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Determinants of Teachers' Adoption of Artificial Intelligence: Evidence from Kazakhstan

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ABSTRACT

In the context of accelerated digitalization of education and national initiatives for the introduction of artificial intelligence (hereinafter – AI) in Kazakhstan, the study aims to identify the factors determining the adoption of AI by teachers. This study examines the determinants of teachers' adoption of AI in Kazakhstan, a context where empirical evidence remains limited despite growing national emphasis on AI integration in education. Drawing on survey data from 662 teachers across diverse regions, the study investigated how demographic factors, professional qualifications, ICT training, self-efficacy, and resource availability influence AI use in classrooms. Results indicate that younger teachers are significantly more likely to use AI, whereas qualification level did not affect use. Formal ICT training during university education emerged as a strong positive predictor of adoption, and initial confidence with ICT was modestly associated with AI use. Age was a statistically significant predictor ($F = 3.72$, $p = 0.0054$): teachers aged 20-39 are more likely to use AI ($M = 2.18$) than teachers in older age groups ($M = 1.82$). On the contrary, the presence of ICT education in higher education significantly increased AI use ($U = 48{,}209.5$, $p = 0.0015$). By contrast, gender, subject specialisation, school location, and language of instruction did not yield meaningful differences. The findings highlight that while AI adoption among Kazakhstani teachers is growing, its use remains selective rather than routine. The study concludes that embedding structured ICT preparation in teacher education and providing sustained professional.

KEYWORDS: Digital Economy, Human Capital, Artificial Intelligence, Education, Training, New Technology, Technology Adoption, Technology Self-Efficacy

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1. INTRODUCTION

Artificial intelligence (hereinafter – AI) is increasingly viewed as a transformative driver of economic and social development. At the macro level, studies demonstrate that integrating AI with human capital fosters economic growth by enhancing productivity and innovation capacity (Gomes, 2025). Similarly, AI is reported to reshape economic development trajectories by altering business models, labour dynamics, and knowledge dissemination (Trabelsi, 2024). These insights highlight that AI is not solely a technological development but a structural force with implications for multiple domains, including education. Given that education systems prepare future workers and citizens to participate in digitally mediated societies, the integration of AI into teaching and learning environments assumes significant practical and policy relevance. The importance of adopting AI has repeatedly been emphasised at the national level. For example, in his speech at the August 2025 conference for educators, the President of the Republic of Kazakhstan stressed that preparing teachers to use AI should be a priority of the country's education policy (Tokayev, 2025).

In education, teachers' roles remain pivotal in mediating the adoption of technological innovations. A growing body of literature explores how teachers perceive and use AI, often applying technology acceptance frameworks to analyse determinants of adoption (Ali et al., 2025; Du et al., 2025; Granström & Oppi, 2025). Central predictors such as performance expectancy and perceived usefulness are consistently associated with positive behavioural intentions to adopt AI, while effort expectancy, confidence, and institutional support further shape actual use (Adigun et al., 2025; Liu, 2025; Molefi et al., 2024).

Despite the rapid expansion of empirical studies across contexts such as China, Estonia, Nigeria, and South Africa, research in Kazakhstan remains limited. The few available studies suggest that Kazakhstani teachers express positive attitudes toward AI's potential but also raise concerns about personalisation, automation bias, and the adequacy of pedagogical preparation (Fazilova & Kayip, 2025; Sulaiman et al., 2025). Given the country's strategic investments in education and innovation, examining how Kazakhstani teachers adopt and use AI is both timely and necessary. Existing evidence on Kazakhstan does not provide a comprehensive analysis of how demographic characteristics, professional qualifications, training experiences, or self-efficacy influence AI adoption in this national context.

The purpose of this study is to explore the determinants of teachers' adoption and use of AI in Kazakhstan, focusing on demographic, professional, and organisational factors. The analysis emphasises both individual characteristics (such as age, qualification level, and confidence in ICT use) and structural supports (such as ICT training and resource availability). In doing so, the study aims to provide evidence-based insights for teacher education and policy initiatives aimed at promoting effective AI integration in schools.

Guided by this purpose, the research addresses the following questions:

(1) Do age and teacher qualification levels determine teachers' adoption and use of AI in classrooms?

(2) Do ICT training in teacher education and technology self-efficacy increase teachers' adoption and use of AI in classrooms?

(3) What other factors affect the adoption and use of AI in classrooms?

