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Assessment of artificial intelligence literacy of preschool administrators in Kazakhstan

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Abstract

This study aims to determine the current state of artificial intelligence (AI) literacy among preschool administrators in Kazakhstan and evaluate its implementation in science, technology, engineering, and mathematics (STEM) contexts. In this study, a correlational survey design within the scope of quantitative methods was employed. The sample consisted of 328 administrators working in different regions, who responded to online forms. Personal information form, AI literacy scale, and AI STEM leadership scale were used as data collection tools in the research. Data were collected during September and October 2025. Analysis was performed using independent samples t-test, ANOVA test, Mann Whitney U test and hierarchical regression. This study reveals that preschool administrators in Kazakhstan possess moderate-to-high awareness of AI technologies, yet significant variations exist in their competency levels. The findings demonstrate that practical usage and critical evaluation skills are the most critical factors for successful STEM integration. The pronounced effect of demographic variables such as gender, education level, and years of service on AI literacy emphasizes that technology adoption in educational leadership is a complex process requiring tailored intervention programs for different administrator groups. The widespread use of general-purpose tools like ChatGPT alongside limited adoption of education-specific technologies indicates that administrators are navigating the AI landscape independently without adequate institutional guidance and strategic frameworks. In this context, targeted professional development programs should be designed for groups with lower AI literacy levels, and systematic training on the introduction and use of education-specific AI tools should be organized. Furthermore, institutional strategic frameworks and guidance mechanisms for AI integration need to be established, and longitudinal research examining the relationship between administrators' AI literacy and classroom-level STEM outcomes should be conducted.

Keywords: AI literacy, preschool administrators, educational leadership, STEM education, Kazakhstan

INTRODUCTION

Artificial intelligence (AI) has evolved into a transformative dimension that fundamentally reshapes pedagogical approaches and administrative practices at every level of education. As education systems worldwide embrace digital transformation, preschool administrators play a critical role in the adoption and effective implementation of AI-supported teaching and learning practices (Voogt et al., 2013). Understanding

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Contribution to the literature

- This study provides the first comprehensive examination of preschool administrators' AI literacy in the context of Kazakhstan's digital transformation, addressing a critical gap in early childhood educational leadership research where existing studies have predominantly focused on secondary and higher education levels.
- The findings reveal the differential impact of demographic and professional variables on AI literacy development among preschool administrators, highlighting the complex relationships between gender, educational background, professional experience, and technological competencies in early childhood educational leadership contexts.
- The study contributes empirical evidence on how AI literacy dimensions predict AI-STEM leadership capabilities, offering insights for designing targeted professional development programs that address both technical proficiencies and pedagogical leadership skills necessary for successful AI integration in preschool settings.

administrators' AI literacy levels and their capacity to integrate these technologies within science, technology, engineering, and mathematics (STEM) frameworks is essential for developing comprehensive professional development programs and institutional policies that support quality early childhood education (Bers, 2020; Holmes et al., 2019).

The concept of AI literacy has been extensively researched in recent years and is defined as the ability to understand, use, and critically evaluate AI technologies in educational contexts (Long & Magerko, 2020). For preschool administrators, AI literacy extends beyond technical competence to encompass pedagogical understanding and the ability to guide ethical assessments (Touretzky et al., 2019). Research demonstrates that administrators' technological literacy significantly influences institutional innovation and teachers' willingness to adopt new educational technologies (Tondeur et al., 2017). However, there exists a significant gap in understanding how preschool administrators in developing countries perceive and utilize AI technologies, particularly from an early childhood education perspective (Sullivan & Bers, 2016). AI-supported STEM guidance provided by preschool administrators to educators within STEM educational frameworks is also important in this context.

As a rapidly developing country with ambitious educational reform initiatives, Kazakhstan's strategic focus on modernizing its education system aligns with global trends; however, the practical application of AI technologies in early childhood settings remains insufficiently researched (Orynbassar et al., 2024; Yelubayeva et al., 2022). This study aims to determine the current state of AI literacy among preschool administrators in Kazakhstan and evaluate its implementation in STEM contexts, thereby contributing to a broader understanding of how educational leaders in transition economies navigate the complexities of technological integration in early childhood education.

AI Literacy, Its Components, and Its Place in Education

AI is rapidly gaining prominence in modern education systems and holds the potential to transform teaching and learning processes. AI applications in education manifest across a wide spectrum, ranging from personalized learning experiences to assessment systems, from student performance analysis to the automation of administrative processes (Wu et al., 2024). Zhang et al. (2024) note that AI literacy education is developing rapidly at a global level and that education systems are taking significant steps to adapt to this transformation. However, this rapid technological advancement necessitates that educators, administrators, and students possess the competencies required to use AI technologies effectively and ethically.

The concept of AI literacy refers to individuals' capacity to understand, use, evaluate, and approach AI technologies with a critical perspective. Kong and Zhang (2021) emphasized that this literacy encompasses not only technical skills but also ethical awareness and competencies in understanding societal impacts. Mills et al. (2024) indicate that AI literacy includes the knowledge and skills for people to critically understand, use, and evaluate AI systems, and that these competencies are necessary for safe and ethical participation in an increasingly digitalized world. Stolpe and Hallström (2024) state that AI literacy in the context of technology education includes students' ability to understand how AI systems function and to assess the societal and environmental impacts of these systems. In this context, it is evident that AI literacy is a concept that encompasses critical thinking and problem-solving skills, beyond being merely a technical competency. Wang et al. (2023) specify that AI literacy consists of four fundamental components. Awareness is recognizing the existence and potential of AI technologies (**Figure 1**). Usage is the ability to effectively use AI tools. Evaluation is the capacity to analyze and assess AI systems with a critical perspective. Ethics is understanding the ethical dimensions, societal impacts, and responsible use of AI.

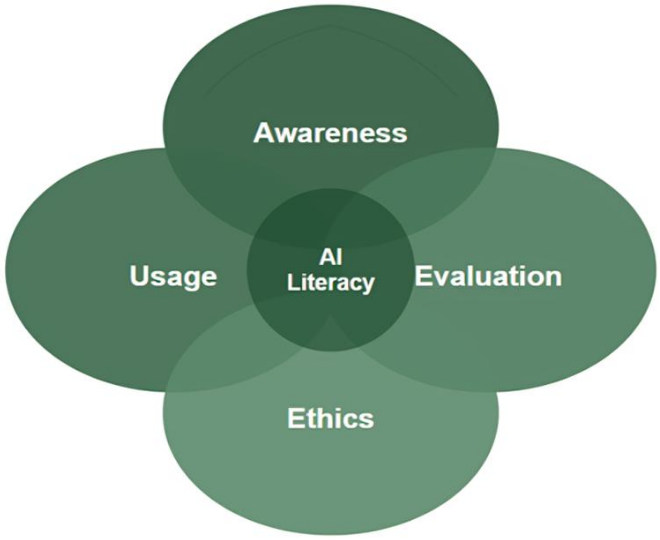

Figure 1. Four-construct model of AI literacy (Wang et al., 2023)

Ventura (2024) emphasizes the role of teachers' AI literacy in developing critical thinking skills, establishing that this literacy should occupy a central position in educators' professional development.

