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Evaluating the Relationship Between Pre-Service Teachers' Artificial Intelligence Readiness and Professional Self-Efficacy

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Abstract

The rapid development of educational technologies requires a deeper understanding of pre-service teachers' readiness for artificial Intelligence and the extent to which their professional self-efficacy beliefs influence this process. Although the integration of emerging technologies has gained increasing attention, the relationship between technological competence and professional confidence among pre-service teachers remains underexplored. This study aims to investigate the interplay between pre-service teachers' readiness for artificial intelligence and their professional self-efficacy. An exploration sequential mixed method design was employed, beginning with a quantitative phase involving 293 pre-service teachers, followed by a qualitative phase to capture deeper insights. Findings revealed that pre-service teachers demonstrated an elevated level of readiness for artificial intelligence and positive self-efficacy beliefs, yet no meaningful relationship emerged between the two variables. The results suggest that professional self-efficacy and technological readiness are influenced by broader contextual and pedagogical factors rather than functioning in a straightforward manner. In the qualitative phase, participants highlighted both opportunities and challenges related to the use of artificial intelligence in primary education. While many emphasized its potential to support personalized learning, reduce workload, and enhance student adaptability, concerns were raised about ethical implications, risks to social-emotional development, cultural values, digital literacy gaps, and infrastructural limitations. The study underscores the necessity for teacher education programs to extend beyond technical training by incorporating pedagogical, ethical, and cultural dimensions to prepare pre-service teachers for meaningful integration of artificial intelligence into educational practice.



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1. Introduction

The training of future educators for artificial intelligence (AI) significantly influences their perception of professional self-efficacy in educational settings. The preparation

for AI includes both the knowledge and attitudes that future educators maintain on the integration of AI technologies into their teaching practices. [Rajapakse et al. \(2024\)](#) assert that a substantial link exists between teachers' preparedness for implementing AI and their confidence in efficiently instructing pupils in this area. The analysis of a cohort of pre-service teachers indicated that individuals with enhanced AI preparation exhibited increased confidence in their capacity to instruct on AI-related content, implying that pedagogical trust can be strengthened through targeted training in AI tools and applications. [Liu \(2025\)](#) investigated the mediating influence of AI preparation, suggesting that enhanced preparation for technologies significantly enhances the relationship between the adoption of these technologies and a teacher's self-efficacy beliefs. This emphasizes the necessity for pre-service educators to engage actively in AI training to enhance security in their professional practice.

The convergence of digital literacy and self-efficacy beliefs elucidates the dynamics involved in AI preparation. [Lim \(2023\)](#) identified a positive correlation between the digital competencies of early childhood educators and their perspectives on artificial intelligence instruction for young children. This discovery underscores the significance of digital competence as a prerequisite for the successful incorporation of AI in educational practices, hence impacting educators' self-efficacy. Future educators' digital literacy enhances the seamless integration of AI technologies in their instruction and bolsters their confidence in utilizing these resources to enhance educational outcomes. Furthermore, the study conducted by [Yao and Wang \(2024\)](#) broadens this discussion to encompass special education, illustrating that digital literacy enhances the self-efficacy beliefs of special education teachers prior to their service on the utilization of AI. They found that individuals with a solid foundation in digital abilities felt more competent and secure in utilizing AI to modify their instructional tactics for diverse students, thereby underscoring the essential importance of technology proficiency in shaping self-efficacy.

Existing studies collectively demonstrate that the cultivation of AI preparation among pre-service educators is strongly associated with their beliefs in professional self-efficacy. By contextualizing professional development programs that prioritize AI and digital literacy, teacher training institutions can enhance future educators' confidence in implementing technology advancements in their classrooms ([Guettala et al., 2023](#); [Alshorman, 2024](#); [Chiu et al., 2025](#); [Farooq, 2025](#)). This involvement directly impacts overall educational outcomes, as enhanced self-efficacy correlates with increased student participation and achievement. Further exploration of these complex relationships could yield essential insights into the requisite elements of teacher preparation necessary to equip educators for the evolving needs of educational technology ([Zainuddin et al., 2024](#)). The ramifications of preparing future educators for artificial intelligence (AI) are substantial for teacher training programs and the resulting educational outcomes. [Guan et al. \(2025\)](#) underscore the imperative of comprehensive training in AI integration for pre-service teachers, claiming that such training is essential for cultivating a sense of preparedness and augmenting beliefs in professional self-efficacy. [Guan et al.'s \(2025\)](#) findings indicate a robust reciprocal association between a teacher's preparation to accept AI and their confidence in efficiently utilizing technology in educational settings. When teacher training programs integrate comprehensive AI training, they furnish educators with essential skills and knowledge, hence enhancing their self-efficacy views.

