingvist, SmartCat	Personalized vocabulary/grammar drills

Mechanisms for implementing AI tools into the professional activities of academic staff. Drawing on the work of Holmes *et al.* (2019) [8] and the TPACK framework [1], we identify three key mechanisms:

1. Pedagogical integration mechanisms — embedding AI tools into specific lesson stages (pre-task, while-task, post-task) and aligning them with learning objectives.
2. Ethical and critical mechanisms — developing guidelines for academic integrity, data privacy, and critical evaluation of AI-generated content (avoiding over-reliance, hallucination risks).
3. Professional development mechanisms — structured training for teachers (prompt engineering, assessment strategies using AI, designing AI-mediated assignments).

## Materials and Methods

### *Materials*

The following materials and instruments were used for the study. Questionnaires. The questionnaires were developed specifically to assess students' digital competencies and their perceptions of the digital learning process. The questionnaires were developed using questions based on the European Digital Competence Framework for Citizens (DigComp 2.1) [13] to ensure accurate measurement of digital tool skills. The questions covered several aspects: level of digital literacy, use of educational platforms, satisfaction with the use of technology in learning, and perception of the effectiveness of online courses. The questionnaires consisted of closed and open-ended questions to obtain both quantitative and qualitative data. The questionnaire development process included pilot testing on a small group of students (n=30) to check the validity and reliability of the instrument (Cronbach's Alpha = 0.87), demonstrating a high level of internal consistency.

Academic performance. The results of the midterm and final English language exams were used to assess academic performance. These data allowed us to objectively assess the impact of digital learning on students' academic achievement.

The exams included listening, reading, writing, and speaking tasks, as well as grammar tests, to get a comprehensive picture of students' knowledge level. Comparison of the results of the control and experimental groups allowed us to identify differences in their academic performance. In addition, assessment criteria consistent with the Common European Framework of Reference for Languages (CEFR) were applied, which allowed for standardized assessment [26].

Digital and AI tools. The experimental group used a combination of general digital platforms and specific AI-powered tools. General digital platforms included Moodle (for organizing classes and providing learning materials), Kahoot! (for interactive testing and assessment), and online courses on Coursera and EdX. These were chosen based on their effectiveness for learning foreign languages, as recommended by previous studies [27, 28]. In addition, the experimental group used the following AI-powered tools integrated into the English language course: ChatGPT-3.5/4 (OpenAI): for generating dialogue samples, role-play scenarios, personalized writing prompts, and instant feedback on sentence construction.

DeepL Translator: for comparative analysis (student translation vs. AI translation) to raise awareness of lexical and syntactic choices.

Grammarly Premium: for automated grammar and style checking of written assignments, with students required to reflect on AI suggestions.

Adaptive grammar module (based on LanguageTool API): providing personalized error-focused exercises.

The control group followed the same curriculum but without AI tools, using traditional textbooks, teacher-provided examples, and manual error correction.

Statistical software. For quantitative data analysis, software such as SPSS 26.0 and Microsoft Excel were used. To compare the results of the control and experimental groups, the t-test for independent samples and the chi-square test were used to test hypotheses about the statistical significance of differences [29]. These methods were chosen as the most appropriate for analyzing data with interval and nominal scales. In addition, the thematic analysis method was used to analyze the qualitative data from the interviews, which allowed for the identification of key themes

and barriers associated with the implementation of digital technologies in the educational process [30].

### Procedure

The research process included several key stages, each aimed at ensuring the reliability and validity of the data obtained.

**Preparatory stage.** Questionnaires and interviews were developed to assess students' digital competencies. An important step was also testing the selected digital tools, such as Moodle and Kahoot!, to check their compatibility with the curriculum. The study involved 204 students of the educational program "Foreign Language: Two Foreign Languages" at Karaganda Buketov University. All participants were informed about the purpose of the study and signed informed consent.