Research conducted on AI literacy at different levels of education demonstrates that this competency has positive effects on learning outcomes. Singh et al. (2024), in their study on generation Z students in North India, found that AI literacy has a significant impact on academic performance and that AI-supported education enriches students' learning experiences. Wang et al. (2025) examined the mediating role of need satisfaction and self-regulatory learning strategies in the development of AI literacy in higher education, revealing that students' motivation and learning approaches are critically important in acquiring AI competencies. These findings indicate that AI literacy is not merely limited to knowledge transfer but represents a process that requires students' active participation and experiential learning. AI literacy in early childhood education has become a particular focus of research in recent years. Su et al. (2023) addressed the challenges and opportunities that AI literacy faces in early childhood education, emphasizing the need to design AI curricula appropriate to young children's developmental characteristics. Su and Yang (2024a) demonstrated that AI literacy curriculum implemented in early childhood education positively affects children's perceptions of robots and their attitudes toward engineering and science. In another study conducted in Hong Kong, Su and Yang (2024b) found that AI literacy intervention in early childhood education enhances children's technology usage skills and problem-solving abilities. Yue Yim (2024) developed an intelligence-based AI literacy framework for primary education, presenting a critical evaluation of AI literacy in teaching and learning processes and emphasizing the importance of age-appropriate pedagogical approaches. These studies demonstrate that early exposure to AI plays a significant role in shaping children's future technological competencies and career choices.

From the perspective of teacher education, Tenberga and Daniela (2024) emphasized the importance of developing teachers' AI literacy competencies through self-assessment tools and highlighted the role of continuous professional development in this process. Sperling et al. (2024) reveal that AI literacy in teacher education has not yet been systematically framed, particularly noting that teachers' applied knowledge and ethical reasoning dimensions are insufficiently addressed in the literature. Daher (2025) evaluates this gap from a more critical perspective, stating that limited approaches focusing solely on technical skills may deepen inequalities in education; therefore, teachers need a holistic educational process encompassing AI's operational mechanisms, pedagogical applications, and ethical consequences. Zhang et al. (2024) emphasized AI's future teaching professional roles. In this context, they establish that strengthening teachers' knowledge, skills, and ethical competencies regarding AI is a fundamental component of comprehensive and inclusive AI literacy education.

AI Literacy and Preschool Administrators

Administrative positions in early childhood education institutions are undergoing a fundamental transformation with the rapid integration of AI technologies in recent years. The roles of preschool administrators, which have traditionally focused on pedagogical leadership, personnel management, and operational oversight, now also encompass technological integration and digital literacy competencies (ReelMind, 2025). Administrators need to understand how to use AI-supported tools for administrative tasks, curriculum development, and professional development. In this context, AI literacy has transitioned from being a peripheral skill to becoming a central component of effective preschool leadership. In particular, administrators' abilities to strategically implement AI technologies, develop dynamic modules for staff training, and communicate effectively with parents directly influence recruitment criteria and performance evaluations (Fullan et al., 2023).

Preschool administrators' AI literacy is a multidimensional concept that includes, alongside technical equipment, the ethical and responsible use of these technologies in educational contexts. The AI literacy framework developed by Digital Promise (2024) emphasizes three fundamental components: understand, use, and evaluation. From the perspective of preschool administrators, this framework requires the ability to assess the transparency, safety, ethics, and impact of AI tools. Specifically, understanding data privacy, security, and ownership issues, being aware of how AI can reproduce societal biases, and questioning the reliability of AI outputs are critically important for administrators (Cimino et al., 2025).

The integration of AI technologies into preschool environments offers administrators significant opportunities to increase operational efficiency and devote more time to instructional leadership. The McCormick Center for Early Childhood Leadership (2024) emphasizes that AI can assist with the daily workload in early childhood programs and increase efficiency. Administrators can use AI tools to automate administrative tasks such as scheduling, data collection, report generation, and family engagement planning. However, the challenges that AI usage brings should not be overlooked (Mack, 2025). Professional development programs and educational initiatives aimed at developing preschool administrators' AI literacy are gaining increasing importance. Frontline Education (2025) indicates how AI plays a transformative role in K-12 professional development and that when administrators empower teachers for AI-supported professional development, flexible and self-directed learning becomes possible. The "traffic light model" developed by the Biggio Center for the Enhancement of Teaching and Learning at Auburn University (https://biggio.auburn.edu/programs/artificial-intelligence) helps educators assess their comfort levels with AI and determine next steps. This model offers three categories: red light (beginner level), yellow light (experimenting level), and green light (advanced level) (Vatchova et al., 2023). Effective AI use for administrators requires the use of prompt techniques such as persona-task-context-format and regular experimentation with AI tools. The Collaborative for Educational Services (2025) emphasizes that school administrators need support in developing policies, establishing protocols, and providing staff training on AI.

The relationship between AI and school leadership presents both significant opportunities and serious challenges. Fullan et al. (2023) note that AI has the potential to automate and facilitate administrative processes, thereby reducing the burden on school leaders and enabling them to focus more on instructional leadership and relationship building. However, excessive use of AI technologies can undermine opportunities for personal interaction and empathy, which are vital for building strong relationships within the school community (Tyson & Sauers, 2021). Richardson et al. (2015) emphasized the importance of effective technology leadership, noting that technology-savvy school principals advocate risk-taking, vision setting, collaboration, and the importance of clear expectations. In this context, preschool administrators' development of AI literacy should also include critical evaluation of how technologies are integrated into pedagogical practices, their ethical use, and their effects on children's development (Adams & Thompson, 2025).

AI Literacy and STEM Leadership in Preschool Administrators

STEM leadership encompasses the capacity to guide educational processes with a visionary perspective in the fields of STEM (Long & Magerko, 2020). Given that the preschool period is a critical phase in which children's fundamental cognitive and social skills are shaped, the technological and pedagogical competencies of administrators working during this period are determinative in preparing institutions for the future (Bers, 2020). Administrators' leadership capacities in AI and STEM fields have a direct effect on supporting teachers' professional development, updating educational programs, and involving families in these processes. Therefore, preschool administrators' acquisition of competencies in both AI literacy and STEM leadership contexts has become a strategic priority for the transformation of the education system.