2. LITERATURE REVIEW

In this section, the paper provides a review of recent literature on factors that affect teachers' adoption of AI. A significant stream of research applies established technology acceptance frameworks, such as the Technology Acceptance Model (TAM) and the Unified Theory of Acceptance and Use of Technology (hereinafter – UTAUT), to AI in education. A prevailing finding from this work is that Performance Expectancy (hereinafter –

PE) and Perceived Usefulness (hereinafter – PU), an educator's belief that using AI will improve their job performance and pedagogical effectiveness, are among the most consistent predictors of the behavioural intention to adopt these tools (Ali et al., 2025). A meta-analysis by Ali et al. (2025) confirmed that PE demonstrated the strongest association with behavioural intention across UTAUT variables. This is empirically supported in specific contexts; for example, perceived usefulness was a salient predictor of readiness among Estonian teachers (Granström & Oppi, 2025), and performance expectancy was the strongest correlate of intention for K–12 mathematics teachers in China (Du et al., 2025) and a key driver of preparedness for teachers in South Africa (Ayanwale et al., 2024).

Alongside utility, Effort Expectancy (hereinafter – EE), or the perceived ease of using the technology, also plays a critical role. While some studies find its effect secondary to performance expectancy, others highlight its situational importance (Ali et al., 2025). Research in resource-constrained contexts, such as a study of Nigerian pre-service teachers, found that EE was the only strong, direct positive predictor of intention, suggesting that when infrastructural barriers are high, usability becomes the paramount concern (Adigun et al., 2025). This highlights a recognised intention-behaviour gap: while beliefs about benefits (PE) may drive willingness to use AI, practical factors like usability (EE) and support often determine actual usage (Du et al., 2025). Educators may see AI's potential but refrain from adoption if the tools are perceived as too complex, time-consuming, or poorly integrated into their workflow (Ofem et al., 2025).

While perceived utility and ease are foundational, the literature demonstrates that teachers' individual competencies and confidence mediate these beliefs. This is where the concepts of technology self-efficacy (an educator's confidence in their own ability to use technology effectively) and AI readiness converge as critical determinants of adoption (Ofem et al., 2025). Recent studies confirm that general knowledge or positive attitudes alone are insufficient. Instead, as Liu (2025) demonstrated, adoption intention is built through a chain in which external support fosters confidence, which in turn builds specific AI readiness, ultimately strengthening the intention to adopt. Confidence facilitates the willingness to engage with new tools, whereas a lack of it is a significant barrier (Granström & Oppi, 2025). Qualitative studies from Nepal and Ethiopia, for instance, found that teachers' primary constraints were not a lack of interest but rather significant knowledge gaps and “limited preparation and confidence” to integrate AI pedagogically or ethically (Bohara & Rana, 2024; Deriba & Sanusi, 2025).

Professional development (hereinafter – PD) and foundational training are essential for successful AI integration. Training is the mechanism that translates abstract support into tangible competence. In a large-scale, two-wave study, Collie et al. (2024) identified professional learning programs as a primary job resource (enAI support type) positively associated with teachers’ generative AI self-efficacy, their valuing of the technology, and their actual integration of it into their work practices. This is because targeted training moves educators beyond mixed awareness, where AI is often conflated with general ICT use, toward pedagogical clarity (Bohara & Rana, 2024). Modelling this pathway, Ayanwale et al. (2024) found that AI-focused PD serves as a crucial mediator, translating factors such as social influence and broader technological, pedagogical, and content knowledge into practical preparedness for AI integration.

Teacher adoption of AI does not occur in a vacuum; it is deeply embedded within an institutional ecosystem of social influences and material resources. The literature is unequivocal that organisational context strongly moderates individual willingness to adopt new technologies. Liu (2025) found that a supportive climate exerts a strong, direct positive effect on willingness to adopt AI. This social factor appears especially critical for

educators in training. Studies of pre-service biology teachers in Nigeria found that attitude and subjective norms were significant predictors of behavioural intention, more so than even perceived control, suggesting that social endorsement and encouragement from leaders are central drivers of uptake among novices (Adelana et al., 2024).