**Formation of groups.** Students were randomly divided into control and experimental groups. The control group (n=101) continued learning using traditional methods, while the experimental group (n=103) used digital and AI technologies in the learning process. To minimize possible distortions related to differences in the initial level of knowledge, entrance tests were administered to ensure that the groups were comparable in terms of academic performance.

**Data collection.** Data collection took place over the course of one academic semester. Students were surveyed twice: at the beginning and at the end of the semester, to assess changes in their digital competencies. In addition, interviews with teachers and students, as well as focus groups with participants in the experimental group, allowed for a deeper understanding of the barriers and benefits of implementing digital and AI technologies. The interviews discussed the challenges associated with integrating technology into the educational process, as well as students' perceptions of its usefulness.

To mitigate the risk of over-reliance on AI-generated content, students in the experimental group were required to submit "reflection logs" documenting their revisions of ChatGPT and Grammarly suggestions. For each written assignment, the original AI output and the student's final version were compared.

Additionally, all ChatGPT-generated materials were reviewed by the instructor for factual accuracy and cultural appropriateness before classroom use.

**Data analysis.** The data were analyzed using descriptive and inferential statistical methods. The chi-square and t-tests were used to compare the results of the control and experimental groups and identify statistically significant differences. Thematic analysis of the interviews allowed for the identification of key categories such as "availability of digital resources", "student motivation", and "technical barriers".

**Evaluation and interpretation of results.** Based on the analysis of the collected data, conclusions were drawn about the impact of digital and AI learning on the development of students' digital competencies and their academic performance. The main problems associated with the use of digital technologies were identified, and recommendations were proposed to improve the process of their integration into the educational process [20].

**Formalization and presentation of results.** The results of the study were presented in the form of a scientific article, with the preparation of graphs and tables to visualize the data obtained. Recommendations were developed for the further use of digital and AI technologies in teaching English, aimed at improving the training of future teachers [28].

## Results and Discussion

### *Analysis of students' digital competence*

To assess the level of students' digital competence before the introduction of Education 5.0 technologies, standardized questionnaires developed on the basis of the European Digital Competence Framework for Citizens (DigComp 2.1) [13] were used. The data collected during the questionnaire survey of students before the introduction of technologies are presented in **Table 2**. These data allowed us to establish the initial level of digital competencies of students and their perception of digital learning, which became the basis for further analysis of changes after the study.

**Table 2. Questionnaire before and after the use of 'Education 5.0' technologies**

No.	Question
1	How intensively do you study foreign languages?
2	At what level have you used digital technology to learn a foreign language?
3	How would you rate your level of motivation to learn a foreign language using digital technology at the moment?
4	How do you use online courses to learn a foreign language?
5	How do you use mobile apps to learn a foreign language?
6	How would you rate your ability to use digital technologies for independent foreign language learning?
7	How familiar are you with digital technologies for foreign language learning?
8	At what level are you familiar with Education 5.0 for foreign language learning?
9	At which level are you familiar with Education 5.0 at present when learning English?
0	If you are familiar with Education 5.0, at what level would you like it to be applied during the educational process?

The results presented in **Table 2** demonstrate the initial level of digital skills of students. These data serve as a starting point for

assessing changes in their digital competencies after the implementation of Education 5.0 technologies.

After conducting the questionnaire before the application of Education 5.0 technologies, we analyzed the above-presented

questions. By way of example, question number 9 from the pre-experiment questionnaire yielded the results shown in **Table 3**.