Moreover, the significance of professional development in enhancing the pedagogical skills of AI is undeniable. [Sun et al. \(2023\)](#) investigated a methodology grounded in the understanding of technological pedagogical content knowledge (TPACK), concentrating on its utility for K-12 computer science educators in the development of AI competitions. This research demonstrates that systematic and ongoing professional development is crucial for

fostering the knowledge and confidence required to incorporate AI into educational practices. When examining the convergence of technology, pedagogy, and knowledge, teacher training programs can enhance the self-efficacy and readiness of pre-service educators to utilize AI tools effectively.

The AI preparation scale by [Ramazanoglu and Akin \(2025\)](#) underscores an immediate necessity for training programs focused on AI competencies. The scale serves as a benchmark to assess instructors' readiness to integrate AI into their teaching methodologies, emphasizing the necessity of tailored training programs. The findings of their study indicate that comprehending the preparedness levels of pre-service teachers can guide the development of training programs that emphasize AI literacy while also enhancing instructors' self-efficacy views.

[Martin et al. \(2020\)](#) investigated various course design attributes that significantly enhance pre-service teachers' perceptions of their instructional competencies, especially for information and communication technology (ICT). Their findings indicate that specific instructional tactics, including experiential learning opportunities and tutoring, are essential for fostering self-efficacy among trained educators. The correlation between course design attributes and enhanced self-efficacy suggests that teacher training programs must emphasize psychological and pedagogical frameworks that foster confidence in employing AI as an educational instrument. [Akcil et al. \(2021\)](#) discovered that integration technology is a complex and multifaceted process characterized by several dynamics, and that complete integration is unattainable. As a result, suggestions were provided concerning diverse models, artificial intelligence, and Google Workspace tools to facilitate technological integration by the challenges outlined in the research.

The collective research underscores a significant connection between the training of pre-service teachers in AI and their attitudes toward professional self-efficacy. Effective teacher training programs that address these characteristics enhance educators' confidence and skill in integrating technology into their work, which eventually supports improved educational outcomes for students. The correlation between the training of pre-service educators in artificial intelligence (AI) and their professional self-efficacy significantly influences educational outcomes. [Oran \(2023\)](#) convincingly illustrates that educators with elevated self-efficacy employ more effective teaching methodologies, resulting in enhanced student performance. These results suggest that the enhancement of self-efficacy is not merely an individual characteristic of educators but a vital element that can transform educational effectiveness and, consequently, student learning outcomes. This link indicates that when pre-service educators possess confidence in their capacity to incorporate AI technologies into their instruction, they are inclined to employ more innovative and successful pedagogical practices. These tactics can enhance student engagement and comprehension, resulting in improved academic outcomes.

Moreover, [Zhang et al. \(2023\)](#) expand this analysis through a multigroup examination of pre-service teachers' acceptance of AI in educational settings. Their findings indicate considerable differences in how various sectors of this population understand and are equipped for AI technologies. Individuals with superior preparation for AI have a heightened inclination to embrace enhanced pedagogical methods involving technology, as well as to indicate elevated self-efficacy. Training programs must consider these disparities in AI preparedness, personalizing techniques to enhance self-efficacy in those who may be more resistant or less equipped for this technological transition. By acknowledging and addressing these disparities, teacher preparation can more efficiently equip educators to confront the challenges of contemporary classrooms, hence enhancing educational outcomes.

Cultural effects significantly shape opinions of AI and its incorporation into educational procedures. [Viberg et al. \(2023\)](#) emphasize that varying cultural contexts can result

in differing opinions regarding the effectiveness of AI in education. For instance, educators from cultures emphasizing social learning may utilize AI tools differently than their counterparts from more individualistic cultures. Cultural differences can influence instructors' perceptions of self-efficacy and their inclination to embrace innovative technologies. The interplay between cultural context and technology readiness creates a dynamic setting that either fosters or inhibits educators' self-efficacy views.

Given these complex relationships, it is evident that equipping pre-service educators with the skills and confidence necessary to effectively interact with AI is essential. Adebago (2025) asserts that a comprehensive teacher training program incorporating AI preparation enhances self-efficacy and equips educators to address the diverse issues encountered in contemporary classrooms. Ayanwale et al. (2022) assert the necessity of aligning teacher education priorities with the evolving educational landscape influenced by technology. This alignment has the potential to enhance learning experiences across diverse contexts, leading to improved educational outcomes. The scholarly discussion underscores that education for AI among pre-service educators is crucial, as it strongly correlates with their self-efficacy beliefs and, consequently, with the overall educational outcomes for their pupils.

