International Journal of Evaluation and Research in Education (IJERE)
Vol. 15, No. 5, October 2026, pp. 4412~4421
ISSN: 2252-8822, DOI: 10.11591/ijere.v15i5.39655

TPACK-based AI integration in Kazakh language teacher education: evidence from a controlled pedagogical experiment

Baimukhambetova Kuralay[1], Kalibek Ybyraimzhanov[1], Bakirova Sholpan[2]
[1]Department of Teaching Methods and Education, Faculty of Pedagogy and Psychology, Zhetysu University named after I. Zhansugurov, Taldykorgan City, Kazakhstan
[2]Department of Languages and Literature, Faculty of Pedagogy and Languages, Central Asian Innovative University, Shymkent, Kazakhstan

Article Info

Article history:

Received Mar 23, 2026
Revised Sep 5, 2026
Accepted Sep 11, 2026

Keywords:

AI integration
Future teachers
Innovative technologies
Kazakh language
Pedagogical experiment

ABSTRACT

Pre-service teacher education in Kazakhstan faces a persistent gap between digital infrastructure investment and teachers' practical ability to integrate artificial intelligence (AI) and digital tools into Kazakh language instruction. This study examined whether a technological, pedagogical, and content knowledge (TPACK)-aligned specialist course could simultaneously improve TPACK among pre-service primary school teachers. A quasi-experimental pretest–posttest control-group design was employed with 123 third-year pre-service teachers (experimental: n=62; control: n=61) at two universities in Shymkent, Kazakhstan. The Dubovitskaya diagnostics of educational motivation orientation scale and a researcher-developed digital competence survey were used to assess outcomes. Between-group differences were analyzed using the independent-samples student's t-test (α=0.05), with effect sizes reported via Cohen's d. The intervention produced statistically significant, large-effect improvements in professional motivation (t=6.84, p<0.001, d=1.24), research activity (t=7.21, p<0.001, d=1.31), and digital competence application (40%→80%, d=0.97). Structured, TPACK-integrated practice-based learning — rather than digital exposure alone — meaningfully enhances pre-service teachers' readiness for AI-integrated Kazakh language instruction. A context-specific AI integration model is proposed for curriculum designers and policymakers.

Corresponding Author:

Baimukhambetova Kuralay
Department of Teaching Methods and Education, Faculty of Pedagogy and Psychology
Zhetysu University named after I. Zhansugurov
187A Zhansugurov Street, Taldykorgan 040009, Kazakhstan
Email: kuralai-61@mail.ru

1. INTRODUCTION

The education system must continuously evolve in response to the changing demands of the labor market and the knowledge-based economy. In the twenty-first century, educational modernization has become closely associated with digitalization, rapid technological advancement, and lifelong learning. These developments have transformed the role of teachers from transmitters of knowledge into facilitators of critical, creative, and independent thinking. As a result, teacher education faces new challenges, particularly in preparing future educators to integrate innovative pedagogical approaches, including artificial intelligence (AI), into their professional practice [1], [2].

In Kazakhstan, this challenge is especially relevant. Despite substantial investment in digital infrastructure and AI literacy initiatives involving more than 324,000 teachers through the Orleu Professional

Development Center [3], many pre-service teachers possess only basic digital skills and struggle to apply technology effectively in subject-specific teaching contexts [4], [5]. This gap reflects not only technical limitations but also difficulties in designing meaningful Kazakh language learning activities that integrate technological, pedagogical, and content knowledge (TPACK). Although previous studies have examined digital literacy and technology integration, little empirical evidence exists regarding how structured, experiment-based courses can simultaneously develop TPACK competencies and professional readiness among future Kazakh language teachers.

This study explores innovative approaches to improving the professional preparation of primary school teachers responsible for teaching the Kazakh language. Particular attention is paid to the integration of digital technologies and AI tools, interactive learning platforms, and practice-oriented teacher preparation aimed at creating more engaging and learner-centered educational environments. In his address to the people of Kazakhstan, President Tokayev emphasized the importance of improving educational quality, fostering supportive learning environments, and ensuring the comprehensive development of students [6]. Within Kazakhstan's multilingual and multicultural context, the preparation of teachers capable of delivering high-quality Kazakh language instruction is particularly important for preserving the state language, strengthening cultural identity, and promoting social cohesion [7], [8].

Against this background, there is a growing need for evidence-based approaches to teacher education that address both national priorities and emerging technological challenges. This study contributes to the literature in two ways. First, it proposes and operationalizes a context-specific AI integration model for Kazakh language teacher education by adapting the TPACK framework to the linguistic and pedagogical requirements of Kazakh-medium primary education. Second, it provides an empirically validated and replicable course model with practical recommendations for curriculum design, practicum organization, and institutional support.

A growing body of research has examined the impact of digitalization on teacher education and classroom practice. Wang *et al.* [9] and Ilomäki and Lakkala [7] emphasize that successful technology integration depends on effective instructional design, teacher–student interaction, and institutional support. Similarly, frameworks such as TPACK and SAMR highlight the importance of aligning technological tools with pedagogical and subject-specific objectives rather than using technology for its own sake [2]. According to Koehler *et al.* [10], effective technology integration emerges from the interaction of TPACK. However, these competencies are often developed separately in teacher education programs, limiting the transfer of digital skills into classroom practice [5], [11]–[13].