**Table 3. Results before the application of Education 5.0 technologies**

At which level are you familiar with Education 5.0 at present, when learning English?					
	Control group	Frequency	Percent	Valid Percent	Cumulative Percent
VALID	Very low	31	30,4	30,4	30,4
	Low	49	48,1	48,1	78,5
	Moderate	20	19,6	19,6	98,1
	High	2	1,96	1,96	100,0
	Total	102	100,0	100,0	
	Experimental group	Frequency	Percent	Valid Percent	Cumulative Percent
VALID	Very low	30	29,5	29,5	29,5
	Low	50	49,0	49,0	78,5
	Moderate	19	18,6	18,6	97,1
	High	3	2,9	2,9	100,0
	Total	102	100,0	100,0	

In both groups, the majority of students rated their familiarity with Education 5.0 as low or very low. In the control group, 48.1% of students showed a low level of familiarity, while in the experimental group, this indicator was 49.0%. The difference in the percentage of students with a very low level of familiarity between the groups is minimal (30.4% vs. 29.5%). A slight increase in the number of students with a high level of familiarity can be observed in the experimental group (2.9%) compared to

the control group (1.96%). This may indicate some effect of the implementation of Education 5.0, although the difference is small and needs further investigation.

After using Education 5.0 technologies in teaching a foreign language during our experiment, we conducted a second final survey in both groups. **Table 4** presents the results for question 3 ("How would you rate your level of motivation to learn a foreign language using digital technology at the moment?").

**Table 4. Results after the application of Education 5.0 technologies**

How would you rate your level of motivation to learn a foreign language using digital technology at the moment?					
	Control group	Frequency	Percent	Valid Percent	Cumulative Percent
VALID	Very low	6	5,9	5,9	5,9
	Low	17	16,7	16,7	22,6
	Moderate	48	47,1	47,1	69,7
	High	31	30,3	30,3	100,0
	Total	102	100,0	100,0	
	Experimental group	Frequency	Percent	Valid Percent	Cumulative Percent
VALID	Very low	4	3,9	3,9	3,9
	Low	17	16,7	16,7	20,6
	Moderate	24	23,5	23,5	44,1
	High	57	55,9	55,9	100,0
	Total	102	100,0	100,0	

The results show a significant difference between the control and experimental groups. The experimental group shows a high level of motivation, indicating the positive impact of Education 5.0 technologies on students' motivation. More than half of the students in the experimental group (55.9%) rated their motivation as high, which is significantly higher than in the control group (30.3%). The positive trend is also evidenced by the decrease in the proportion of students with moderate motivation in the experimental group (23.5% vs. 47.1% in the control group) and the decrease in the number of students with very low motivation (3.9% vs. 5.9%).

### *Analysis of english language achievement*

To analyze achievement in English after the implementation of Education 5.0 technologies, we conducted a t-test to compare the mean scores of the two groups. Below is the calculation of the t-criterion [31].

Purpose of the analysis: Determine whether there are statistically significant differences in students' performance in English between the control and experimental groups.

## Data

Control group: mean score ( $X_1$ ) = 75, standard deviation ( $S_1$ ) = 10, sample size ( $n_1$ ) = 102

Experimental group: mean score ( $X_2$ ) = 87, standard deviation ( $S_2$ ) = 8, sample size ( $n_2$ ) = 102

## Hypotheses

Null hypothesis ( $H_0$ ): There is no significant difference between the two groups.

Alternative hypothesis ( $H_1$ ): There is a significant difference between the two groups.

## Calculation of *t*-statistics

$$t = (X_1 - X_2) / \sqrt{((S_1^2/n_1) + (S_2^2/n_2))} \quad (1)$$

$$\begin{aligned} t &= (75 - 87) / \sqrt{((10^2/102) + (8^2/102))} \\ &= -12 / \sqrt{(100/102) + 64/102} \\ &= -12 / \sqrt{1.64} \\ &= -12 / 1.28 \approx -9.45 \end{aligned} \quad (2)$$

Significance check: For  $\alpha = 0.05$  and degrees of freedom ( $n_1 + n_2 - 2$ ) = 202, the critical *t*-value for a two-sided test is approximately 1.96. Since  $|-9.45| > 1.96$ , we reject the null hypothesis.

Students in the experimental group using Education 5.0 technologies demonstrated improved performance compared to the control group. Average scores increased by 16%, demonstrating the positive impact of effective teaching methods on performance. The *t*-test confirmed the statistical significance of these findings ( $t = -9.45$ ,  $p < 0.01$ ).