Based on the findings listed above, the rapid proliferation of artificial intelligence technologies in education makes it crucial to determine the extent to which pre-service teachers are ready for this transformation and their professional efficacy beliefs. Teachers' attitudes toward technology and their perceptions of self-efficacy directly impact how these technologies are implemented in the classroom. In this context, comprehensive studies that address both pre-service teachers' AI readiness and their professional self-efficacy beliefs are quite limited.

This study aims to evaluate the relationship between teacher candidates' readiness for artificial intelligence and their professional self-efficacy beliefs.

To achieve this aim, answers to the following questions were sought.

1. What is the level of preparedness of teacher candidates for artificial intelligence?
2. What is the level of professional self-efficacy beliefs of pre-service teachers?
3. What is the relationship between teacher candidates' readiness for artificial intelligence and their professional self-efficacy beliefs?
4. What are the views of pre-service teachers on the use of artificial intelligence in primary education?

2. Materials and Methods

2.1. Research Model

This research was conducted using an exploratory sequential mixed-method design. Quantitative data were first collected, followed by qualitative data to further explain and support this data. This methodology allowed us to determine the relationship between pre-service teachers' AI readiness levels and their professional self-efficacy beliefs using numerical data, while their views on the use of AI at the primary school level were analyzed in depth using qualitative data. Mixed methods is a research approach that uses both quantitative (closed-ended) and qualitative (open-ended) data to gain a deeper understanding of research questions, and where these data are analyzed and interpreted in a mutually complementary manner. This method is particularly popular in fields based on human interaction, such as the social, health, and behavioral sciences (Creswell, 2021).

This study also provides in-depth qualitative data on pre-service teachers' views on the use of artificial intelligence in primary education, demonstrating that technological integration should be evaluated not only from a technical perspective but also from a pedagogical and ethical perspective. This study aimed to offer concrete recommendations

for updating the content of teacher education programs and developing strategic plans for artificial intelligence education. In this respect, the study offers guidance for educational policies, teacher education programs, and the integration of technology.

2.2. Participants

The study group consisted of 293 pre-service teachers enrolled in the Faculty of Education at a state university in Kazakhstan during the 2024–2025 academic year. The qualitative study was conducted with 20 pre-service teachers selected from this quantitative sample using a purposive sampling method. Participants were selected from a variety of grade levels and branches, aiming to contribute to the study in a multifaceted manner. This provided a more comprehensive assessment of pre-service teachers' readiness for artificial intelligence and their professional self-efficacy beliefs in the Kazakh context.

2.3. Data Collection Tools

The study yielded both quantitative and qualitative data. Data collection was conducted using three different tools: one qualitative and two quantitative. These tools aimed to quantitatively measure pre-service teachers' readiness levels for artificial intelligence and their professional self-efficacy beliefs, as well as to provide an in-depth, qualitative analysis of their views on the use of artificial intelligence in primary education. The scales used were adapted to Kazakh culture, and validity and reliability studies were conducted.

2.3.1. Artificial Intelligence Readiness Scale

In this study, the Artificial Intelligence Readiness Scale, developed by [B. Wang et al. \(2023\)](#) and adapted into Turkish by [Özüdoğru and Yıldız Durak \(2024\)](#), was used to determine teacher candidates' readiness levels for artificial intelligence. The scale is structured on a 5-point Likert-type scale and consists of 18 items in total. According to the rating scale, 1 is scored as strongly disagree, and 5 is scored as strongly agree. This scale consists of 18 items and 4 sub-dimensions. The sub-dimensions are "cognition, ability, vision, and ethics in teaching". The score ranges for the answer options of the scale are calculated as: 1.00–1.79 Strongly Disagree, 1.80–2.59 Agree, 2.60–3.39 Undecided, 3.40–4.19 Agree, and 4.20–5.00 Strongly Agree.

The "cognition" sub-dimension (5 items) measures participants' understanding of the role of teachers in the age of artificial intelligence. The "Competence" sub-dimension (6 items) assesses their ability to use artificial intelligence effectively in the classroom. The "Vision" sub-dimension (3 items) measures candidates' foresight regarding the potential of artificial intelligence in education. The "Ethics" sub-dimension (4 items) addresses teachers' awareness of their ethical responsibilities in the use of artificial intelligence.