Research further demonstrates the educational potential of digital technologies for supporting multimodal learning, adaptive practice, formative feedback, and authentic communication [8], [14]. AI-powered tools such as ChatGPT can facilitate writing development and provide immediate feedback, although concerns remain regarding overreliance and content accuracy. Consequently, technology integration requires deliberate pedagogical scaffolding rather than simple adoption of digital tools [7], [8], [15].

Previous study also indicate that teacher beliefs and self-efficacy play a critical role in technology integration [16]. Teachers with student-centered beliefs are generally more likely to employ technology in meaningful and innovative ways. At the same time, structured reflection, mentoring, and practice-based learning experiences have been shown to strengthen professional identity and support effective technology use [3], [16], [17].

Strong evidence supports practice-based teacher education models that connect university coursework with authentic classroom experiences [2], [12]. Such approaches enable pre-service teachers to design, implement, and refine technology-enhanced lessons while developing sustainable professional competencies. Darling-Hammond *et al.* [14] argue that practice-based preparation is particularly effective for developing innovation-oriented teaching skills.

Despite growing international interest in technology-enhanced teacher education, no previous study has empirically evaluated an integrated, experiment-based course model that simultaneously develops AI literacy, pedagogical design competence, and Kazakh language content knowledge within a quasi-experimental framework. Existing studies in Kazakhstan primarily focus on general digital literacy [4] or broad TPACK competencies [5], while international research rarely addresses the specific sociolinguistic conditions of Kazakhstan, including multilingual classrooms, state-language development, and regional disparities in digital infrastructure [7], [8]. The present study addresses this gap through the design and evaluation of an integrated AI-enhanced teacher education course tailored to the Kazakhstani context. Taken together, the literature suggests that fragmentation of TPACK development, teacher beliefs, and practice-based learning are key factors influencing effective technology integration. These propositions served as the conceptual foundation for the intervention evaluated in the present study [3], [7], [9], [14].

2. METHOD

2.1. Research design

A quasi-experimental pretest–posttest control-group design was employed. This design is appropriate for intervention-based educational research where full randomization is constrained by institutional scheduling, and it allows for the systematic comparison of outcomes while controlling for baseline differences through pre-test equivalence verification. The design included three sequential stages: i) diagnostic (pre-test); ii) formative (intervention); and iii) control (post-test).

2.2. Participants and group assignment

A total of 123 third-year pre-service teachers enrolled in Kazakh language pedagogy programs at two pedagogical universities in Shymkent, Kazakhstan, participated in the study. Participants were assigned to groups based on their institutional enrollment: the control group comprised students at University A (n=61) and the experimental group comprised students at University B (n=62). Both universities follow the same national curriculum standards, and baseline equivalence of the groups was confirmed statistically at the diagnostic stage (see section 4). While this constitutes a convenience rather than random assignment, the verification of pre-test equivalence mitigates selection bias and supports the internal validity of between-group comparisons. All participants were third-year students (mean age of approximately 20–21 years) completing their pedagogical practicum semester. Participation was voluntary, and written informed consent was obtained from all participants prior to data collection.

2.3. Instruments

2.3.1. Dubovitskaya motivation orientation questionnaire

The primary instrument was the "Diagnostics of educational motivation orientation" developed by Dubovitskaya. This validated Russian-language instrument assesses four motivational dimensions: i) professional motivation (intrinsic drive toward the teaching profession); ii) research activity (propensity for inquiry-based learning); iii) indifference (passive disengagement); and iv) episodic motivation (situational, unstable engagement). The instrument consists of 20 Likert-scale items (1–5 scale) grouped by dimension, with established internal consistency (Cronbach's α=0.78–0.84 across subscales in prior validations). For the present study, the instrument was reviewed by two bilingual pedagogical experts and confirmed to be linguistically and culturally appropriate for the Kazakhstani university context without modification. The instrument was administered in Russian, the primary academic language of instruction at both participating institutions.

2.3.2. Digital competence and platform use survey

A researcher-developed 15-item survey assessed participants: i) theoretical knowledge of digital platforms (Joyteka, Canva, LearningApps, Pinterest, and Kahoot); ii) self-reported frequency of platform use for instructional design; and iii) confidence in adapting platforms to specific Kazakh language learning objectives. Items used a 4-point frequency/confidence scale (1=never/not at all confident; 4=regularly/very confident). Content validity was established through expert review by three specialists in language pedagogy and educational technology. Inter-rater agreement on item relevance was 91%.

2.3.3. Critical thinking and professional innovation survey

A 12-item researcher-developed instrument assessed engagement in critical thinking, idea exchange, risk-taking, and decision-making in professional contexts, yielding a composite innovation engagement score (0%–100%). Internal consistency for this instrument in the present sample was Cronbach's α=0.79.