Beyond social encouragement, educators require tangible Facilitating Conditions (FC), defined by Molefi et al. (2024) as school support and resources (SSR), including adequate infrastructure, time, managerial encouragement, and access to training. This support structure acts as a pivotal lever (Molefi et al., 2024). Their research demonstrated that SSR functions as a key mediator: positive attitudes and perceptions of usefulness are far more likely to translate into intention when the school actively provides the necessary time, resources, and collegial support (Molefi et al., 2024). Conversely, a lack of FC can neutralise the positive effects of other predictors; infrastructural constraints may lead to a counterintuitive negative relationship between high performance expectations and intention, as teachers grow frustrated by the gap between AI's potential and their school's reality (Adigun et al., 2025).

Educators simultaneously recognise AI's potential for efficiency such as automating routine tasks or providing 24/7 learner support, while harbouring substantial concerns (Brandhofer & Tengler, 2025). Persistent risks cited across studies include data protection, algorithmic bias, the transparency of AI systems, plagiarism, and the reliability of AI-generated content (Brandhofer & Tengler, 2025; Erümit & Özdemir Sarıalioğlu, 2025).

Although research on the adoption and use of artificial intelligence (AI) in education has expanded rapidly, there are limited empirical studies on the case of Kazakhstan. The survey by Fazilova and Kayip (2025) examined Kazakhstani EFL teachers' attitudes toward AI-generated lesson plans, finding overall positive perceptions due to efficiency, customisation, and creative ideas, but with concerns about automation bias, lack of personalisation, and the need for teacher modification. Similarly, Sulaiman et al. (2025) highlighted how Malaysia and Kazakhstan view AI as a transformative tool for enhancing STEM education, bridging disparities, and fostering collaborative initiatives like Malaysia's AI TEACH program and Kazakhstan's NURIS Innovation Cluster. This paper contributes to the growing literature on educators' use of AI by drawing on survey data.

Hypothesis development

Prior research indicates that age is linked to AI competency, with competency reflecting an individual's ability and confidence to use AI effectively, which in turn supports adoption. Empirical evidence confirms this association, showing a significant negative correlation between age and AI competency in both UK and Arab samples, indicating that older individuals tend to report lower levels of AI competency (Naiseh et al., 2025). Accordingly, the following hypothesis 1 was formulated:

H1: Younger teachers are expected to report higher levels of AI use than older teachers.

The literature on the use of ICT suggests that teachers' qualifications and related professional characteristics influence how effectively they integrate technology into their teaching (Gil-Flores et al., 2017). In Kazakhstan, teachers are assigned qualification levels that reflect their professional growth and expertise: trainee-teacher, teacher, teacher-moderator, teacher-expert, and teacher-researcher. These levels indicate a progressive system of competencies, where advancement is linked to demonstrated pedagogical skills, professional development, and contributions to educational practice and research. Hypothesis 2 was formulated:

H2: That Teachers' professional qualifications will be associated with differences in AI use.

Teacher training and preparation are central to technology integration, as they shape both confidence and competence in using digital tools. Teachers with lower professional development needs in ICT are significantly

more likely to frequently use technology in classrooms, while those reporting higher training needs are less likely to do so (Gil-Flores et al., 2017). Thus, the following hypothesis 3 was formulated:

H3: Teachers who received formal ICT preparation during initial teacher education will report higher AI use than those without such preparation.

Previous research consistently links self-efficacy, defined as confidence in one's ability to use technology, to adoption and sustained use of emerging digital tools. Individuals with greater self-efficacy approach AI with less anxiety and more openness to learning, which fosters both skill acquisition and positive attitudes toward integration (Naiseh et al., 2025). Based on this, hypothesis 4 was proposed:

H4: Higher initial confidence in using ICT will predict greater AI use.

Literature on technology adoption highlights that access to appropriate digital resources, especially educational software, plays a significant role in determining the extent to which teachers integrate technology into their practice. While the availability of hardware and internet access did not show strong effects, the presence of suitable instructional software was positively linked to more frequent classroom use of ICT (Gil-Flores et al., 2017). The following hypothesis 5 was formulated:

H5: Greater perceived availability of instructional materials will be positively associated with teachers' AI use.

Evidence from ICT and AI adoption studies shows gender-related differences, though often nuanced. In AI specifically, males reported higher favourable attitudes toward AI compared to females in the UK sample, though not in Arab contexts (Naiseh et al., 2025). A recent meta-analysis of active teachers' ICT attitudes found that overall gender differences were slight and inconsistent. However, it revealed domain-specific patterns: female teachers scored higher in affective-emotional attitudes, while males showed stronger self-efficacy beliefs (Guillén-Gámez & Rodríguez-Fernández, 2022). To test the association between gender and AI use, the following hypothesis 6 was proposed:

H6: Male and female teachers will differ in their levels of AI use.