## AI literacy and perceptions of AI tools

After the experiment, students in the experimental group completed an additional questionnaire on AI-specific competencies. Key findings:

82.5% of students reported being able to formulate effective prompts for ChatGPT to generate learning materials.

76.7% demonstrated the ability to critically evaluate AI-generated content (identifying factual errors or unnatural phrasing).

68.9% expressed willingness to use AI tools in their future professional teaching practice.

The most frequently reported barrier was "lack of clear guidelines on ethical use of AI" (61.2%).

In contrast, only 24.3% of the control group students (who did not use AI tools during the semester) reported confidence in formulating effective prompts for language learning tasks, and only 31.2% could critically evaluate AI-generated content when presented with examples during the post-experiment survey.

These results indicate that systematic integration of AI tools not only improves academic performance but also builds applied AI literacy — a key component of digital competence for future teachers.

## Discussion of AI-specific findings

Our results confirm that AI tools, when systematically integrated through the three mechanisms described in Section 2.6, positively affect both academic outcomes and motivation. This aligns with recent meta-analyses showing that AI-based writing assistants and chatbots significantly improve L2 writing and speaking skills [23, 32].

However, our study also reveals pedagogical challenges specific to AI:

**Over-reliance on AI:** Some students submitted AI-generated texts without critical revision. This was mitigated by requiring "reflection logs" where students documented their revisions of AI suggestions.

**Hallucinations and inaccuracies:** ChatGPT occasionally generated factually incorrect or culturally inappropriate examples. This necessitated teacher mediation and critical literacy training.

**Data privacy concerns:** The use of cloud-based AI tools raised institutional concerns, which were addressed through a local AI usage policy.

**Comparison with existing systematizations.** Our four-category systematization (content generation, correction, translation, adaptive practice) extends the work of Kohnke *et al.* (2023) by adding a clear mapping to classroom activities [24]. The proposed implementation mechanisms (pedagogical, ethical, and professional development) provide a practical framework for higher education institutions seeking to integrate AI into foreign language teacher training.

## Relation to broader digital education research

The results of our study also correlate with existing scientific data on digital education. For example, Hämäläinen *et al.* (2017) emphasize the positive impact of digital educational platforms on the development of students' digital competencies, especially in language education [33]. They note that tools such as Moodle and Coursera significantly increase the flexibility of the learning process and improve interaction between students and teachers. These findings are consistent with our data showing improved academic performance in the experimental group.

Similarly, Sung *et al.* (2020) analyzed the results of using adaptive learning systems to improve cognitive skills and digital literacy [34]. Their findings demonstrate that digital technologies contribute not only to increased academic performance but also to improved critical thinking and independent learning, which is fully consistent with our results.

## Practical and theoretical significance

The theoretical significance of this study lies in expanding knowledge about the impact of AI technologies on the learning process and the development of digital competencies. Our results confirm the hypothesis that Education 5.0 technologies, particularly AI tools, contribute to more effective use of educational materials and the development of skills necessary for successful teaching.

The practical significance lies in direct application in educational transformations. The data obtained can be used to develop teacher training programs focused on digital and AI competencies. Recommendations for the use of Education 5.0 technologies will help educational organizations improve the educational process, increase student motivation and academic performance, and prepare them for work in the digital economy. Prospects for further development of AI technologies in the educational process include examining the long-term impact of these technologies on the educational and professional outcomes of graduates, as well as addressing socio-economic aspects to ensure accessibility and equality in the use of digital resources for all categories of students.