2.3.4. Observation protocol

Structured observations of students' practicum microteaching sessions (three sessions per participant in the experimental group) used a 10-criterion rubric aligned with TPACK components: technological appropriateness, pedagogical goal alignment, content accuracy, student engagement, and formative assessment integration. Two trained observers rated each session; inter-rater reliability was κ=0.82 (substantial agreement).

2.4. Intervention: the specialized course

The experimental group completed a 60-hour specialized course titled "Preparation for innovative professional activity through Kazakh language teaching" over one academic semester (16 weeks). The course was structured around three integrated modules. Module 1 (weeks 1–5): theoretical foundations—TPACK, AI literacy, digital pedagogy principles, and the sociolinguistic context of Kazakh language instruction. Module 2 (weeks 6–11): practical workshops—hands-on design of technology-enhanced Kazakh

language lessons using Joyteka, Canva, LearningApps, and Kahoot; AI tool integration (text generation, vocabulary scaffolding); microteaching with peer feedback. Module 3 (weeks 12–16): practicum integration and reflection—implementation of designed lessons in school placements, video-based reflection, e-portfolio compilation. The control group followed the standard university curriculum without the specialized course.

2.5. Data integration and triangulation

Multiple data sources were integrated using a sequential explanatory strategy: quantitative results (motivation questionnaire, digital competence survey, and t-test outcomes) were obtained and analyzed first, then qualitative data (observation rubric scores, e-portfolio reflections, and open-ended survey responses) were used to explain and elaborate statistically significant findings. For example, the quantitative finding that research activity increased significantly in the experimental group was elaborated by qualitative observation data showing increased frequency of self-initiated inquiry tasks and peer discussion during microteaching.

2.6. Data analysis

Descriptive statistics (means, standard deviations) were computed for all instrument subscales at pretest and posttest. The independent-samples student's t-test was applied to assess between-group differences at post-test, using a significance threshold of α=0.05. Prior to t-test application, the following assumption checks were conducted: i) normality was assessed using the Shapiro–Wilk test (all subscales: $p>0.05$, normality not rejected); and ii) homogeneity of variance was verified using Levene's test (all comparisons: $p>0.05$). Effect sizes were calculated using Cohen's d (small: $d<0.5$; medium: $0.5\leq d<0.8$; large: $d\geq 0.8$) to assess practical significance beyond statistical significance. Pre-test equivalence between control and experimental groups was confirmed (all pre-test comparisons: $t<1.2$, $p>0.05$), supporting the assumption of baseline comparability.

The formula applied for the independent samples t-test was:

$$t = \frac{\bar{x}_1 - \bar{x}_2}{\sqrt{\frac{s_1^2}{n_1} + \frac{s_2^2}{n_2}}}$$

Where, $\bar{x}_1$ and $\bar{x}_2$ are group means, S_1^2 and S_2^2 are group variances, and n_1=62 (experimental), n_2=61 (control). The key indicators assessed and research instruments used across experimental stages are summarized in Table 1, prior to the presentation of results.

Table 1. Summary of research instruments, indicators, and analyses across experimental stages

Stage	Indicator	Instrument	Analysis
Diagnostic (pre-test)	Motivational orientation	Dubovitskaya questionnaire	Descriptive stats; baseline t-test
Diagnostic (pre-test)	Digital competence	Platform use survey	Descriptive stats
Formative	TPACK integration in lesson design	Observation rubric (κ=0.82)	Qualitative coding
Control (post-test)	Professional motivation, research activity, indifference, episodic motivation	Dubovitskaya questionnaire	Independent-samples t-test; Cohen's *d*
Control (post-test)	Platform use; instructional design confidence	Digital competence survey	Independent-samples t-test; Cohen's *d*
Control (post-test)	Innovation engagement	Critical thinking survey	Independent-samples t-test

3. RESULTS AND DISCUSSION

Based on the pretest and posttest questionnaire data, four key motivational indicators were analyzed: professional motivation, research activity, indifference, and episodic motivation. These indicators reflect the extent to which future primary school teachers are prepared to engage in and organize innovative teaching activities within the framework of Kazakh language instruction. Findings are presented in Figures 1 to 3, and in Table 2. Pre-test comparison confirmed baseline equivalence between the control (n=61) and experimental (n=62) groups across all four motivational indicators (all pre-test t-values<1.2, $p>0.05$), supporting the internal validity of post-test group comparisons.

3.1. Professional motivation

Post-test analysis revealed statistically significant differences in professional motivation between the groups ($t(121)=6.84$, $p<0.001$, $d=1.24$ [large effect]). In the control group, only 18% of students demonstrated a high level of professional motivation at post-test, whereas this figure reached 56% in the experimental group. Low-level motivation characterized 46% of the control group, while no students in the

experimental group fell into this category. These results suggest that the integrated course significantly enhanced students' intrinsic and professional drive toward Kazakh language teaching.