Administrators' ability to understand the fundamental operating principles of AI systems, data usage, algorithmic decision-making processes, and potential biases is vitally important for establishing ethical and effective technology policies in their institutions (Holmes et al., 2019; Ng et al., 2021). STEM leadership refers to preschool administrators' capacities to promote a culture of interdisciplinary thinking, problem-solving, creativity, and innovation in their institutions. Effective STEM leaders not only incorporate STEM content into the curriculum but also transform learning environments to support design thinking and inquiry-based approaches (English & King, 2019). STEM education in the preschool period aims to nurture children's natural sense of curiosity and lay the foundations for scientific thinking skills and technological literacy from early ages (McClure et al., 2017). Administrators' STEM leadership requires taking concrete steps in providing professional development opportunities for teachers, supplying appropriate materials and resources, involving families in STEM learning processes, and developing collaborations with community partners. This leadership approach, in addition to creating an institutional-level vision, also enables sustainable changes to occur in daily educational practices (Wan, 2021).

Administrators' competencies in AI and STEM fields are critically important in reducing teachers' concerns about technology integration, encouraging innovative pedagogical approaches, and creating a positive culture for digital transformation in the educational community (Ng et al., 2024). Moreover, they enable the development of data-driven decision-making processes, more effective monitoring of student learning, and timely and targeted implementation of educational interventions (Touretzky et al., 2019). The development of AI literacy and STEM leadership in preschool administrators is a fundamental requirement for preparing educational institutions for the future and for children to acquire 21st century skills. To provide these competencies, it is necessary to design comprehensive and continuous professional development programs for administrators, strengthen collaborations among universities, civil society organizations, and the private sector, and implement supportive regulations at the policy level (Bocconi et al., 2022). Enhancing administrators' technological and pedagogical leadership capacities will contribute to raising the quality not only of individual institutions but of the entire education system.

Research Gap and Significance of the Study

When the literature is examined, it is evident that AI literacy research has predominantly concentrated on secondary and university levels, neglecting the unique needs of the early childhood period (Su et al., 2023; Yim, 2024). Despite AI's widespread impact, elementary and preschool levels generally have insufficient research on understanding AI principles and mechanisms (Yim, 2024). Although the role of administrators and educational leaders in AI integration is as critical as that of teachers, research on this topic is extremely limited. Mandinach and Gummer (2015) emphasized that research on AI in educational leadership is inadequate and noted that most studies in this area have remained conceptual in nature. Similarly, Tariq et al. (2021) stated that the impact of AI in school management and leadership has been largely neglected in the literature. Berkovich (2025) revealed that school administrators experience a lack of guidance on how to integrate AI technologies. Additionally, Kim and Wargo (2025) found that educational leaders in rural areas acknowledge the importance of AI literacy but lack access to adequate training opportunities.

Although significant steps have been taken in AI and STEM education specifically in Kazakhstan, research focusing on the role of preschool administrators is quite limited. The country has launched a pioneering initiative to integrate AI education into the school system in line with digital transformation (Madiyev, 2025). However, the use of AI in Kazakhstan's education system is still in its early stages of development (Nurbekova et al., 2025). In particular, despite Kazakhstan having established STEM standards in preschool and secondary education (Abdrakhmanova et al., 2025), empirical studies examining preschool administrators' AI literacy levels and how they use these technologies are lacking. This research gap becomes even more critical considering Kazakhstan's goals of establishing a national AI center and expanding digital education (Sultan et al., 2025). The study fills an important knowledge gap by expanding the limited literature focusing on preschool administrators' AI literacy and usage. Moreover, by addressing AI literacy in the STEM context, it provides an interdisciplinary perspective on technology integration in early childhood education. It offers empirically-based recommendations to policymakers and educational institutions for countries undergoing digital transformation, such as Kazakhstan. Finally, this study contributes to identifying the professional development needs of preschool administrators and developing the necessary strategies for successful implementation of AI-supported educational environments.

This study aims to determine the current state of AI literacy among preschool administrators in Kazakhstan and evaluate its implementation in STEM contexts. Within the scope of this objective, the following research questions were addressed:

1. What are preschool administrators' AI tool usage habits?
2. What are the levels of preschool administrators' AI literacy and AI-STEM leadership?
3. What variables influence preschool administrators' AI literacy?
4. How are preschool administrators grouped in the context of AI literacy, and what are the characteristics of these groups?
5. Do preschool administrators' AI literacy levels predict their AI-STEM leadership levels?

METHOD

Research Design

This study employed a correlational survey design, which falls under quantitative research methods. This design is a research approach that aims to reveal existing relationships between variables without external manipulation. Through this method, possible connections between variables can be systematically examined, and various inferences can be made based on the obtained findings (Creswell & Creswell, 2018).

Population and Sample

The population of the study consists of administrators working in preschool education institutions in Kazakhstan in 2025. The sample comprised a total of 328 administrators working in different regions determined through convenience sampling method and who responded to online forms. Demographic information about the participants is presented in **Table 1**.

According to **Table 1**, when examined in terms of gender, 94.2% of the administrators are female and 5.8% are male. In terms of professional experience, a significant portion of the participants have been working as administrators for 16 years or more (43.6%). This is followed by those with 11-15 years of experience (28.4%), those who have worked for 1-5 years (17.7%), and those with 6-10 years of experience (10.4%). When educational background is evaluated, it is observed that the vast

Table 1. Demographic information of participants

Variable	Category	Frequency (N)	Percentage (%)
Gender	Female	309	94.2
	Male	19	5.8
Years of experience	1-5 years	58	17.7
	6-10 years	34	10.4
	11-15 years	93	28.4
	16 years and above	143	43.6
Educational background	Bachelor's degree	246	75.0
	Master's degree	82	25.0
Total		**328**	**100**

majority of administrators hold a bachelor's degree (75.0%), while 25.0% have a master's degree.

Data Collection Instruments

Personal information form, AI literacy scale (AILS) and AI STEM leadership scale were used as data collection instruments in the study.

Personal information form

This form was developed by the researcher and explains the purpose of the research and data security to participants, indicating voluntary participation. Additionally, information about participants' age, gender, seniority, and most frequently used AI tools was collected in this section.

