Evaluation of Teacher Candidates' Attitudes, Perceptions, and Opinions towards Artificial Intelligence and Project-Based Learning

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***Abstract*—With the rapid developments in the field of artificial intelligence in recent years, teachers' project-based learning skills and attitudes have become very important. This study aims to evaluate primary school teacher candidates' attitudes, perceptions, and views toward artificial intelligence-supported project-based research within the context of interactive online education. As a result of pilot studies conducted outside the research participants, the measurement tools were standardized. Adopting a mixed-methods research design, the study involved 80 teacher candidates enrolled in primary education programs during the 2024–2025 academic year. Quantitative data was collected using adapted scales measuring attitudes toward project-based learning and general attitudes toward artificial intelligence. An eight-week artificial intelligence-supported project-research interactive online education program was implemented. Pre-test and post-test data were collected to assess changes in attitudes. Qualitative data were gathered through semi-structured interviews designed by the researchers. The Kolmogorov–Smirnov test confirmed normal distribution of the quantitative data, enabling the use of parametric tests. Descriptive analysis was employed for the qualitative data. Findings revealed that prior to the intervention, teacher candidates exhibited moderately positive attitudes toward project-based learning and highly positive attitudes toward artificial intelligence. Following the intervention, attitudes toward both areas became significantly more positive. Most teacher candidates expressed strong support for integrating artificial intelligence and project-based learning in educational settings. Additionally, they identified various advantages and challenges associated with the use of artificial intelligence and project-based learning in education. These findings underscore the potential of innovative, technology-enhanced pedagogical approaches in shaping future educators' readiness for evolving educational contexts.**

***Keywords*—education program, innovative, primary school, quantitative, qualitative**

I. Introduction

Artificial Intelligence (AI) has emerged as a transformative force in the educational industry, particularly in teacher education. Project-based interactive online training centered on projects and research signifies a pedagogical shift to integrate intelligent technology into the curriculum [1]. This method leverages AI algorithms to deliver personalized learning experiences tailored to students' specific needs, while also enhancing the collaborative elements of project-based learning. For prospective primary school teachers, engagement with innovative approaches is essential, since the team must be proficient in contemporary teaching strategies and possess a comprehensive awareness of how technology can enhance student engagement and achievement [2, 3].

Project based learning and creativity function as essential mechanisms for fostering competencies required in the context of twenty-first-century education. This dynamic has stimulated considerable advancement in educational research focusing on project-based learning and technological integration [4]. The integration of artificial intelligence into pedagogical practice elicits a spectrum of responses among teacher candidates, characterized by both optimism and skepticism. Uzunboylu *et al*. [5] define teacher candidates as senior students of education faculties who are close to graduation or teachers who have graduated but have not started teaching in schools. Virue *et al*. [6] identified a divergence in attitudes; certain candidates exhibit enthusiasm regarding the potential of artificial intelligence to support lesson planning and facilitate differentiated instruction, whereas others express concerns about the dependability of artificial intelligence systems and their influence on student assessment. These varied perspectives underscore a critical need to evaluate the preparedness of teacher candidates to navigate digitally mediated educational settings. According to Alshammari and Al-Enezi [7], attitudes toward classroom technologies are significantly influenced by previous engagement with digital tools, prompting further inquiry into the role of experiential learning in cultivating constructive perceptions of artificial intelligence.

The concept of individualized learning, which is increasingly embraced by educators and students, is central to the integration of AI in education. Personalized learning enabled by AI provides potential to tailor educational information to accommodate diverse learning styles and stages, as highlighted in the research of Labadlia [8] and Mononen [9]. The responsiveness of AI systems enables instructors to identify and address the unique needs of students more effectively, hence fostering an inclusive educational atmosphere. The effective execution of personalized learning using AI is contingent upon educators' perceptions of technology. Labadlia [8] indicates that skepticism among teacher candidates regarding the efficacy of artificial intelligence tools may lead to resistance toward the implementation of personalized methodologies, thereby limiting the transformative potential of technology within

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educational practices.

Comprehending the perspectives on AI is crucial for shaping future educational methodologies and guiding governmental decisions on technology adoption [10]. Doğru and Durak [11] contend that teacher training programs must include these attitudes and views, while formulating curricula that integrate technological advancements. By meticulously incorporating AI-supported training solutions, educator preparation programs can enhance teacher candidates' comprehension of AI's relevance in fostering project-based learning settings. This guarantees future educators' possession not only proficiency in new technology but also the ethical preparedness to evaluate the implications of such tools on student learning outcomes, equity, and classroom dynamics.