3. RESEARCH METHODS

The study employed an online survey to investigate teachers' working conditions, practices, and opinions in Kazakhstan, with particular emphasis on professional development, AI use, career aspirations, and school environments. The questionnaire was first tested on a pilot group to identify ambiguities and refine its structure. Following revisions, the instrument was submitted to the Ethics Committee of JSC "Taldau" and received approval. The survey was administered via the SurveyMonkey platform. Participation was voluntary and preceded by the presentation of an informed consent form. Respondents who agreed proceeded to the questionnaire, which was fully anonymous.

To ensure representativeness, a stratified cluster sampling approach was applied. In the first stage, settlements from five regions of Kazakhstan (central, southern, northern, western, and eastern) were selected, each stratified by urban location (regional centres or cities of national significance) and surrounding rural districts. From these strata, 50 schools were randomly chosen. Invitations to participate were shared with regional education departments and school administrations to broaden outreach and encourage participation.

In total, 662 valid responses were collected. Data preparation and statistical analysis were conducted using. The primary data processing and statistical analysis were carried out using Microsoft Excel and Python programs. During data preparation, the questionnaires were checked for completeness, value correctness, and the exclusion of duplicate entries. Descriptive statistics confirmed that the sample was broadly representative of the teaching workforce in Kazakhstan, with demographic indicators, such as gender distribution, qualification level, and teaching experience,

closely aligned with the national population. The demographic indicators are presented in the next section.

To assess the extent of AI adoption among educators, respondents were asked: "How often do you use AI tools in your professional activities?". The answers were recorded on a five-point scale, where the value of 1 corresponded to the option 'never', 2 – 'rarely', 3 – 'sometimes', 4 – 'often' and 5 – 'always'. This gradation enabled quantifying the level of teachers' involvement in the use of artificial intelligence technologies and conducting a comparative analysis of various socio-professional characteristics, including age, qualification level, availability of training in information and communication technologies, and other demographic and organisational factors. Additionally, the questionnaire included questions aimed at identifying teachers' levels of digital competence, their confidence in working with ICT, and a subjective assessment of the school's provision of the necessary educational, methodological, and technical resources. The combination of these indicators enabled a comprehensive evaluation of the factors influencing the adoption and use of artificial intelligence in Kazakhstan's educational environment.

The study's stages are shown in Figure 1, which outlines the sequence of actions.

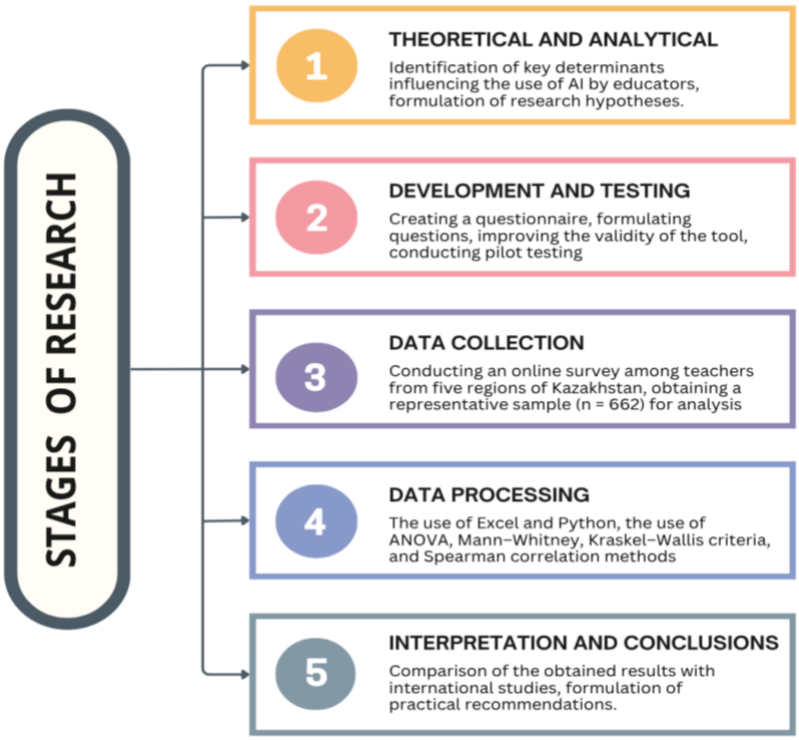

Figure 1. The steps of conducting scientific research

Statistical data processing was carried out in Python using methods of univariate analysis of variance (ANOVA), the Mann-Whitney criterion, the Kruskal–Wallis criterion and Spearman's rank correlation. These methods allowed us to determine the significance of differences and relationships between teachers' demographic, professional, and organisational characteristics and the level of AI use.