AILS

AILS developed by Wang et al. (2023) consists of 12 items and four dimensions. The first of these dimensions, awareness, encompasses skills for recognizing the existence and potential of AI technologies; usage refers to the ability to effectively use AI tools. The evaluation dimension represents the ability to analyze and assess AI systems with a critical perspective, and finally, ethics involves understanding the ethical dimensions, societal impacts, and responsible use of AI. All dimensions consist of three items each. The scale is a 7-point Likert-type scale scored from 1 to 7. Items 2, 5, and 11 are reverse-coded. A high score from AILS indicates that participants have high AI literacy. The lowest possible score from the scale is 12, while the highest score is 84. The researchers who developed the data collection instrument found Cronbach's alpha for AILS to be 0.83. In this study, it was determined as 0.862.

AI STEM leadership scale

In the study, the AI STEM leadership scale, developed by the researchers to evaluate preschool administrators' abilities to manage AI integration in STEM learning processes, was used. The scale consists of six items and is a 7-point Likert-type scale. The content of these items includes:

(1) pedagogical integration knowledge–knowing how to incorporate AI tools into STEM activities,

(2) assessment competency–ability to analyze AI's impact on problem-solving and creativity,

(3) resource selection–identifying appropriate AI-based educational materials,

(4) instructional leadership–guiding teachers in AI-supported STEM instruction,

(5) critical awareness–knowing the limitations and challenges of AI use, and

(6) ethical leadership–ensuring ethical and safety standards in AI use.

Scale items were prepared by the researchers based on relevant literature review and expert opinions.

To ensure content validity, scale items were prepared by the researchers based on a comprehensive literature review and subsequently reviewed by five experts in early childhood education, educational technology, and AI in education. Expert feedback was incorporated to refine item clarity and relevance. The reliability of the scale was tested on the sample, and the Cronbach's alpha coefficient was calculated as 0.876. As a result of exploratory factor analysis, the Kaiser-Meyer-Olkin sampling adequacy value was 0.895, the Bartlett sphericity test result was statistically significant (χ^2 = 1,247.63, $p < 0.001$), and the total explained variance was determined as 51.42%. According to confirmatory factor analysis results, the model's fit indices were found to be at acceptable levels ($\chi^2/df = 2.14$, CFI = 0.92, TLI = 0.91, RMSEA = 0.065, SRMR = 0.058). Based on these findings, the data collection instrument was determined to be valid and reliable.

Data Collection and Analysis

Data were collected in the form of online surveys in September and October 2025. The AILS was translated into the local language by two independent experts. Following the translation process, the scale was back-translated into English to verify the accuracy and ensure that there were no semantic differences or discrepancies in meaning between the original and translated versions. This back-translation method was employed to maintain

Table 2. AI tools used by preschool administrators and their frequency of use

Variable	Category	Frequency (N)	Percentage (%)
Most frequently used AI tools*	ChatGPT	313	95.4
	Canva AI	111	33.8
	Google Gemini	103	31.4
	Kahoot AI	57	17.4
	Quizlet AI	34	10.4
	NotebookLM	24	7.3
	Grammarly	12	3.7
	Quillbot	12	3.7
AI usage frequency	Other	55	16.8
	Once a week	78	23.8
	Almost every day	166	50.6
Total		**328**	**100**

Note. *Since one participant could indicate more than one AI tool, the total number of uses exceeds the number of participants

the conceptual equivalence and validity of the scale items.

Information about the purpose of the research and its conduct was provided at the beginning of the form, and participants were informed of their ethical rights. Subsequently, participation consent was obtained on a voluntary basis. After the data collection process was completed, before the obtained data were analyzed electronically, it was verified that the scale forms were filled out appropriately. Data analysis was conducted using SPSS for Windows 26.0 software.

As a result of the analyses performed to demonstrate that the distribution of the scales was normal, it was determined that the kurtosis and skewness coefficients were adequate. These values meet the reference values in the range of -2 to +2 recommended by George and Mallery (2020). In this context, analysis was performed using parametric tests (independent samples t-test and ANOVA test, post-hoc Tukey), and in analyses where group membership fell below 30 participants, non-parametric tests were continued.

In the study, participants' AI literacy levels were defined as low, medium, and high literacy groups (1.0-3.4 as low, 3.4-5.2 as medium, and 5.2-7.0 as high) (Elçiçek, 2024). The predictive status of AI literacy level on AI-STEM leadership was determined through hierarchical regression.

FINDINGS

This section presents the findings obtained after data analysis.

AI Tool Usage Habits of Preschool Administrators

Within the scope of the first research question, findings regarding preschool administrators' AI tool usage habits are presented in **Table 2**.

When participants' AI tool usage preferences are examined, it is observed that the vast majority of preschool administrators actively use ChatGPT (95.4%). This is followed by Canva AI (33.8%) and Google Gemini (31.4%). Kahoot AI (17.4%), Quizlet AI (10.4%), NotebookLM (7.3%), and language support tools Grammarly and Quillbot (3.7%) are used at lower rates. Additionally, 16.8% of participants reported using different AI tools.

When participants' AI usage frequency is evaluated, it is observed that nearly half (50.6%) use these tools almost every day; 25.6% reported using them multiple times per week, and 23.8% once a week. These findings indicate that administrators use AI technologies intensively and show a high level of orientation toward tools specifically designed for text generation and content development.

AI Literacy and AI-STEM Leadership Levels of Preschool Administrators

Within the scope of the second research question, findings regarding preschool administrators' AI literacy and AI-STEM leadership levels are presented in **Table 3**. The findings presented in **Table 3** demonstrate that preschool administrators' AI literacy and AI-STEM leadership levels are generally above the medium level. When the four dimensions of AI literacy are examined, it is observed that the highest mean is in the awareness dimension (mean [M] = 4.47), followed by the usage dimension (M = 4.44).

The evaluation (M = 4.27) and ethics (M = 4.27) dimensions have lower means. The total scale score (M = 4.36) reveals that administrators' AI literacy is generally at a medium-high level. The mean score obtained from the AI-STEM leadership scale (M = 4.03) also indicates that administrators' tendency to demonstrate leadership in AI-STEM processes is lower compared to their literacy. In this context, it can be stated that administrators' knowledge, awareness, and usage skills related to AI are relatively developed, but their application in leadership practices is more limited.