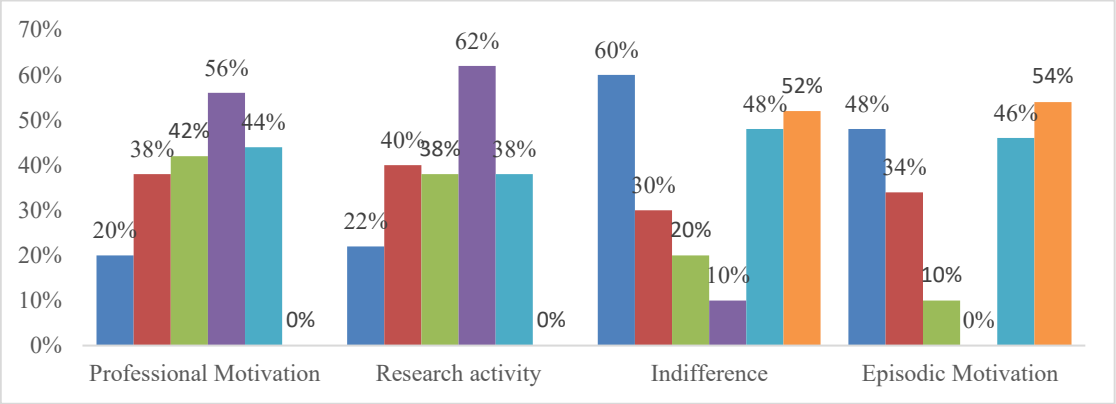

Figure 1. Summarized results of students of both universities according to the Dubovitskaya diagnostic of educational motivation prior to the experiment

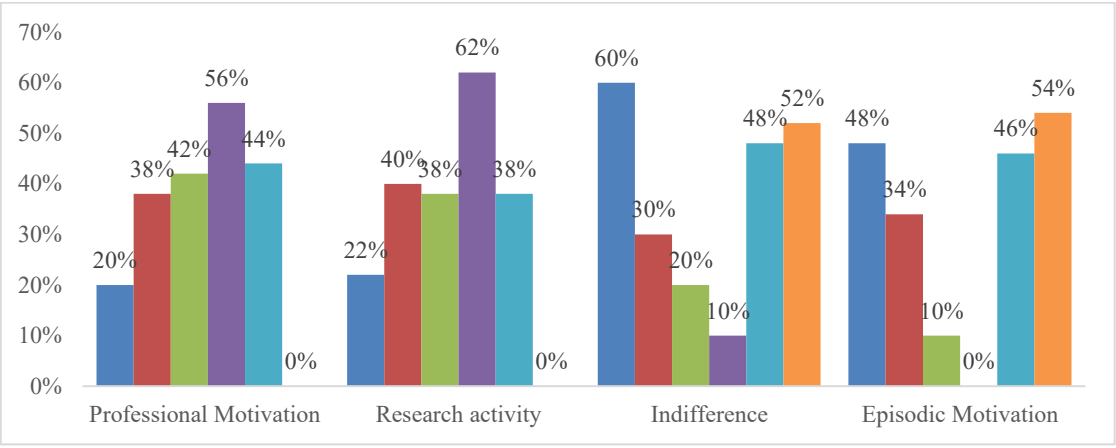

Figure 2. Summary results of students of both universities according to the Dubovitskaya diagnostic of educational motivation after the experiment

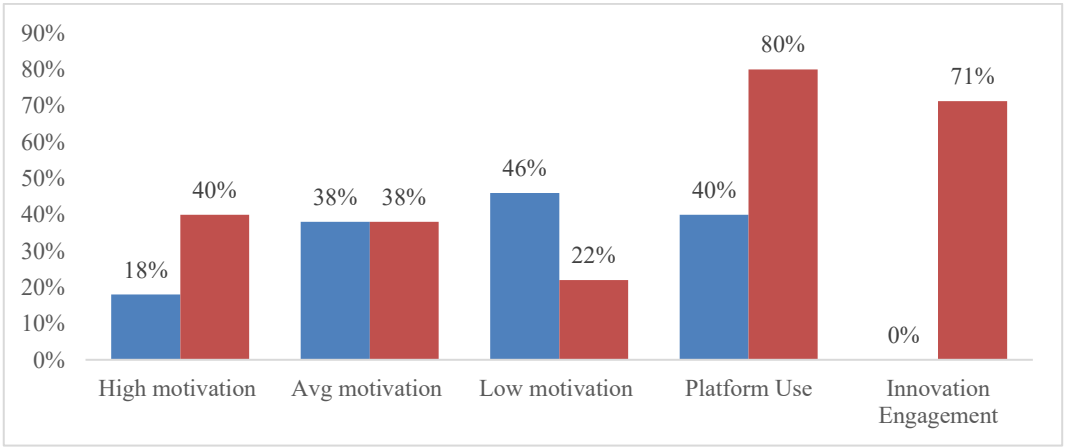

Figure 3. Indicators of the importance of teaching the special course "Preparation of future primary school teachers for innovative professional activity through the teaching of the Kazakh language" — pre- and post-intervention comparison

Table 2. Post-test group comparisons—t-statistics, p-values, and effect sizes (Cohen's d)