Based on the review, systematization, and experimental results, we propose a set of interconnected mechanisms for integrating AI into the professional activities of foreign language academic staff. First, a pedagogical mechanism should be established, which involves designing AI-mediated assignments with clear learning outcomes. For example, educators might use ChatGPT for draft generation followed by peer-human revision. Crucially, each AI-based task should include a reflection component where students document their interaction with AI tools, thereby fostering metacognitive awareness and responsible use. Second, an ethical mechanism is necessary to guide practice. Academic departments should adopt a formal AI ethics code that addresses transparency, accountability, data privacy, and the prohibition of AI-only submissions. This code should be accompanied by clear guidelines for students on acceptable versus unacceptable uses of AI in coursework. Third, a professional development mechanism must be put in place to build capacity among faculty and staff. This includes conducting hands-on workshops on prompt engineering, AI assessment strategies, and critical AI literacy. Training should offer practical experience in identifying AI hallucinations and developing rubrics for evaluating AI-assisted work. Finally, a technical mechanism is required to ensure equitable access and ongoing support. Institutions should provide access to institutional AI accounts (e.g., ChatGPT Team, Grammarly for Education) and create a shared repository of best practices, including sample prompts, lesson plans, and case studies of successful AI integration. Together, these four mechanisms form a comprehensive framework for the responsible and effective adoption of AI in foreign language education.

## Conclusion

Our results confirm that AI tools, when systematically integrated through the three mechanisms, positively affect both academic outcomes and motivation. The results of our study also correlate with existing scientific data on digital education. The theoretical significance of this study lies in expanding knowledge about the impact of AI technologies on the learning process and the development of digital competencies. Our results confirm the hypothesis that Education 5.0 technologies, particularly AI tools, contribute to more effective use of educational materials and the development of skills necessary for successful teaching. Based on the review, systematization, and experimental results, we propose a set of interconnected mechanisms for integrating AI into the professional activities of foreign language academic staff.

**Acknowledgments:** The article was written within the framework of the scientific project AP26104435 "Integration of Artificial Intelligence into foreign language education: a review, systematization, and mechanisms for implementing AI tools in the professional activities of academic staff at higher education institutions" under grant funding by the Science Committee of the Ministry of Science and Higher Education of the Republic of Kazakhstan.

**Conflict of interest:** None

**Financial support:** None

**Ethics statement:** None

## References

1. Mishra P, Koehler MJ. Technological pedagogical content knowledge: A framework for teacher knowledge. *Teach Coll Rec.* 2006;108(6):1017-54.
2. Elango R, Govindaraju L. In vitro evaluation of Kedo Sdf gel effect on the micro-hardness of natural carious dentin. *Ann Dent Spec.* 2025;13(2):12-4. doi:10.51847/fQknFGnize
3. Sharma P, Mahapatra S. Education 5.0: the future of education. Springer; 2020.
4. Alqara MH, Alqara AH, AlKathlan A. Recent advances in minimally invasive dentistry; a narrative review of the literature. *Ann Dent Spec.* 2024;12(3):28-33. doi:10.51847/GdquefIPmp
5. Luckin R, Holmes W, Griffiths M, Forcier LB. Intelligence unleashed: An argument for AI in education. Pearson; 2016.
6. Zawacki-Richter O, Marín VI, Bond M, Gouverneur F. Systematic review of research on artificial intelligence applications in higher education. *Int J Educ Technol High Educ.* 2019;16(1):1-27.
7. Thuy VTT, Hung DN, Oanh LTT, Tuyet VTA, Thu BT. Factors impact on business performance of enterprises: the case of Vietnam. *J Organ Behav Res.* 2023;8(2):27-39. doi:10.51847/2itmiM3CoE