Table 3. AI literacy and AI-STEM leadership levels of preschool administrators

Scale-dimension	N	Minimum	Maximum	M	SD
Awareness	328	3.00	7.00	4.47	0.93
Usage	328	1.00	7.00	4.44	1.11
Evaluation	328	1.00	7.00	4.27	1.80
Ethics	328	1.00	7.00	4.27	1.17
AILS total	328	2.75	6.83	4.36	1.08
AI STEM leadership scale	328	1.00	7.00	4.03	1.81

Table 4. Findings on the variation of AI literacy according to gender variable

Scale-dimension	Gender	N	Mean rank	Mann-Whitney U	Z	p
Awareness	Female	309	160.46	1,687.50	-3.15	.002**
	Male	19	230.18			
Usage	Female	309	160.24	1,618.00	-3.33	.001**
	Male	19	233.84			
Evaluation	Female	309	159.98	1,540.00	-3.50	.000**
	Male	19	237.95			
Ethics	Female	309	159.27	1,319.00	-4.08	.000**
	Male	19	249.58			
AILS total	Female	309	159.22	1,303.50	-4.08	.000**
	Male	19	250.39			

Note. **p < .01

Variables Influencing Preschool Administrators' AI Literacy

Within the scope of the third research question, findings regarding which variables affect preschool administrators' AI literacy are presented in this section. **Table 4** presents findings on the variation of preschool administrators' AI literacy according to the gender variable.

When the findings in **Table 4** are evaluated considering rank means by gender, it is observed that male administrators' AI literacy scores are significantly higher than female administrators' across all dimensions. In the awareness dimension, the mean rank of male administrators (mean rank = 230.18) is significantly higher than that of female administrators (mean rank = 160.46) (U = 1687.50; Z = -3.15; p < .01). Similarly, in the usage dimension, males' mean rank (mean rank = 233.84) is higher than females' (mean rank = 160.24) (U = 1618.00; Z = -3.33; p < .01). In the evaluation dimension, male administrators' mean rank was 237.95 while female administrators' mean rank was found to be 159.98, and this difference is statistically significant (U = 1540.00; Z = -3.50; p < .01). In the ethics dimension as well, males' mean rank (mean rank = 249.58) is significantly higher than females' (mean rank = 159.27) (U = 1319.00; Z = -4.08; p < .01). In terms of total AI literacy score, male administrators' mean rank (mean rank = 250.39) is significantly higher compared to female administrators (mean rank = 159.22) (U = 1303.50; Z = -4.08; p < .01). These findings indicate that male administrators demonstrate significantly higher levels of AI literacy across all dimensions and total score of the scale.

Table 5 presents findings on the variation of AI literacy according to education level variable.

According to **Table 5**, preschool administrators' AI literacy levels show significant differences according to educational background. In the awareness dimension, no statistically significant difference was found between the mean score of bachelor's degree holders (M = 13.27) and master's degree holders (M = 13.83) (t = -1.58; p > .05). However, in the usage dimension, the mean of master's degree holders (M = 15.27) is significantly higher than bachelor's degree holders (M = 12.81) (t = -6.36; p < .01). In the evaluation dimension as well, the mean score of master's degree holders (M = 14.29) is significantly higher than that of bachelor's degree holders (M = 12.54) (t = -2.53; p < .05). Similarly, in the ethics dimension, the mean of master's degree holders (M = 14.46) shows a significant difference compared to bachelor's degree holders (M = 13.31) (t = -2.60; p < .05). When the total AI literacy score is examined, it is observed that the total mean of master's degree holders (M = 57.85) is significantly higher than bachelor's degree holders (M = 51.93) (t = -3.64; p < .01). Overall, the findings indicate that as education level increases, AI literacy increases markedly, particularly in the usage, evaluation, and ethics dimensions.

Table 6 presents findings on the variation of AI literacy according to years of service variable.

The findings in **Table 6** demonstrate that preschool administrators' AI literacy scores differ significantly according to years of service. In the awareness dimension, the mean score of administrators with 1-5 years of service (M = 15.16) and those with 6-10 years (M = 15.35) are significantly higher than both the 11-15 years (M = 12.24) and 16 years and above service groups (M =

Table 5. Findings on the variation of AI literacy according to education level variable

Scale-dimension	Education level	N	M	SD	t	p
Awareness	Bachelor's	246	13.27	2.82	-1.58	.116
	Master's	82	13.83	2.71		
Usage	Bachelor's	246	12.81	2.76	-6.36	.000**
	Master's	82	15.27	3.73		
Evaluation	Bachelor's	246	12.54	5.73	-2.53	.012*
	Master's	82	14.29	4.40		
Ethics	Bachelor's	246	13.31	3.28	-2.60	.010*
	Master's	82	14.46	4.06		
AILS total	Bachelor's	246	51.93	12.65	-3.64	.000**
	Master's	82	57.85	13.13		

Note. *p < .05 & **p < .01

Table 6. Findings on the variation of AI literacy according to years of service variable

Scale-dimension	Years of service	N	M	SD	F	p	Direction of difference
Awareness	1-5 years	58	15.16	1.60	23.51	.000**	1-5 > 11-15, 16+ 6-10 > 11-15, 16+
	6-10 years	34	15.35	4.50			
	11-15 years	93	12.24	2.66			
	16 years and above	143	13.00	2.11			
Usage	1-5 years	58	14.98	0.63	9.58	.000**	1-5 > 11-15, 16+ 6-10 > 16+
	6-10 years	34	14.65	4.50			
	11-15 years	93	13.11	3.30			
	16 years and above	143	12.71	3.13			
Evaluation	1-5 years	58	15.72	5.82	12.60	.000**	1-5 > 11-15, 16+ 6-10 > 11-15, 16+
	6-10 years	34	15.71	5.17			
	11-15 years	93	12.56	4.11			
	16 years and above	143	11.49	5.57			
Ethics	1-5 years	58	14.19	1.93	3.13	.026*	1-5 > 6-10 16+ > 6-10
	6-10 years	34	12.18	1.85			
	11-15 years	93	13.26	3.10			
	16 years and above	143	13.92	4.38			
AILS total	1-5 years	58	60.05	8.70	9.47	.000**	1-5 > 11-15, 16+ 6-10 > 11-15, 16+
	6-10 years	34	57.88	15.47			
	11-15 years	93	51.16	12.39			
	16 years and above	143	51.12	13.14			

Note. *p < .05 & **p < .01

13.00) (F = 23.51; p < .01). A similar trend is observed in the usage dimension; the mean of administrators with 1-5 years of service (M = 14.98) is significantly higher than the 11-15 years (M = 13.11) and 16+ years (M = 12.71) groups. Additionally, administrators with 6-10 years of service (M = 14.65) have a higher mean than the 16 years and above group (F = 9.58; p < .01).