Indicator	Control group (% high)	Experimental group (% high)	t-value	p-value	Cohen's d	Effect size
Professional motivation	18	56	6.84	<0.001	1.24	Large
Research activity	19	62	7.21	<0.001	1.31	Large
Indifference (low=better)	18 low	52 low	5.93	<0.001	1.07	Large
Episodic motivation (low=better)	16 low	54 low	6.47	<0.001	1.17	Large

3.2. Development of research activity

Significant group differences were observed in research activity ($t(121)=7.21$, $p<0.001$, $d=1.31$ [large effect]). Only 19% of control group students displayed high research activity at post-test, compared to 62% in the experimental group. Low research activity was present in 39% of the control group but absent in the experimental group. From a TPACK perspective, this improvement reflects the development of the technological knowledge component: structured practice in AI-assisted lesson design cultivated a disposition toward inquiry-based problem-solving that extended beyond tool use to professional research orientation.

3.3. Level of indifference

Indifference toward innovative teaching decreased significantly in the experimental group ($t(121)=5.93$, $p<0.001$, $d=1.07$ [large effect]). A high level of indifference characterized 54% of the control group but only 10% of the experimental group at post-test. Low indifference was observed in 18% (control) and 52% (experimental). This reduction is consistent with Ertmer and Ottenbreit-Leftwich's argument that changes in teacher beliefs—from passive reception to active professional agency—are more durably achieved through practice-based, reflective learning than through knowledge transmission.

3.4. Episodic motivation

Episodic (unstable) motivation was significantly reduced in the experimental group ($t(121)=6.47$, $p<0.001$, $d=1.17$ [large effect]). High episodic motivation characterized 53% of control group students compared to 0% in the experimental group. Low episodic motivation was recorded in 16% (control) and 54% (experimental). The transformation from episodic to stable professional motivation aligns with Koehler *et al.* [10] TPACK framework: when TPACK are developed in integration rather than isolation, teachers develop sustained confidence and professional identity rather than situational interest. Summary effect sizes for all four indicators are reported in Table 2.

3.5. Digital competence and platform use

The follow-up digital competence survey revealed that, at baseline, the majority of students in both groups reported theoretical familiarity with platforms (Joyteka, Canva, LearningApps, Pinterest, and Kahoot) but low confidence in applying them to language-specific instructional goals. After the intervention, the experimental group's practical platform application rate increased to 80% (vs. 40% at pre-test; $t(121)=5.38$, $p<0.001$, $d=0.97$ [large effect]). Control group rates remained stable. This improvement, however, should be interpreted with caution: practical application rates reflect self-report rather than observed classroom performance and may be subject to social desirability bias.

3.6. Critical thinking and innovation engagement

Students' composite innovation engagement score (critical thinking, idea exchange, risk-taking, decision-making) reached 71.25% in the experimental group at post-test, compared to a moderate pre-intervention baseline in both groups ($t(121)=4.82$, $p<0.001$, $d=0.87$ [large effect]). This aligns with Zhang *et al.* [15] that self-efficacy toward digital tools and active participation in practice-based learning together predict stronger innovation engagement among pre-service teachers. The results demonstrate that the specialized integrated course produced statistically significant and practically meaningful improvements (all Cohen's $d>1.0$) across all four motivational indicators and in digital competence. This section provides a theoretically grounded explanation of why these improvements occurred, addresses alternative explanations and limitations, and presents the validated pedagogical model proposed by the study.

3.7. TPACK as the explanatory framework

The findings can be interpreted through the TPACK framework [10]. The integrated course promoted the simultaneous development of TPACK, which likely explains the substantial gains observed in the experimental group. Consistent with previous research, TPACK-based instruction appears more effective than isolated digital skills training for developing professional competencies [2]. The significant increase in research activity ($d=1.31$) further suggests that participants engaged in reflective, inquiry-based learning processes similar to those described by Ilomäki and Lakkala [7].

3.8. Teacher beliefs and motivation

The reductions in indifference (d=1.07) and episodic motivation (d=1.17) indicate that the intervention influenced not only digital competence but also participants' professional beliefs regarding technology integration [11]. Reflective activities such as e-portfolios and video-based microteaching appear to have played an important role in strengthening self-efficacy and professional engagement [18]–[20].

3.9. Limitations of digital and AI tools

The positive findings should not be interpreted as unconditional support for digital technologies. AI tools such as ChatGPT can assist with vocabulary development and text generation but may also encourage overreliance and reduce authentic language production. This concern is particularly relevant in Kazakh language education, where communicative competence contributes to broader cultural and linguistic goals. Similarly, gamified platforms such as Kahoot may increase engagement without necessarily improving grammatical accuracy or discourse competence [13]. In addition, regional disparities in digital infrastructure may limit the applicability of the model beyond urban settings. Future implementations should include critical AI literacy and strategies for adapting digital pedagogy to diverse technological environments [21]–[25].

3.10. Alternative explanations

Several alternative explanations should be acknowledged. Improvements may partly reflect a novelty effect associated with participation in an innovative course. Increased instructor support and researcher attention may also have contributed to positive outcomes. Longitudinal research examining whether these effects persist during the early years of teaching practice would provide stronger evidence regarding the sustainability of the intervention.