The scale was subjected to linguistic adaptation from Turkish to Kazakh. During the translation process, two linguists translated it back and forth, and the original and Kazakh versions were compared in terms of semantic equivalence. Necessary corrections were made in line with expert opinions to form the definitive version of the scale. In addition, the finalized items were carefully read and approved by two (2) educational technologists and two (2) experts with doctorates in educational psychology. As part of the pilot study, exploratory factor analysis (EFA) was conducted on 132 pre-service teachers. The KMO value was 0.79, the Bartlett test result was $\chi^2 = 548.665$, $p < 0.001$, and the factor structure of the scale was determined to be appropriate. The four (4) factor structure, explaining 75.9% of the total variance, was preserved. Cronbach's Alpha reliability coefficient of the scale was calculated as 0.872, while the sub-dimensions were calculated as "cognition" 0.819, "competence" 0.889, "vision" 0.850, and ethics 0.933.

2.3.2. Professional Self-Efficacy Beliefs Scale

The Professional Self-Efficacy Beliefs Scale, developed by Çolak et al. (2017), was used to determine pre-service teachers' professional self-efficacy perceptions. The scale consists of four sub-dimensions: "academic," "social," "intellectual," and "professional competence." The scale was rated on a 5-point Likert-type scale. The score ranges for the answer options of the scale are calculated as follows: 1:00–1:79 Strongly Disagree, 1:80–2:59 Agree, 2:60–3:39 Undecided, 3:40–4:19 Agree, and 4:20–5:00 Strongly Agree.

This scale was also adapted from Turkish to Kazakh using a forward-backward translation method, and expert assessments were obtained as part of linguistic equivalence studies. A pilot study was conducted with a separate sample of 132 teacher candidates. The overall reliability coefficient of the scale was found to be Cronbach's alpha = 0.858. The values for the sub-dimensions were calculated as "academic" 0.828, "social" 0.863, "intellectual" 0.851, and "professional competence" 0.893. The findings demonstrated that the scale is valid and dependable in the Kazakh context.

2.3.3. Semi-Structured Interview Form

For the qualitative aspect of the study, a semi-structured interview form was developed to examine pre-service teachers' views on the use of artificial intelligence in primary education. The form included open-ended questions regarding the role of artificial intelligence in education, its impact on teaching processes, potential advantages and disadvantages, ethical and pedagogical implications, and recommendations.

During the form development process, field experts (at least PhD-level, working in primary education programs) were consulted to assess its content validity. Adjustments were made to the form based on feedback from four experts working in primary education programs who hold at least PhD degrees. Additionally, the interview form was piloted with three pre-service teachers to evaluate for clarity and appropriateness of questions. Pilot participants were not included in the main study sample. During the interviews, each participant's responses were clarified when necessary, and the researchers took care to avoid any loss of meaning. Qualitative data were analyzed by dividing them into themes using content analysis.

2.4. Procedure

The data collection for the study was conducted during the 2024–2025 academic year. Before the process began, pre-service teachers were provided with detailed information about the purpose, scope, data confidentiality, and conditions of participation, and it was clearly stated that their participation was voluntary.

Quantitative data were collected primarily through online (Google Form) and in-person surveys. Participants completed the Artificial Intelligence Readiness Scale and the Professional Self-Efficacy Beliefs Scale in an average of 20–30 min. The qualitative data collection process then began, with a semi-structured form administered to 20 pre-service teachers selected through a purposive sampling method. Technical support was provided throughout the process, and the data was securely stored digitally.

2.5. Ethical Principles

All ethical guidelines were adhered to in this study. Approval was obtained from the relevant university's Ethics Committee before data collection. Participants were provided with informed consent, and they were assured that their data would be used solely for scientific purposes and that their identities would be kept confidential. Participants in the study participated voluntarily, and it was clearly stated that they had the right to withdraw from the process at any time if they wished. Furthermore, participant codes and personal

information used in the qualitative data were kept confidential, and data security was ensured by national legislation.

2.6. Data Analysis

Quantitative data were analyzed using SPSS version 26. Relationships between variables were determined using descriptive statistics (mean, standard deviation) and Pearson correlation analysis. The significance level was set at 0.05. Qualitative data were analyzed using content analysis. In this research, qualitatively collected data were analyzed using thematic analysis techniques. Participant responses were thematically coded and classified into specific categories. As a result of the analysis, pre-service teachers' views on the use of artificial intelligence in primary education were described under the headings of opportunities, limitations, ethical/pedagogical concerns, and recommendations.