In the evaluation dimension, the 1-5 years (M = 15.72) and 6-10 years (M = 15.71) service groups scored significantly higher than both the 11-15 years (M = 12.56) and 16 years and above (M = 11.49) service groups (F = 12.60; p < .01). In the ethics dimension, a more limited differentiation is observed; the mean of administrators with 1-5 years of service (M = 14.19) is significantly higher than those with 6-10 years (M = 12.18). Additionally, the administrator group with 16 years and above service (M = 13.92) scored higher compared to the 6-10 years group (F = 3.13; p < .05). When the total AI literacy score is examined, the mean of administrators with 1-5 years of service (M = 60.05) is significantly higher than both 11-15 years (M = 51.16) and 16 years and above administrators (M = 51.12). Similarly, administrators with 6-10 years of service (M = 57.88) also demonstrate higher levels of AI literacy than the 11-15 years and 16+ years groups (F = 9.47; p < .01). Overall, the findings indicate that administrators with lower seniority are in a more advantageous position in terms of AI literacy, and scores decrease markedly as seniority increases.

Table 7 presents findings on the variation of AI literacy according to AI usage frequency variable.

The data presented in **Table 7** demonstrate that preschool administrators' AI literacy levels differ significantly according to AI usage frequency. In the awareness dimension, the mean score of administrators who use AI "almost every day" (M = 14.85) is significantly higher than both those who use it "once a week" (M = 11.85) and "multiple times per week" (M = 12.01) (F = 61.11; p < .01). A similar trend is observed in the usage dimension; daily users' mean score (M = 14.58)

Table 7. Findings on the variation of AI literacy according to AI usage frequency variable

Scale-dimension	Years of service	N	M	SD	F	p	Direction of difference
Awareness	Once a week	78	11.85	1.52			
	Multiple times per week	84	12.01	1.67	61.11	.000**	Almost every day > once a week, multiple times per week
	Almost every day	166	14.85	2.96			
Usage	Once a week	78	11.78	2.07			
	Multiple times per week	84	12.67	1.72	27.25	.000**	Almost every day > once a week, multiple times per week
	Almost every day	166	14.58	3.73			
Evaluation	Once a week	78	10.46	5.33			
	Multiple times per week	84	12.99	4.86	12.98	.000**	Almost every day > once a week
	Almost every day	166	14.16	5.46			
Ethics	Once a week	78	11.17	1.89			
	Multiple times per week	84	12.88	1.24	45.10	.026*	Almost every day > multiple times per week > once a week
	Almost every day	166	15.10	4.10			
AILS total	Once a week	78	45.26	10.08			
	Multiple times per week	84	50.55	8.92	38.11	.000**	Almost every day > multiple times per week > once a week
	Almost every day	166	58.69	13.57			

Note. **p < .01

Table 8. AI literacy clusters and characteristics of preschool administrators

Cluster	Category	N	Percentage (%)	Score range	M	SD
Cluster 1	Low	71	21.6	1.0-3.4	3.20	0.25
Cluster 2	Moderate	164	50.0	3.4-5.2	4.43	0.51
Cluster 3	High	93	28.4	5.2-7.0	5.62	0.46

is higher than those who use it once a week (M = 11.78) and multiple times per week (M = 12.67) (F = 27.25; p < .01). In the evaluation dimension, daily users' mean (M = 14.16) was found to be significantly higher than those who use it once a week (M = 10.46). Additionally, the mean of those who use it multiple times per week (M = 12.99) is higher than those who use it once a week (F = 12.98; p < .01).

In the ethics dimension, a distinct ranking has formed among the three groups: daily users (M = 15.10) have the highest score; followed by those who use it multiple times per week (M = 12.88) and those who use it once a week (M = 11.17) (F = 45.10; p < .01). When the total AI literacy score is examined, daily users' mean (M = 58.69) is significantly above those who use it multiple times per week (M = 50.55) and those who use it once a week (M = 45.26) (F = 38.11; p < .01). Overall, the findings indicate that as AI usage frequency increases, AI literacy rises markedly across all dimensions, and daily usage is associated with the highest competency levels.

Cluster Profiles of Preschool Administrators Based on AI Literacy

Within the scope of the fourth research question, how preschool administrators can be grouped in the context of AI literacy is presented in **Table 8** and **Figure 2**.

According to the findings in **Table 8**, half of the administrators (50.0%) are in the "moderate level" AI literacy cluster, with this group's mean score being 4.43 (standard deviation [SD] = 0.51). 28.4% of participants are in the "high level" cluster, and this group's mean is 5.62 (SD = 0.46). The remaining 21.6% are in the "low level" AI literacy cluster, with this group's mean being 3.20 (SD = 0.25).

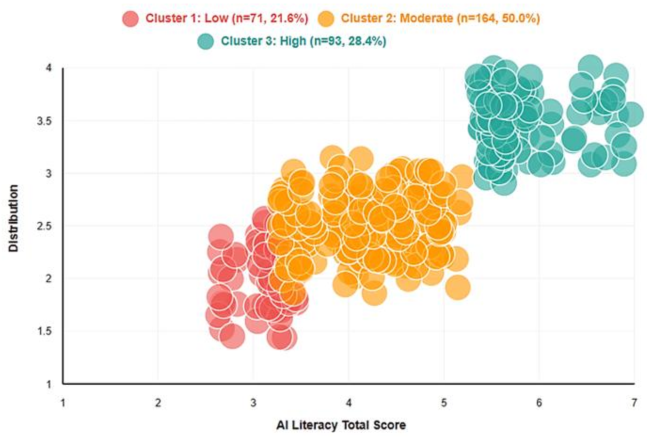

Figure 2. AI literacy clusters scatter plot (Source: Authors' own elaboration)

The Predictive Role of AI Literacy on AI-STEM Leadership

Within the scope of the fifth research question, findings regarding the extent to which preschool administrators' AI literacy levels predict their AI-STEM leadership are presented in **Table 9** and **Table 10**.