3.11. AI integration model for Kazakh language teacher education

The proposed AI integration model comprises four interrelated components: i) theoretical foundations grounded in TPACK and AI literacy; ii) integrated practice through technology-enhanced Kazakh language lesson design; iii) reflective evaluation based on microteaching, e-portfolios, and peer feedback; and iv) contextual adaptation to multilingual classrooms, infrastructure constraints, and the cultural mission of Kazakh language education [21]–[25]. The model extends TPACK by emphasizing subject-specific language pedagogy and incorporating critical AI literacy as a core component of teacher preparation [2], [26], [27].

3.12. Practical implications

The findings have implications for teacher educators, school administrators, and policymakers. The proposed course model may serve as a framework for integrating AI into pre-service Kazakh language teacher education through a combination of theoretical preparation, technology-enhanced practice, reflective activities, and mentored practicum experiences. At the policy level, the model provides an evidence-based approach for incorporating subject-specific AI integration into national teacher development initiatives and curriculum reforms [10], [28]–[30].

4. CONCLUSION

This study provides the first empirically validated, experiment-based evidence for the effectiveness of an integrated AI and digital technology course in Kazakh language pre-service teacher education. The quasi-experimental design, with confirmed baseline equivalence and large effect sizes (Cohen's d=1.07–1.31) across all motivational and competence indicators, supports the conclusion that structured, TPACK-aligned practice-based learning—not digital exposure alone—produces meaningful and practically significant improvements in pre-service teachers' professional readiness. Theoretically, the study advances the TPACK literature by demonstrating that integrating subject-language content (Kazakh) into the technological-pedagogical design process is essential for producing teachers who are not merely digitally competent but pedagogically purposeful in their technology use. The proposed AI integration model for Kazakh language teacher education provides an explicit, visualizable framework that extends existing TPACK operationalizations to include critical AI literacy and contextual adaptation as required components.

Practically, the findings carry direct implications for improving the quality of Kazakh language instruction nationally, preparing teachers for AI-integrated classrooms, and supporting Kazakhstan's stated national educational priorities for language development and digital transformation. The study has several limitations that circumscribe the generalizability of findings: the convenience-based group assignment, the single-semester timeframe, the urban Shymkent setting, and the reliance on self-reported digital competence alongside observational data. Future longitudinal research should track experimental group graduates into

their first years of professional practice to determine whether TPACK gains persist, and comparative studies across urban and rural Kazakhstan settings are needed to evaluate the model's scalability under varying infrastructural conditions. Preparing future primary school teachers for innovative professional activity in the process of teaching the Kazakh language should be regarded as a key mechanism for driving qualitative change in teacher education—and the AI Integration Model presented in this study provides a theoretically grounded, empirically tested pathway toward that goal.

ACKNOWLEDGMENTS

The authors thank the students and faculty members of Zhetysu University named after I. Zhansugurov and Central Asian Innovative University for their participation and support.

FUNDING INFORMATION

This research received no specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

AUTHOR CONTRIBUTIONS STATEMENT

This journal uses the Contributor Roles Taxonomy (CRediT) to recognize individual author contributions, reduce authorship disputes, and facilitate collaboration.

Name of Author	C	M	So	Va	Fo	I	R	D	O	E	Vi	Su	P	Fu
Baimukhambetova Kuralay	✓	✓		✓	✓	✓		✓	✓	✓	✓	✓		
Kalibek Ybyraimzhanov	✓	✓		✓		✓	✓			✓				
Bakirova Sholpan		✓		✓		✓	✓	✓	✓	✓	✓			

C : **C**onceptualization
M : **M**ethodology
So : **So**ftware
Va : **Va**lidation
Fo : **Fo**rmal analysis
I : **I**nvestigation
R : **R**esources
D : **D**ata Curation
O : Writing - **O**riginal Draft
E : Writing - Review & **E**diting
Vi : **Vi**sualization
Su : **Su**pervision
P : **P**roject administration
Fu : **Fu**nding acquisition

CONFLICT OF INTEREST STATEMENT

The authors declare no competing interests.

INFORMED CONSENT

Informed consent was obtained from all individual participants included in this study. All 123 pre-service teachers who participated in the study were fully informed of the study's purpose, procedures, voluntary nature, and data confidentiality protocols prior to their participation. Participants were advised that they could withdraw from the study at any time without consequence. Written informed consent was obtained from each participant before data collection commenced. No personally identifiable information was collected or disclosed in this manuscript. The study involved only standard educational activities and posed no risk of harm to participants. All data were anonymized prior to analysis and are reported in aggregate form only.

ETHICAL APPROVAL

All participants were fully informed of the study's purpose, voluntary nature, and data confidentiality protocols. The study was conducted in accordance with the ethical guidelines of the participating institutions and poses no risk of harm to participants, as it involved standard educational activities. Ethical approval was granted by the research ethics committee of Zhetysu University named after I. Zhansugurov.

DATA AVAILABILITY

The datasets generated and analyzed during the current study are available from the corresponding author, [BK], on reasonable request.