3. Results

3.1. What Is the Level of Preparedness of Teacher Candidates for Artificial Intelligence?

Table 1 presents the total and sub-dimensional means and standard deviation values for the readiness levels of pre-service teachers towards artificial intelligence. According to the findings, the general readiness level of the participants was high ($M = 68.29$; $SD = 12.35$). When the sub-dimensions were examined, a high level of readiness was observed in the dimensions of cognitive readiness ($M = 19.35$; $SD = 4.27$), artificial intelligence use skills ($M = 23.42$; $SD = 5.28$), and artificial intelligence perception ($M = 11.86$; $SD = 2.86$). These findings indicate that pre-service teachers have a sufficient level of understanding of the basic concepts of artificial intelligence, using technology, and developing a positive perception. In the ethical awareness sub-dimension, the participants' mean score remained at a moderate level ($M = 13.65$; $SD = 3.13$). This suggests that pre-service teachers' awareness of the ethical dimensions of AI is more limited than other dimensions and that more educational support is needed in this area. Overall, pre-service teachers in Kazakhstan have an elevated level of cognitive, practical, and perceptual readiness for AI, but there are areas in which ethical awareness needs to be developed.

Table 1. Pre-service teachers' readiness levels for artificial intelligence.

	N	Minimum	Max	M	SD	Level
Artificial Total	293	23.00	90.00	68.29	12.35	High
Artificial Cognition	293	5.00	25.00	19.35	4.27	High
Artificial Ability	293	6.00	30.00	23.42	5.28	High
Artificial Vision	293	3.00	15.00	11.86	2.86	High
Artificial ethics	293	6.00	20.00	13.65	3.13	Moderate
Valid N (listwise)	293					High

3.2. What Is the Level of Professional Self-Efficacy Beliefs of Pre-Service Teachers?

Table 2 presents the weighted mean (M) and standard deviation (SD) values for the total and sub-dimension levels of pre-service teachers' professional self-efficacy beliefs. According to the findings, the participants' general professional self-efficacy levels were high ($M = 99.74$; $SD = 17.40$). When the sub-dimensions were examined, high levels of self-efficacy were found in all of the sub-dimensions: academic self-efficacy ($M = 19.51$; $SD = 3.63$), social self-efficacy ($M = 30.17$; $SD = 6.68$), intellectual self-efficacy ($M = 25.55$; $SD = 5.09$), and professional self-efficacy ($M = 24.49$; $SD = 5.25$). These results demonstrate that pre-service teachers possess academic knowledge and skills related to teaching processes, can communicate effectively with students and stakeholders, are confident in intellectual competencies such as critical thinking and accessing information, and have a

high level of internalization of professional competencies such as professional ethics and responsibility. Overall, pre-service teachers in Kazakhstan have strong self-efficacy for the teaching profession across all dimensions and are highly confident in their ability to fulfill their professional roles.

Table 2. Professional self-efficacy beliefs of pre-service teachers.

	N	Minimum	Max	M	SD	Level
Self-Total	293	59.00	135.00	99.74	17.40	High
Self-Academic	293	11.00	25.00	19.51	3.63	High
Self-Social	293	10.00	40.00	30.17	6.68	High
Self-intellectual	293	14.00	35.00	25.55	5.09	High
Self-Professional	293	14.00	35.00	24.49	5.25	High
Valid N (listwise)	293					

3.3. What Is the Relationship Between Teacher Candidates' Readiness for Artificial Intelligence and Their Professional Self-Efficacy Beliefs?

Table 3 examines the relationship between AI readiness and self-efficacy. The correlation analysis revealed a low-level relationship between the total AI readiness score and the total self-efficacy score ($R = -0.053$, $p > 0.05$), and this relationship was not statistically significant. This result suggests that pre-service teachers' AI readiness levels and their general self-efficacy perceptions do not influence each other.

Table 3. The relationship between teacher candidates' readiness for artificial intelligence and professional self-efficacy.

		Artificial Intelligence Total	Self-Efficacy Total
Artificial Intelligence Total	Pearson Correlation	1	−0.053
	Sig. (2-tailed)		0.363
	N	293	293
Self-Efficacy Total	Pearson Correlation	−0.053	1
	Sig. (2-tailed)	0.363	
	N	293	293

3.4. What Are the Views of Pre-Service Teachers on the Use of Artificial Intelligence in the Primary Education Teaching Process?

Table 4 presents the themes related to prospective teachers' views on the use of artificial intelligence in primary education.

Table 4. Themes regarding pre-service teachers' views on the use of artificial intelligence in primary education.

Theme	Subtheme	f (n = 20)	%	Examples of Participant Opinions
Opportunities	• Individualized learning • Saving time for the teacher	15	75%	"AI can deliver content based on students' learning styles." (K9)
Limitations	• Lack of infrastructure • Digital competence issues	9	45%	"There are still basic equipment shortages in schools." (K14)

Table 4. Cont.