The results of the hierarchical regression analysis demonstrate that each variable added to the model significantly increases the explanatory power on AI in STEM Education. In the first model, only the awareness variable is included, and this model explains approximately 25% of the total variance. Adding the usage variable to the second model increased the

Table 9. Hierarchical regression analysis summary

Model	Predictors	R	R^2	Adjusted R^2	ΔR^2	F change	df1	df2	p	SE
1	Awareness	.502	.252	.250	.252	109.76	1	326	< .001	1.569
2	Awareness, usage	.719	.517	.514	.265	178.22	1	325	< .001	1.263
3	Awareness, usage, evaluation	.798	.637	.633	.120	106.90	1	324	< .001	1.097
4	Awareness, usage, evaluation, ethics	.805	.648	.644	.011	10.55	1	323	.001	1.081

Note. SE: Standard error

Table 10. Regression coefficients (final model-model 4)

Predictor	B	SE	β	t	p	VIF*
(Constant)	0.087	0.331	-	0.262	.793	-
Awareness	-0.209	0.096	-.107	-2.179	.030	1.38
Usage	0.763	0.084	.468	9.078	<.001	1.95
Evaluation	0.545	0.050	.541	10.977	<.001	2.07
Ethics	-0.194	0.060	-.126	-3.248	.001	1.38

Note. Dependent variable: AI in STEM education; *VIF = 1/tolerance; & SE: Standard error

explained variance to 52%, providing a strong contribution to the model. In the third stage, adding the evaluation variable raised the explained variance ratio to 64%, bringing a notable increase to the model. In the final model, adding the ethics variable elevated the total explained variance to 64.8%, and this increase was found to be small but statistically significant. The F change values in all models are significant, and each variable makes a significant contribution to the model.

When the regression coefficients for the final model are examined, it is observed that the usage and evaluation variables are the strongest predictors of AI in STEM education. The standardized coefficient of the usage variable is .468, and the evaluation variable is .541; both are highly significant. In contrast, the coefficients of the awareness and ethics variables are in the negative direction, and their effects are more limited. The awareness variable shows a significant negative relationship with $p = .030$, and the ethics variable with $p = .001$. All variance inflation factor (VIF) values in the final model are below 2, indicating no multicollinearity problem. These findings reveal that AI literacy components have varying levels of effect on the dependent variable, and particularly the usage and evaluation dimensions are the strongest determinants of AI integration in STEM education.

DISCUSSION

This study investigated the AI literacy levels and AI integration in STEM education among preschool administrators in Kazakhstan, revealing significant patterns in their technological competencies and usage behaviors. The findings indicate that preschool administrators demonstrate moderate-to-high levels of AI literacy (M = 4.44), with the awareness dimension (M = 4.47) scoring highest, followed by usage (M = 4.44), while evaluation (M = 4.27) and ethics (M = 4.27) dimensions showed comparatively lower scores. These results align with previous research suggesting that while educators possess foundational awareness of AI technologies, deeper critical evaluation and ethical considerations remain underdeveloped (Ng et al., 2024; Su et al., 2023). The predominant use of ChatGPT (95.4%) as the primary AI tool reflects a global trend toward generative AI adoption in educational contexts, consistent with findings by Berkovich (2025) who documented widespread integration of AI-assisted tools in school leadership practices. However, the limited adoption of specialized educational AI tools such as Kahoot AI (17.4%) and Quizlet AI (10.4%) suggests that administrators may not yet be fully leveraging the pedagogical potential of AI technologies specifically designed for early childhood education contexts.

The clustering analysis revealed three distinct groups of administrators based on their AI literacy levels: low (21.6%, M = 3.20), moderate (50.0%, M = 4.43), and high (28.4%, M = 5.62). This distribution indicates considerable heterogeneity in AI competencies among preschool leaders, with half of the participants positioned at moderate levels. These findings are similar with research by Mansoor et al. (2024), who identified similar variations in AI literacy among university students across different national contexts, suggesting that AI literacy development remains uneven across educational sectors globally. The substantial proportion of administrators in the moderate cluster suggests that while basic AI awareness exists, there remains significant room for advancement in sophisticated AI integration practices. This pattern is particularly concerning given the critical role that educational leaders play in shaping technology integration policies and practices within their institutions (Kim & Wargo, 2025). The presence of a notable low-literacy cluster (21.6%) underscores the urgent need for targeted professional development programs specifically designed to elevate fundamental AI competencies among preschool administrators.

Gender emerged as a significant predictor of AI literacy levels, with male administrators demonstrating significantly higher scores across all dimensions compared to their female counterparts. These findings contradict some previous research in early childhood education contexts, where Sullivan and Bers (2016) found minimal gender differences in technology-related competencies among young learners. However, the current results align more closely with broader patterns documented in educational leadership literature, where technology adoption and confidence levels have historically shown gender disparities (Richardson et al., 2015). This gender gap may reflect differential access to professional development opportunities, varying levels of institutional support, or cultural factors specific to the Kazakhstani educational context. The finding is particularly noteworthy given that early childhood education is a predominantly female profession globally, suggesting that gender-responsive professional development initiatives may be necessary to ensure equitable AI literacy development among preschool leaders.

Educational background and professional experience showed complex relationships with AI literacy levels. Administrators with graduate degrees demonstrated significantly higher AI literacy scores in usage, evaluation, and ethics dimensions compared to those with undergraduate degrees only, supporting the notion that advanced education facilitates more sophisticated engagement with emerging technologies (Tondeur et al., 2017). Interestingly, the relationship between professional experience and AI literacy followed an inverse pattern, with less experienced administrators (1-5 years) demonstrating higher AI literacy levels than their more experienced counterparts (16+ years). This finding suggests that newer professionals may enter the field with greater exposure to digital technologies and AI concepts through their recent educational experiences, whereas veteran administrators may face challenges in adapting to rapidly evolving technological landscapes. This pattern echoes concerns raised by Abdrakhmanova et al. (2025) regarding the need for continuous professional learning in STEM competencies for Kazakhstani educators. The inverse relationship between experience and AI literacy also underscores the importance of ongoing professional development rather than assuming that accumulated experience alone ensures technological proficiency.

The finding that less experienced administrators demonstrated higher AI literacy levels than their veteran counterparts has important implications for professional development design. This pattern suggests that recent exposure to AI concepts through initial teacher education may provide a foundation for technological engagement, but sustained professional learning is essential for maintaining currency with rapidly evolving AI tools. Banas and Beyda-Lorie (2025) emphasize that faculty adoption of generative AI is influenced by decision-making processes that require ongoing support and optimal professional development structures, highlighting the need for systematic approaches to technology integration across career stages. Furthermore, Garcia Peinado (2025) argues that educational AI in early childhood contexts must be grounded in child rights and human care perspectives, suggesting that professional development for preschool administrators should extend beyond technical competencies to encompass ethical and pedagogical considerations specific to young learners. These insights underscore the necessity of designing differentiated professional learning pathways that address both the technical skills gap among experienced administrators and the pedagogical depth required for responsible AI implementation in early childhood settings.