4. RESULTS

According to the survey results, the majority of participants were middle-aged

teachers. The largest groups were those aged 30–39 years (212 participants, 32.02%) and 40–49 years (207 participants, 31.27%). Teachers aged 50–59 years accounted for 19.03% (126 participants).

Younger teachers aged 20–29 years were less represented, comprising 102 participants (15.41%), while only 15 respondents (2.27%) reported being 60 years or older (see Figure 2).

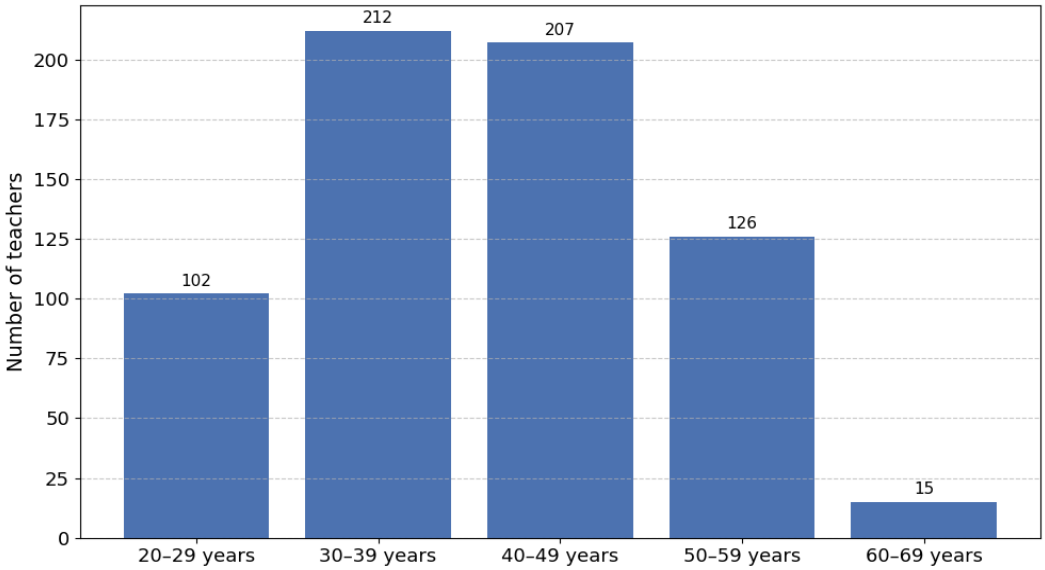

Figure 2. Distribution of teachers by age group

The distribution of participants by age closely reflects the national teacher population structure, with an average age of 41 years according to the National Open Database of Education (NOBD, June 2025). Since the survey captured age ranges rather than exact values, an estimated mean age of 40.57 years was calculated using midpoints of the ranges. The survey sample was predominantly female, with 548 women (82.78%) compared to 114 men (17.22%) (see Figure 3).