Theme	Subtheme	f (n = 20)	%	Examples of Participant Opinions
Ethical/Pedagogical Concerns	• Decreased teacher-student interaction • Data security • Exposure to technology at an early age	11	55%	"The teacher figure is very important for primary school children." (K6)
	• The need for teacher training • Development of guide materials • Continuous teacher support	13	65%	"First of all, teachers should receive good training." (K2)

3.5. Qualitative Results

3.5.1. Opportunities

In Table 4, under this theme, pre-service teachers emphasized the potential of artificial intelligence technologies to support individualized learning processes and reduce teacher workload.

In the personalized learning subtheme, many participants noted that AI can provide content tailored to students' learning styles, paces, and needs. One participant expressed this as follows:

"AI can present content according to students' learning styles. It makes learning easier." (K9)

3.5.2. Limitations

As seen in Table 4, under this theme, participants stated that there are some technical and individual obstacles to the effective use of artificial intelligence at the primary education level. The subtheme of infrastructure deficiency highlighted the lack of adequate technology equipment in schools and inadequate internet access. One participant expressed this problem as follows:

"There are still basic equipment shortages in schools. These equipment deficiencies need to be addressed." (K14)

3.5.3. Ethical/Pedagogical Concerns

As seen in Table 4, a sizable portion of the participants stated that some ethical and pedagogical risks may arise with the introduction of artificial intelligence technologies into the classroom environment.

The subtheme "decreased teacher-student interaction" emphasized that the teacher, particularly at the primary school level, plays a role not only of imparting knowledge but also of providing emotional and moral guidance. In this context, one participant emphasized the irreplaceable importance of the teacher with the following words:

"The teacher figure is especially important for primary school children. Primary school is one of the most important periods for children." (K6)

Under the data security subtheme, ethical concerns were raised due to the lack of transparency in how AI systems collect and process student data. It was emphasized that this could create trust issues in the educational environment.

3.5.4. Recommendations

In Table 4, participants made some concrete suggestions for the healthy and efficient integration of artificial intelligence into the educational environment. The subtheme "need for teacher training" emphasized that teachers should undergo comprehensive training,

both technically and pedagogically, to ensure the informed use of artificial intelligence technologies. This view is evident in one participant's statement:

"First of all, teachers should receive good training." (K2)

The subtheme "Developing Guidance Materials" emphasized the importance of creating sample lesson plans, user guides, and ethical frameworks that teachers can refer to when implementing AI in the classroom.

4. Discussion

The findings of the study indicate that pre-service teachers' readiness levels for artificial intelligence are high. The high means in the sub-dimensions of cognitive competence, practical skills, and ethical sensitivity reveal that preserved teachers possess basic knowledge of artificial intelligence and have a cheerful outlook toward using this technology in educational settings. This indicates that preserved teachers have strong potential in the integration process of pedagogical technologies in the age of digital transformation. There are studies in the literature that reach similar conclusions, such as the study of [Ayanwale et al. \(2022\)](#). Similarly, in a study conducted by [Örücü and Hasırcı \(2024\)](#), assessments conducted using the Artificial Intelligence Readiness Scale revealed that pre-service teachers demonstrated an elevated level of cognitive and practical readiness for artificial intelligence. [Ramazanoglu and Akin \(2025\)](#) and [Hopcan et al. \(2024\)](#) emphasize that pre-service teachers' knowledge and skills regarding artificial intelligence directly affect the formation of their teacher identities and their perceptions of professional competence. In this context, the findings obtained in our study are consistent with the relevant literature and indicate that pre-service teachers can integrate technological innovations. However, some opinions reflected in the qualitative data indicate that, in addition to positive attitudes towards artificial intelligence, there are also certain reservations. Ethical and pedagogical concerns, differences in digital competence levels, and infrastructure deficiencies raise the question of the extent to which readiness levels can be effectively used in practice. In this regard, it is important that teacher preparation programs do not limit AI training to technical skills alone; they should address it comprehensively, including ethical, pedagogical, and cultural dimensions ([Rajapakse et al., 2024](#); [Darmawan et al., 2024](#)).