The hierarchical regression analysis revealed that AI literacy components differentially predicted AI integration in STEM education contexts, with the usage and evaluation dimensions emerging as the strongest positive predictors (β = .468 and β = .541, respectively), collectively explaining 64.8% of the variance. These findings suggest that practical engagement with AI tools and the ability to critically evaluate their educational applications are paramount for successful STEM integration, consistent with frameworks proposed by Long and Magerko (2020) emphasizing hands-on competencies in AI literacy. Notably, the awareness and ethics dimensions showed negative relationships with STEM integration when controlling other variables, suggesting potential suppressor effects or indicating that theoretical knowledge alone, without corresponding practical skills, may not translate into effective implementation. This pattern aligns with research by Wang et al. (2025) who found that self-regulated learning strategies mediate the relationship between AI awareness and practical application in higher education contexts. The strong predictive power of the usage dimension particularly supports the implementation of experiential learning approaches in professional development programs, as advocated by Zhang et al. (2024) in their analysis of AI literacy education globally. Furthermore, the significant role of the evaluation dimension underscores the importance of developing critical thinking competencies that enable administrators to assess AI tools' appropriateness for specific STEM learning objectives, a concern highlighted by Ventura (2024) in research on enhancing teacher critical thinking through AI literacy.

Implications of the Findings

The findings of this study carry significant implications for policy, practice, and professional development in early childhood education. First, the identification of three distinct AI literacy clusters among preschool administrators underscores the need for differentiated professional development programs that address varying competency levels rather than adopting a one-size-fits-all approach. Given that usage and evaluation dimensions emerged as the strongest predictors of AI integration in STEM contexts, professional development initiatives should prioritize hands-on experiences with AI tools and cultivate critical evaluation skills that enable administrators to assess the pedagogical appropriateness of emerging technologies (Sperling et al., 2024). The gender disparity observed in AI literacy levels necessitates intentional efforts to create inclusive learning environments that actively support female administrators through mentorship programs, peer learning communities, and accessible training opportunities. Furthermore, the inverse relationship between professional experience and AI literacy suggests that veteran administrators require targeted upskilling programs, while newer professionals need sustained support to translate their digital fluency into effective leadership practices. At the policy level, Kazakhstan's ongoing digital transformation initiatives should incorporate systematic AI literacy frameworks specifically designed for early childhood education leaders, building upon the country's established STEM education infrastructure (Madiyev, 2025). Educational institutions must also recognize that superficial awareness of AI technologies is insufficient; meaningful integration requires deep engagement with both the technical and ethical dimensions of AI application in STEM learning environments (Daher, 2025).

Limitations

This study acknowledges several methodological and contextual limitations that should be considered when interpreting the findings. First, the use of convenience sampling, while practical given the geographical expanse and administrative structure of Kazakhstan's early childhood education system, limits the generalizability of findings to the broader population of preschool administrators, as participants who voluntarily completed online surveys may possess higher digital literacy or greater interest in AI technologies than non-respondents. Another the reliance on self-report measures for assessing AI literacy introduces potential response bias, as participants may overestimate their competencies due to social desirability or lack of awareness regarding their actual skill levels; future research employing performance-based assessments or observational methods could provide more objective measures of AI integration practices. After this the cross-sectional design captures a snapshot of AI literacy at a single point in time during Kazakhstan's ongoing digital transformation, precluding conclusions about causality or developmental trajectories in administrators' technological competencies. Later, the notable gender imbalance in the sample (94.2% female, 5.8% male) reflects the demographics of early childhood education leadership in Kazakhstan but limits the statistical power for detecting gender differences and may influence the reliability of comparative analyses. While the AI STEM Leadership Scale demonstrated acceptable psychometric properties, it represents a newly developed instrument requiring further validation across diverse cultural and educational contexts to establish robust construct validity. The study's focus exclusively on preschool administrators in Kazakhstan limits the transferability of findings to other national contexts with different educational systems, cultural attitudes toward technology, and levels of AI infrastructure development, suggesting the need for cross-cultural comparative studies to identify universal versus context-specific patterns in educational leaders' AI literacy development.

Recommendations

Based on the study's findings, several concrete recommendations emerge for enhancing AI literacy and STEM integration among preschool administrators. Educational authorities should establish comprehensive, multi-tiered professional development programs that move beyond introductory awareness sessions to include sustained, practice-based learning experiences focusing on AI tool evaluation, pedagogical integration strategies, and ethical decision-making frameworks. Given the strong predictive power of the usage dimension, training programs should incorporate extended hands-on workshops where administrators experiment with diverse AI applications in authentic STEM education scenarios, receive feedback, and develop implementation plans tailored to their institutional contexts. To address the identified gender gap, professional development initiatives should employ gender-responsive pedagogies, create supportive cohort-based learning structures, and actively recruit female mentors who have successfully integrated AI technologies in their administrative practices. Institutions should establish collaborative learning communities that pair experienced administrators with digitally fluent newer colleagues, facilitating bidirectional knowledge exchange that honors both pedagogical expertise and technological innovation. Furthermore, preschool administrators should be encouraged to explore specialized educational AI tools beyond generative text applications, particularly platforms designed specifically for early childhood STEM learning such as adaptive assessment tools, interactive simulation environments, and AI-enhanced learning analytics systems. Finally, higher education institutions preparing future educational leaders must embed AI literacy and STEM integration competencies within administrative certification programs, ensuring that emerging administrators enter the field equipped with both theoretical understanding and practical skills necessary for technology-enhanced educational leadership in the AI era.

CONCLUSION

This study provides empirical evidence of the current state of AI literacy among preschool administrators in Kazakhstan and its relationship to AI integration in STEM education contexts. The findings reveal that while administrators demonstrate moderate-to-high awareness of AI technologies, significant variation exists in their competency levels, with practical usage and critical evaluation skills emerging as the most critical factors for successful STEM integration. The identification of demographic factors—particularly gender, educational background, and professional experience—as significant predictors of AI literacy underscores the complexity of technology adoption in educational leadership and highlights the need for tailored interventions addressing diverse administrator populations. The predominance of generic AI tools like ChatGPT alongside limited adoption of specialized educational technologies suggests that administrators are navigating the AI landscape independently, potentially without adequate institutional guidance or strategic frameworks. As Kazakhstan advances its digital transformation agenda in education, these findings provide a foundation for developing evidence-based policies and professional development programs that build administrators' capacity to lead AI-enhanced STEM education effectively. Future research should explore longitudinal changes in AI literacy as professional development initiatives are implemented, investigate the relationship between administrator AI competencies and classroom-level STEM outcomes, and examine contextual factors that facilitate or impede AI integration in diverse early childhood education settings. Ultimately, equipping preschool administrators with robust AI literacy is not merely a technological imperative but a pedagogical necessity for ensuring that young learners develop the foundational STEM competencies required for thriving in an increasingly AI-integrated world.

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