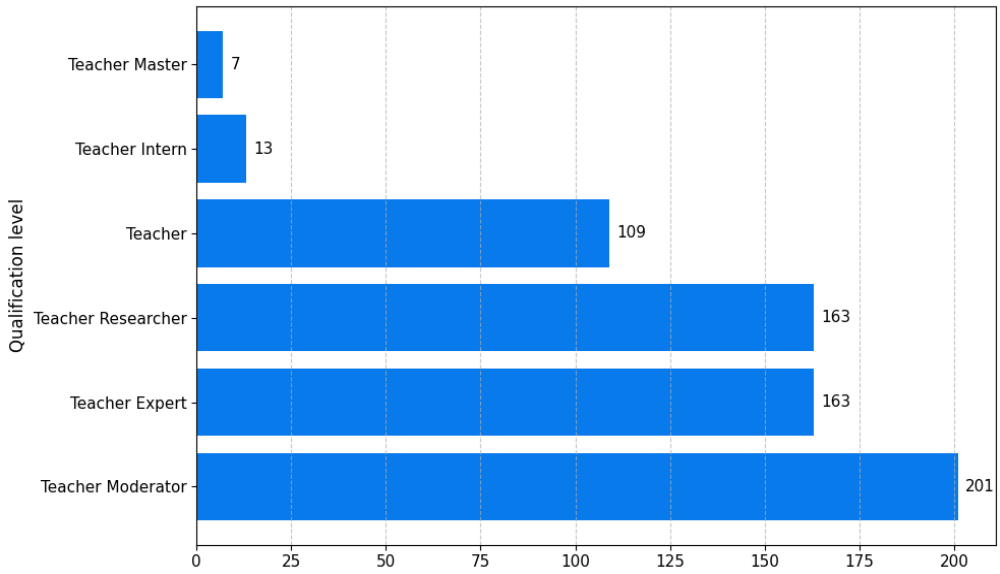

Figure 3. Distribution of teachers by qualification level

This gender distribution is consistent with national statistics, which show that women represent 82.1% of the teaching workforce in Kazakhstan as of 2025. Respondents also provided information on their professional qualification levels. The largest group was teachers with the "Teacher Moderator" qualification (201 participants, 30.64%). Nearly equal proportions of participants reported qualifications as "Teacher Expert" (163 participants, 24.85%) and "Teacher Researcher" (163 participants, 24.85%). A total of 109 respondents (16.61%) identified as holding the base level "Teacher" qualification. Less common were the categories of "Teacher Intern" (13 participants, 1.98%) and "Teacher Master" (7 participants, 1.07%). These proportions generally align with national statistics from the NOBD (June 2025), where the largest group is also Teacher Moderators (29%), while Teacher Interns (0.6%) and Teacher Masters (0.8%) are the smallest groups.

The results on teachers' use of AI are presented in Table 1.

TABLE 1. Frequency of teachers' use of AI

Frequency of AI use	Number of respondents	Percentage (%)
Sometimes	254	40.8
Often	145	23.3
Rarely	121	19.5
Never	56	9.0
Always	46	7.4

Note: compiled by authors

The most common response was 'sometimes' (40.8%), followed by 'often' (23.3%) and 'rarely' (19.5%). Only 9.0% of teachers reported never using AI, while 7.4% reported consistently using such tools. In other words, approximately one-third of the surveyed teachers reported using AI frequently (often or always) in their professional practice. These results suggest that while complete non-use of AI remains relatively uncommon, the technology has not yet become an integral or routine part of most teachers' professional activities. Instead, AI tools appear to be used selectively and situationally, with only a minority of teachers reporting consistent integration into their work.

Hypothesis testing results

For Hypothesis 1, which posited that younger teachers would report higher levels of AI use than older teachers, a one-way ANOVA was conducted to compare the extent of AI use across five independent age groups. This test is appropriate when assessing whether the means of more than two groups differ. The analysis revealed a statistically significant effect of age on AI use ($F = 3.72$, $p = 0.0054$), indicating that the extent of AI adoption varies by age category. The mean levels of AI use by age category are presented in Table 2, which shows that younger teachers reported higher adoption than older cohorts.

TABLE 2. Mean AI use by age group

Age group	Mean	Standard deviation	Sample size
20–29	2.16	1.09	96
30–39	2.20	1.00	193
40–49	1.89	1.03	183
50–59	1.81	1.11	98
60–69	1.83	0.72	12

Note: compiled by authors

Comparison of group means showed that AI use was highest among teachers aged 20–29 (M = 2.16) and 30–39 (M = 2.20). In contrast, teachers aged 40–49 (M = 1.89) and 50–59 (M = 1.81) reported lower levels of use, while the oldest group, aged 60–69, reported a comparable level (M = 1.83). These findings suggest that younger teachers are more active in adopting AI and digital technologies, whereas older age groups demonstrate relatively lower levels of engagement.

For hypothesis 2, which posited that teachers' professional qualification level would be associated with differences in AI use. A Kruskal–Wallis test was conducted to examine the relationship between teachers' qualification level and AI use. This nonparametric test was chosen because more than two independent groups were compared, and the data were ordinal and not normally distributed. The analysis revealed no significant differences in AI use across qualification levels (H = 2.38, p = 0.795), indicating that AI use was similar across levels.

Across all qualification categories, the average level of AI use was approximately 2.0, with consistent medians of 2.0. The only exception was the master teacher group, which reported a higher mean (M = 2.67, median = 3.0). However, this subgroup was very small (n = 3), and no reliable conclusions can be drawn from this finding. Overall, these results suggest that teachers' qualification level does not influence their engagement with AI technologies, as use remains comparable across groups.