Pre-service teachers have elevated levels of professional self-efficacy. Participants' high mean scores in academic, social, intellectual, and professional subscales indicate that they have developed a sense of confidence in the teaching profession. This suggests that pre-service teachers have strong beliefs in both their pedagogical skills and their competencies related to professional roles such as classroom management, communication, and problem-solving. This finding aligns with [Bandura's \(1997\)](#) social cognitive theory, which argues that teacher self-efficacy is a multifaceted construct encompassing cognitive, motivational, and affective dimensions. Furthermore, as noted in [Zhang et al.'s \(2023\)](#) study on teacher self-efficacy focused on artificial intelligence, pre-service teachers' professional self-efficacy depends not only on technical skills but also on cognitive and affective factors such as self-confidence, decision-making ability, and pedagogical fit. Professional self-efficacy, one of the fundamental elements of qualified teacher training, directly affects teachers' ability to overcome the challenges they encounter in the teaching process and their impact on student achievement ([Tatliesme & Gürgil, 2025](#)). Therefore, the findings of this study indicate that pre-service teachers are at a positive level in the process of internalizing their professional competencies and are ready to assume effective teaching roles in the future. Furthermore, it is frequently emphasized in the literature that professional self-efficacy perceptions are directly related not only to individual factors but also to the learning opportunities offered in pre-service education ([Aydede, 2022](#)), practical experiences, and digital pedagogical content ([Berlin et al., 2021](#); [Keppens et al., 2021](#)). In this context, supporting teacher

training programs with practice-based and technology-supported teaching environments will further strengthen these beliefs of pre-service teachers.

In the study, no statistically significant relationship was found between pre-service teachers' readiness levels for artificial intelligence and their professional self-efficacy beliefs ($r = -0.053$; $p > 0.05$). This finding shows that the expected positive relationship between the two variables did not emerge. While some studies in the literature state that teachers' digital competencies are significantly related to their professional self-efficacy perceptions (Katsarou, 2021; Dai, 2023; Z. Wang & Chu, 2023), the results obtained in the current study suggest that this relationship may be due to more complex and contextual factors. The finding shows that pre-service teachers' high readiness for technology does not directly strengthen their perception of professional self-efficacy. This may suggest that individuals' technical knowledge and skills in artificial intelligence have a limited effect on their professional identity development and pedagogical efficacy perceptions. Indeed, Bandura (1997) emphasizes that the perception of self-efficacy is nourished not only by the level of knowledge but also by the individual's belief that he or she can use this knowledge effectively. In this framework, although pre-service teachers' level of awareness about artificial intelligence technologies is high, the fact that they have not developed sufficient experience or confidence in how to use this awareness in a pedagogical context can be considered as one of the possible reasons for the lack of relationship (Aydede, 2022). In addition, the development of self-efficacy beliefs is influenced by multidimensional factors such as individual characteristics, teaching experience, social support, and the quality of educational environments (Keppens et al., 2021). Therefore, the weak relationship between AI readiness and professional self-efficacy may be due to pre-service teachers viewing this technology solely as a technical tool and not evaluating it within pedagogical integrity. In line with these results, simply conveying AI-related content at a cognitive level in teacher education programs should not be considered sufficient. Applied learning environments that support candidates' skills in integrating technology into pedagogical practices are needed. Thus, a stronger link can be established between technological knowledge and pedagogical self-efficacy.

The qualitative data obtained in the study reveal that pre-service teachers have a cheerful outlook towards the use of artificial intelligence at the primary school level. A substantial portion of participants emphasized that artificial intelligence technologies have the potential to support personalized learning processes, provide materials tailored to students' learning pace and needs, and reduce teachers' workload. In this regard, the view that artificial intelligence can provide flexibility and efficiency in learning environments was widely expressed. Within the subtheme "saving teachers' time," it was asserted that AI will assume time-intensive responsibilities in the educational process, enabling educators to concentrate more on pedagogical endeavors. In this regard, pre-service educators perceive AI as an auxiliary instrument for time management. Moreover, Dung (2025) demonstrated that artificial intelligence offers opportunities for language instruction by emphasizing the necessity for professional development that improves instructors' competencies and delivers systemic support.

However, pre-service teachers also noted various limitations and reservations regarding the integration of artificial intelligence into educational processes. Inadequate technical infrastructure, particularly in rural and disadvantaged areas, hinders the effective use of AI-based applications. Factors such as internet access, hardware deficiencies, and software support could further exacerbate educational inequalities. According to the sub-theme of digital competence issues, teachers and pupils have different capacities for using technology, which may make artificial intelligence applications less successful. Similarly to this study, Kartimi et al. (2023) discovered that school-level digital abilities vary among

science teachers. However, there were no variations in digital competencies based on years of service or gender. Collaborative learning can be enhanced by educators who possess strong digital competencies.

Furthermore, concerns have been expressed that with the widespread adoption of artificial intelligence applications, teacher-student interactions could become mechanized, weakening the pedagogical relationship. In the sub-theme of exposure to technology at an early age, concerns were expressed that shaping the developmental processes of primary school students with artificial intelligence-based digital tools could have negative effects on their social and emotional development. Similarly, [Santhakumar and Joseph \(2024\)](#) revealed in their study that the most significant limitation of emerging learning technologies is their limitations in terms of pedagogical interaction characteristics.