REFERENCES

[1] M. Bower, "Technology-mediated learning theory," *British Journal of Educational Technology*, vol. 50, no. 3, pp. 1035–1048, May 2019, doi: 10.1111/bjet.12771.

[2] J. Voogt, P. Fisser, N. Pareja Roblin, J. Tondeur, and J. van Braak, "Technological pedagogical content knowledge – a review of the literature," *Journal of Computer Assisted Learning*, vol. 29, no. 2, pp. 109–121, Apr. 2013, doi: 10.1111/j.1365-2729.2012.00487.x.

[3] UNESCO-ICHEI, "ICHEI courses empower 324,000 teachers in Kazakhstan with AI," *UNESCO-ICHEI*, 2025. Accessed: Jan. 4, 2026. [Online]. Available: https://en.ichei.org/en/news/information/1962.html

[4] S. Nurzhanova, A. Stambekova, K. Zhaxylikova, G. Tatarinova, E. Aitenova, and Z. Zhumabayeva, "Investigation of future teachers' digital literacy and technology use skills," *International Journal of Education in Mathematics, Science and Technology*, vol. 12, no. 2, pp. 387–405, 2023, doi: 10.46328/ijemst.3826.

[5] B. E. Amiresheva, L. A. Butabayeva, G. B. Ibatova, S. K. Ismagulova, and G. A. Nogaibayeva, "Are they prepared for the use of digital technology? The competencies of prospective teachers in terms of technological pedagogical content knowledge," *Eurasia Journal of Mathematics, Science and Technology Education*, vol. 21, no. 11, p. em2727, 2025, doi: 10.29333/ejmste/17340.

[6] K.-J. Tokayev, "Just Kazakhstan: Law and Order, Economic Growth, Social Optimism," (in Kazakh), *Akorda*, 2024. Accessed: Jan. 4, 2026. [Online]. Available: https://www.akorda.kz/en/president-kassym-jomart-tokayevs-state-of-the-nation-address-just-kazakhstan-law-and-order-economic-growth-social-optimism-482433.

[7] L. Ilomäki and M. Lakkala, "Digital technology and practices for school improvement: innovative digital school model," *Research and Practice in Technology Enhanced Learning*, vol. 13, no. 1, p. 25, Dec. 2018, doi: 10.1186/s41039-018-0094-8.

[8] Republic of Kazakhstan, "On the status of a teacher," Law No. 293-VI ZRK, Dec. 27, 2019, amended Dec. 30, 2024. [Online]. Available: https://adilet.zan.kz/eng/docs/Z1900000293

[9] X. Wang, H. Sun, and L. Li, "An innovative preschool education method based on computer multimedia technology," *International Journal of Emerging Technologies in Learning (iJET)*, vol. 14, no. 14, pp. 57–68, Jul. 2019, doi: 10.3991/ijet.v14i14.10714.

[10] M. J. Koehler, P. Mishra, and W. Cain, "What is technological pedagogical content knowledge (TPACK)?" *Journal of Education*, vol. 193, no. 3, pp. 13–19, Oct. 2013, doi: 10.1177/002205741319300303.

[11] P. A. Ertmer and A. T. Ottenbreit-Leftwich, "Teacher technology change," *Journal of Research on Technology in Education*, vol. 42, no. 3, pp. 255–284, Mar. 2010, doi: 10.1080/15391523.2010.10782551.

[12] Ministry of Education of the Republic of Kazakhstan, "Professional standard for the 'Teacher' profession," Order No. 500, Dec. 15, 2022. [Online]. Available: https://adilet.zan.kz/eng/docs/V2200031149

[13] M. Imankulova, T. Nurgaziyev, and B. Moldagali, "Effectiveness of language education in Kazakhstan: integration of the Kazakh language with technology, pedagogy, and content (KFL-TPACK)," *Journal of Social Studies Education Research*, vol. 16, no. 3, pp. 332–348, 2025.

[14] L. Darling-Hammond *et al*., *Preparing teachers for deeper learning*. Cambridge, MA: Harvard Education Press, 2019.

[15] L. Zhang, C. Yang, and Y. Zheng, "Digital competence for sustainable education of pre-service teachers: a systematic literature review (2014–2024)," *Frontiers in Psychology*, vol. 16, p. 1710983, Jan. 2026, doi: 10.3389/fpsyg.2025.1710983.

[16] D. Kim, K. Borowiec, and S. Wortham, "A new era in EdTech: emerging challenges and opportunities," *ECNU Review of Education*, vol. 7, no. 2, pp. 252–257, Jun. 2024, doi: 10.1177/20965311231200510.

[17] Y. Gelişli, P. Yelubayeva, and G. Shynassylova, "Developing digital competencies in language education to enhance teaching practices and professional growth," *Bulletin of Ablai Khan KazUIRandWL: Series 'Pedagogical Sciences'*, vol. 78, no. 3, pp. 34–50, 2025, doi: 10.48371/PEDS.2025.78.3.003.

[18] M. Jeon *et al.*, "An inquiry-based artificial intelligence curriculum for upper elementary students: a design case of Primaryai," *International Journal of Designs for Learning*, vol. 15, no. 3, pp. 94–108, 2024, doi: 10.14434/ijdl.v15i3.36757.