For hypothesis 3, which posited that teachers who received formal ICT preparation during initial teacher education will report higher AI use than those without such preparation, a Mann–Whitney test was conducted to assess differences in AI use between teachers who reported having ICT training in their university program and those who did not. This nonparametric test was selected because it compares two independent groups using ordinal data without assuming normality. The analysis revealed a statistically significant difference in AI use between the two groups (U = 48,209.5, p = 0.0015).

Teachers who received ICT training during their university studies reported higher levels of AI use (M = 2.17) compared to those without such training (M = 1.89). Although the median was identical in both groups (2.0), the difference in means and the overall distributions indicate greater engagement with AI among teachers with ICT in their academic preparation (see Table 3).

TABLE 3. Mean and median "AI use" by inclusion of ICT in university training

Group	Mean [Median]	Standard deviation	Sample size
Not included in university program (0)	1.89 [2.0]	1.03	314
Included in university program (1)	2.17 [2.0]	1.06	268

Note: compiled by authors

These results suggest that the inclusion of ICT training in university programs is positively associated with the adoption of AI in professional practice.

For hypothesis 4, which argued that higher initial confidence in using ICT will predict higher levels of AI use, Spearman's rank-order correlation was conducted, revealing a weak but statistically significant positive relationship between initial ICT confidence and current AI use ($\rho = 0.172$, $p < 0.001$). This suggests that teachers who entered the profession with higher ICT confidence are somewhat more likely to engage with AI in their practice. However, the small effect size indicates that ICT confidence is only one contributing factor, not a decisive predictor of AI adoption. Teachers reported relatively high confidence in using ICT when they began working at their current school (M = 4.10, median = 4.0). In contrast, their current level of AI use was considerably lower (M = 2.01, median = 2.0), reflecting only moderate integration of AI into teaching practice.

For hypothesis 5, which argued that greater perceived availability of instructional materials will be positively associated with teachers' AI use, Spearman's correlation analysis revealed a weak but statistically significant positive association between perceived availability of materials and AI use ($\rho = 0.102$, $p = 0.014$). This finding suggests that teachers in better-resourced schools tend to report slightly higher levels of AI use.

Teachers rated the statement "Necessary materials, such as textbooks, supplies, and photocopiers, are available to staff as needed" at an average of 3.06 (median = 3.0). This suggests that while resources are generally available, they are not consistently provided at an optimal level. The variability in responses (range 1–4) indicates differences across schools, with some teachers perceiving access as sufficient and others as limited. In comparison, AI use was rated lower, with a mean of 2.02 (median = 2.0), reflecting only moderate integration of such technologies into teaching practice.

Finally, for hypothesis 6, which posited that male and female teachers will differ in levels of AI use, a t-test comparison showed no significant difference in AI use between female ($M = 2.03$) and male ($M = 1.97$) teachers ($t = 0.493$, $p = 0.623$). These results align with previous findings, suggesting that gender is not a determining factor in the adoption of AI technologies.

5. DISCUSSION

This study investigated the determinants of teachers' adoption of AI in Kazakhstan, with a particular focus on demographic factors, professional qualifications, ICT training, and self-efficacy. Age emerged as a significant factor, with younger teachers more likely to use AI. This supports earlier evidence from cross-national samples that identified a negative relationship between age and AI competency (Naiseh et al., 2025). By contrast, qualification level did not significantly influence AI adoption. ICT training during initial teacher education was found to be a positive predictor of AI adoption. This finding resonates with studies emphasising professional development and training as pivotal in bridging the gap between readiness and actual classroom practice (Collie et al., 2024; Ayanwale et al., 2024; Molefi et al., 2024). Similarly, higher self-reported ICT confidence modestly predicted AI use, aligning with evidence that self-efficacy underpins willingness to engage with emerging technologies (Liu, 2025; Granström & Oppi, 2025).

Resource availability also showed a weak but significant association with AI use, consistent with prior findings that facilitating conditions, such as infrastructure and access to materials, mediate the translation of positive attitudes into practice (Molefi et al., 2024; Adigun et al., 2025). However, gender, subject specialisation, school location, and language of instruction did not yield significant differences, suggesting that these factors may be less influential in the Kazakhstani context than in other regions.