Participants emphasized the importance of not only transferring knowledge but also cultural values, ethical understanding, and social-emotional skills in education, and noted that AI tools may be limited in this context. The subtheme “Continuous Teacher Support” underscored the necessity for ongoing technical, pedagogical, and ethical assistance for teachers throughout the AI integration process, ensuring they are not isolated. In addition to these findings, [Alzahrani and Al-malaji \(2025\)](#) emphasize the significance of professional development programs and legislative actions to improve teachers’ proficiency and assurance in employing immersive instruments for innovative learning.

Particularly in the Kazakhstani cultural context, because teachers provide not only academic but also moral and cultural guidance to students, there were views that AI-supported education may not adequately fulfill these roles. These findings reveal that cultural factors significantly shape teachers’ attitudes toward technological innovations.

Indeed, [Kim and Lee \(2024\)](#) and [Ma et al. \(2024\)](#) state that teachers’ attitudes toward AI vary significantly depending on the cultural context, and that technological integration processes should be shaped not only by universal pedagogical principles but also by local values. [Ramazanoglu and Akin \(2025\)](#) similarly emphasize that the integration of AI into education is not merely a technical process; pedagogical, ethical, and cultural dimensions must also be considered. In this context, simply developing teacher candidates’ technical competencies is not sufficient.

A holistic professional development approach is also needed that strengthens their ethical sensitivities, prioritizes cultural awareness, and fosters pedagogical relationships. Effectively integrating AI technologies into educational environments requires addressing these three dimensions (technical, ethical, and pedagogical) simultaneously. Furthermore, the continuity of AI integration in teaching: It should be considered that the differences between AI integration for teaching tasks and the direct use of AI with future students cannot be measured or represented on a single scale when discussing “AI integration in teaching”. The continuity of AI applications, especially the effects of teacher-centered and student-centered use, should always be taken into account.

5. Conclusions

The findings demonstrate that teacher candidates in Kazakhstan possess a positive and sufficient level of readiness for artificial intelligence across cognitive knowledge, usage skills, and ethical awareness. This readiness supports the potential for the effective integration of artificial intelligence into educational processes within the cultural context of Kazakhstan. The elevated level of self-efficacy observed in academic, social, intellectual, and professional domains further indicates preparedness for the teaching profession, marked by strong self-confidence and versatile competencies. At the same time, the absence of a meaningful relationship between readiness for artificial intelligence and general self-efficacy suggests that preparedness for technology may not necessarily translate into professional

self-confidence. These results underline the multifaceted nature of teacher readiness, which requires attention not only to technological competence but also to professional identity and confidence.

Positive attitudes toward the use of artificial intelligence in primary education point to important opportunities, including individualized learning processes and the reduction in teacher workload. Nevertheless, concerns expressed by teacher candidates regarding the preservation of cultural values, the maintenance of teacher–student interaction, and existing infrastructure limitations highlight those cultural and contextual dimensions shape perceptions of technological integration. In particular, the emphasis on Kazakh cultural values demonstrates that the integration of artificial intelligence into education cannot be approached solely from a technological perspective, but must also reflect social, ethical, and cultural considerations.

Several recommendations emerge from the findings. Comprehensive training programs should be designed for the integration of artificial intelligence, incorporating not only cognitive knowledge and technical skills but also ethical and pedagogical dimensions to ensure effective use within educational practice. Applied learning opportunities such as internships, workshops, and simulations should be expanded to enable teacher candidates to engage directly with artificial intelligence technologies in authentic educational environments, thereby strengthening professional self-efficacy. Cultural values and social interaction should remain central in the development and implementation of artificial intelligence applications, given the importance of teacher–student relationships and social roles in Kazakh society. Infra-structure deficiencies must be addressed, particularly in rural and disadvantaged regions, through the improvement of technological resources and the promotion of digital literacy among both teachers and students. In addition, continuous professional development programs should be prioritized to support the pedagogical use of artificial intelligence, with a focus on enhancing teachers' self-confidence and perceptions of competence.

Additionally, the dual roles of pre-service teachers as students and emerging professionals—how their roles as students and future/early teachers can affect their readiness for AI in complex ways—should be considered. They benefit from their readiness to use AI both as students and as professionals, considering how/why they might use AI; this could be addressed as a research topic.

Overall, the study emphasizes that the successful integration of artificial intelligence into education in Kazakhstan requires not only technological readiness but also cultural sensitivity, ethical responsibility, and sustained professional development. Attention to these dimensions will contribute to the creation of an educational environment where artificial intelligence enhances teaching and learning while remaining consistent with cultural values and professional practices.

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