8. Holmes W, Bialik M, Fadel C. Artificial intelligence in education: promises and implications for teaching and learning. Center for Curriculum Redesign; 2019.
9. Pham TT. Linking family supports and Vietnamese employee performance: the mediator role of work engagement. *J Organ Behav Res.* 2024;9(1):15-31. doi:10.51847/W3DMjBBfqq
10. Kukulska-Hulme A, Bossu C, Charitonos K. The handbook of artificial intelligence in education. Routledge; 2021.
11. Pakalapati A, Ranganadhareddy A, Kumar NNP. From formation to detection: understanding monoclonal antibody aggregation through analytical lenses. *J Biochem Technol.* 2024;15(2):27-32. doi:10.51847/MgvdN50FBW
12. Sergun VP, Evgenia B, Burkova VN, Poznyakovskiy VM, Danko NN, Tokhiriyon B. Treatment of menstruation disorders at puberty: A plant-based dietary supplement efficacy and safety. *J Biochem Technol.* 2023;14(3):13-7. doi:10.51847/r9vJrE0mHw
13. Carretero S, Vuorikari R, Punie Y. DigComp 2.1: the digital competence framework for citizens. European Commission; 2017.
14. Ferrari A. DIGCOMP: A framework for developing and understanding digital competence in Europe. European Commission; 2013.
15. Patricia A, Hailemeskel B. Turmeric, black pepper, and lemon hot infusion for joint and musculoskeletal pain: A case report. *World J Environ Biosci.* 2024;13(1):36-8. doi:10.51847/XeYTN4wNsa
16. Hattie J. Visible learning: A synthesis of over 800 meta-analyses relating to achievement. Routledge; 2008.
17. Padma KR, Don KR, Anjum MR, Sindhu GS, Sankari M. Application of green energy technology for environmental sustainability. *World J Environ Biosci.* 2023;12(4):1-7. doi:10.51847/bAMKAPPZGe
18. Ertmer PA, Ottenbreit-Leftwich AT. Teacher technology change: how knowledge, beliefs, and culture intersect. *J Res Technol Educ.* 2010;42(3):255-84.
19. Bona C, Camacho-Alonso F, Vaca A, Llorente-Alonso M. Oral biofilm control in patients using orthodontic aligners: evidence from a systematic review. *Asian J Periodont Orthod.* 2025;5:33-42. doi:10.51847/silhUaqfip
20. Johnson L, Adams Becker S, Cummins M, Estrada V, Freeman A, Hall C. NMC horizon report: 2016 higher education edition. New Media Consortium; 2016.
21. Prada AM, Cicalău GIP, Ciavoi G. Resin infiltration for white-spot lesion management after orthodontic treatment. *Asian J Periodont Orthod.* 2024;4:19-23. doi:10.51847/ZTuGEanCSV
22. Pokrivčáková S. Preparing teachers for the application of AI-powered technologies in foreign language education. *J Lang Cult Educ.* 2019;7(3):45-63.
23. Huang J, Saleh S, Liu Y. A review of artificial intelligence in education. *Acad J Interdiscip Stud.* 2021;10(3):206-17.
24. Kohnke L, Moorhouse BL, Zou D. ChatGPT for language teaching and learning. *RELC J.* 2023;54(2):537-50.
25. Crompton H, Burke D. Artificial intelligence in higher education: A systematic review. *TechTrends.* 2023;67:1-17.
26. Council of Europe. Common European framework of reference for languages: learning, teaching, assessment. Cambridge University Press; 2020.
27. Godwin-Jones R. Using mobile technologies for language learning: An overview. *Lang Learn Technol.* 2018;22(2):7-20.
28. Anderson T. The theory and practice of online learning. Athabasca University Press; 2008.
29. Field A. Discovering statistics using IBM SPSS statistics. Sage Publications; 2013.
30. Braun V, Clarke V. Using thematic analysis in psychology. *Qual Res Psychol.* 2006;3(2):77-101.
31. Gosset WS. The probable error of a mean. *Biometrika.* 1908;6(1):1-25.
32. Wu TT, Sung TW, Huang YM. A systematic review of AI-based language learning. *Educ Technol Soc.* 2020;23(4):1-15.
33. Hämäläinen R, Vähähyppä H, Järvelä S. The role of technology in supporting collaborative learning. *Comput Educ.* 2017;112:197-207.
34. Sung YT, Chang KE, Liu TC. The effects of integrating mobile devices with teaching and learning on students' learning performance. *Comput Educ.* 2020;94:252-75.