The results reinforce previous findings that technological readiness plays a strong role, impacting perceived usefulness and preparedness to adopt AI (Ofem et al., 2025). Practically, the evidence underscores the value of embedding ICT training into teacher education curricula and induction programs as a foundation for future AI adoption. Future research in the Kazakhstan context should also examine the role of AI-related professional development in AI use. The study is limited by its cross-sectional design and reliance on self-reported measures, which constrain causal inference.

Practical implications

The results of this study carry several important implications for teacher education policy, school-level implementation, and national digital transformation strategies. Because younger teachers demonstrated higher levels of AI use, policymakers should prioritise scalable professional learning pathways that specifically support mid- and late-career teachers. Targeted capacity-building, such as modular short courses, mentorship from

digitally fluent peers, and school-embedded coaching, may help reduce generational gaps in adoption and prevent fragmentation in pedagogical innovation.

The positive association between prior ICT training and subsequent AI use indicates that foundational digital competencies act as an enabling condition for more advanced technologies. Teacher preparation institutions should therefore integrate AI-related competencies into existing ICT courses, focusing on pedagogical applications rather than general digital literacy. Accreditation bodies may consider requiring demonstrated capability in AI-assisted planning, feedback, and assessment practices. Continuous professional development should extend these competencies throughout the career lifecycle to sustain adoption.

Although qualification levels were not linked to AI use, resource availability showed a small but significant effect, suggesting that infrastructure remains a prerequisite for consistent integration. Policymakers should ensure equitable access to devices, connectivity, and school-approved AI platforms across regions. Investments should emphasise not only hardware but also technical support and time allowances for experimentation, as teachers rarely adopt tools that increase workload.

Schools should also develop clear guidelines addressing ethical use, student data protection, academic integrity, and transparency in AI-supported teaching. Such policies can reduce uncertainty and facilitate responsible engagement. Highlighting subject-specific exemplars and facilitating collaborative planning communities can further translate interest into routine practice.

6. CONCLUSION

This study contributes to the growing body of research on AI adoption in education by providing large-scale empirical evidence from Kazakhstan. The findings demonstrate that while AI is increasingly present in teachers' professional practice, its integration remains selective rather than routine. Younger teachers were more likely to adopt AI, whereas qualification level did not. More importantly, formal ICT training during initial teacher education and higher levels of technology self-efficacy emerged as positive predictors of AI use, underscoring the importance of foundational preparation that equips educators with the skills and confidence to integrate emerging technologies into their classrooms. The results also indicate that resource availability has a modest influence on AI uptake. However, other demographic and contextual factors, such as gender, subject specialisation, school location, and language of instruction, did not show significant effects.

These outcomes reinforce the centrality of ICT preparation and induction/professional development as critical levers for effective AI integration. Embedding structured ICT training in teacher education curricula, alongside sustained opportunities for AI-focused professional development, may help bridge the gap between willingness to adopt and actual classroom practice. The findings also suggest that strengthening institutional support systems and ensuring adequate resources can further facilitate adoption. Additionally, the development of digital competencies among teachers helps increase the productivity of the educational system, create prerequisites for the introduction of adaptive and personalised learning technologies, and train specialists capable of working in the knowledge economy.

From a theoretical perspective, the study confirms the relevance of the TAM and UTAUT models in the context of emerging market countries, demonstrating that individual and institutional factors mutually enhance the process of technological adoption. The practical significance lies in the fact that the data obtained can be used to develop national education digitalisation programs, improve teachers' digital literacy, and create targeted courses on the use of AI in the educational process.

In the future, it is promising to expand the research methodology by including longitudinal data, assessing the impact of AI on

learning outcomes, and comparing these findings with those from other Central Asian countries. This will enable the identification of institutional differences, the assessment of the dynamics of digital inequality, and the establishment of an empirical basis for integrating AI into the education system at the level of public policy.

AUTHOR CONTRIBUTION

Writing – original draft: Kairat Moldashev.
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Formal analysis and investigation: Kairat Moldashev, Birzhan Sahimbekov.
Funding acquisition and research administration: Kairat Moldashev, Birzhan Sahimbekov.
Development of research methodology: Kairat Moldashev.
Software and supervisions: Kairat Moldashev.
Data collection, analysis and interpretation: Kairat Moldashev, Birzhan Sahimbekov.
Visualization: Kairat Moldashev.
Writing review and editing research: Kairat Moldashev, Birzhan Sahimbekov.

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