[19] J. Tondeur, R. Scherer, F. Siddiq, and E. Baran, "A comprehensive investigation of TPACK within pre-service teachers' ICT profiles: mind the gap!" *Australasian Journal of Educational Technology*, vol. 33, no. 3, pp. 46–60, 2017, doi: 10.14742/ajet.3504.

[20] S. Bothe, "Incorporating digital technologies into initial teacher education: enhancing preservice teachers' skills," *Australian Journal of Teacher Education*, vol. 48, no. 8, pp. 32–56, 2023, doi: 10.14221/1835-517X.6170.

[21] S. Kuzu, "Artificial intelligence in pre-service teacher education: Bibliometrics analysis," *Pedagogical Research*, vol. 10, no. 4, p. em0249, 2025, doi: 10.29333/pr/17402.

[22] J. Meegan and K. Young, "It's a tool not a crutch: a pilot generative AI intervention to enhance pre-service teachers' self-efficacy and AI literacy," *Technology, Knowledge and Learning*, vol. 30, no. 4, pp. 1895–1916, Dec. 2025, doi: 10.1007/s10758-025-09875-1.

[23] H. Khatimah, "Digital pedagogical innovations in English language education: a systematic literature review," *BATARA DIDI: English Language Journal*, vol. 2, no. 3, pp. 151–164, Dec. 2023, doi: 10.56209/badi.v2i3.119.

[24] B. Berendt, A. Littlejohn, and M. Blakemore, "AI in education: learner choice and fundamental rights," *Learning, Media and Technology*, vol. 45, no. 3, pp. 312–324, Jul. 2020, doi: 10.1080/17439884.2020.1786399.

[25] G. E. Coşgun, "Artificial intelligence literacy in assessment: empowering pre-service teachers to design effective exam questions for language learning," *British Educational Research Journal*, vol. 51, no. 5, pp. 2340–2357, Oct. 2025, doi: 10.1002/berj.4177.

[26] A. D. Ali and H. Waer, "Integrating TPACK in a pre-service teachers' EFL course: impacts on perception, knowledge, and practices," *Australian Journal of Teacher Education*, vol. 48, no. 3, pp. 67–94, 2023, doi: 10.14221/1835-517X.6089.

[27] S. Heine and J. König, "Applying artificial intelligence in teacher education: preservice teachers' attitudes and reflections in using ChatGPT for teaching and learning," *European Journal of Teacher Education*, vol. 48, no. 5, pp. 934–963, Oct. 2025, doi: 10.1080/02619768.2025.2540791.

[28] J. W. Creswell and V. L. Plano Clark, *Designing and conducting mixed methods research*, 3rd ed. Thousand Oaks, CA: SAGE Publications, Inc., 2018.

[29] A. Bautista *et al.*, "Preservice teachers' readiness towards integrating AI-based tools in education: a TPACK approach," *Educational Process: International Journal*, vol. 13, no. 3, pp. 40–68, 2024, doi: 10.22521/edupij.2024.133.3.

[30] M. Kashif, M. Ammar, A. Sellami, T. K. F. Chiu, S. A. Abbasi, and Z. Ahmad, "Teachers' perspectives on AI integration in K-12 education: challenges, opportunities, and preliminary assessment model–a systematic review," *Computers in the Schools*, pp. 1–27, Dec. 2025, doi: 10.1080/07380569.2025.2602507.

BIOGRAPHIES OF AUTHORS

Baimukhambetova Kuralay completed her doctoral studies in the 8D01301 – Pedagogy and Methodology of Primary Education program at Zhetysu University named after I. Zhansugurov, Kazakhstan, in 2024. She is currently senior lecturer at the Department of Teaching Methods and Education, Faculty of Pedagogy and Psychology, Zhetysu University named after I. Zhansugurov, Taldykorgan, Kazakhstan. Her research interests include innovative teacher education, digital pedagogy, and Kazakh language instruction. She can be contacted at email: kuralai-61@mail.ru.

Kalibek Ybyraimzhanov received his Doctor of Pedagogical Sciences in 13.00.01–General Pedagogy, History of Pedagogy and Education, Ethnopedagogy from Abai Kazakh National Pedagogical University, Kazakhstan, in 2008. He is currently position at the Department of Teaching Methods and Education, Faculty of Pedagogy and Psychology, Zhetysu University named after I. Zhansugurov, Taldykorgan, Kazakhstan. His research interests include methodology of education, technology-enhanced learning, and teacher professional development. He can be contacted at email: tarmpi_school@mail.ru.

Bakirova Sholpan received her Candidate of Philological Sciences in 10.02.02–Kazakh Language from Al-Farabi Kazakh National University, Kazakhstan, in 2010. She is currently a senior lecturer in the Department of Kazakh Language and Literature, Zhe. A. Tashenov University, Shymkent, Kazakhstan. Her research interests include language pedagogy, KFL (Kazakh as a foreign/second language), and content-based instruction. She can be contacted at email: Sholpan.2030@mail.ru.