The domain of primary teacher education occupies a critical intersection between technological innovation and pedagogical development, necessitating a thorough assessment of teacher candidates' perspectives on project-based interactive instruction and the integration of artificial intelligence support. Evaluation of these viewpoints and incorporation into the educational framework may enable stakeholders to strengthen the effectiveness of teacher preparation programs and improve the overall quality of the learning experience for both instructors and learners within digitally enhanced educational environments. The integration of artificial intelligence-supported educational systems within research initiatives exerts a substantial influence on the instructional approaches adopted by teacher candidates and the projected outcomes for future student populations. The pedagogical transition toward artificial intelligence technologies is reflected in enhanced capacities for personalized learning, real-time feedback, and the facilitation of collaborative projects, all of which contribute to the advancement of comprehensive educational practices. Empirical evidence indicates that participation in artificial intelligence-integrated project-based learning increases the likelihood of adopting innovative instructional strategies that promote critical thinking and problem-solving skills among students [12–14]. Implementation of such methodologies not only transforms traditional teaching practices but also deepens educators' understanding of the learning process, thereby improving the capacity to meet diverse learner needs.

An essential aspect of this discussion is the correlation between AI literacy and instructor competency. AI literacy encompasses comprehension of AI technologies, their functionalities, and pedagogical applications, which directly impact the readiness of candidates to use these technologies in their teaching methodologies. Findings from Meinel *et al*. [15] and Niemi *et al*. [16] underscore that candidates with elevated AI literacy exhibit greater empowerment and confidence in their capacity to utilize AI technologies proficiently. This preparation profoundly influences its AI perspectives, transitioning from apprehension to appreciation of its potential advantages in educational settings. Therefore, a thorough training program emphasizing AI literacy is essential for developing proficient instructors capable of managing the intricacies of contemporary classrooms.

The increasing viewpoints of teacher candidates toward AI highlight a growing inclination to perceive AI not as a danger to their profession, but as a supportive instrument that enriches educational delivery. Research by Uwosomah and Dooly [17] further elucidated by Ciampa *et al*. [18], indicate that exposure to high-quality AI training experiences fosters a more favorable attitude toward the integration of AI in teaching techniques. Candidates increasingly acknowledge the function of AI as an adjunct to teaching techniques, enhancing the execution of intricate projects and augmenting student engagement. This paradigm shift signifies a wider acceptance of technological innovations in education, highlighting collaboration, creativity, and empirical research in relation to conventional teaching methods.

The implications of these findings provide a foundation for the development of future training programs and the revision of curriculum frameworks to prioritize the integration of artificial intelligence technologies. Recognition of the central role played by artificial intelligence in modern educational practices, as emphasized by Fang *et al*. [19] and Cheng and Lander [20], offers critical guidance for institutions aiming to design curricula that embed literacy competencies aligned with the demands of the Age of Fundamental Stages. This integration equips teacher candidates to utilize AI capabilities effectively while fostering an educational climate that encourages innovation, hence creating a culture of continuous learning and adaptation within the teaching profession. In this evolving context, it is increasingly clear that the integration of AI into teacher preparation is not merely beneficial; it is essential for developing educators who can thrive in the 21st century.

The inclusion of AI in education has garnered considerable attention, particularly among prospective educators, who possess varying perspectives regarding its integration into instructional practices. Comprehending these attitudes is essential, since they can influence future instructional methodologies and student engagement. Pokrivcakova [21] emphasizes that pre-service teachers frequently regard the IA as a valuable instrument for enhancing teaching and learning processes, particularly in English as a Foreign Language (EFL) situation. These favorable opinions reflect a broader trend wherein prospective educators acknowledge the potential advantages of AI in personalizing education and aiding both teachers and pupils. Agehaziati *et al*. [22] further investigate this subject, suggesting that numerous educators perceive the IA as a tool for enhancing their teaching efficacy and student learning outcomes.

Nonetheless, alongside these favorable opinions, obstacles concerning the incorporation of AI in educational settings are equally prominent. Hopcan *et al*. [23] examine the anxiety experienced by teacher candidates regarding the intricacies of autonomous learning systems, which may impede their willingness to fully adopt these innovations. This fear may stem from unfamiliarity with technology and apprehensions regarding its impact on teaching methods. Furthermore, Yetiszay [24] emphasizes that Turkish social studies educators exhibit ambivalence towards the IA, fluctuating between optimism regarding its potential advantages and skepticism concerning its practical implementation in actual classroom settings. This ambivalence highlights the necessity for professional development programs that teachers prepare for reluctant integration into their teaching techniques.

The correlation between teachers' digital proficiency and their attitudes towards AI is essential. Galind-Domennguez *et al*. [25] demonstrate that individuals with higher digital competence exhibit more positive views towards AI, establishing a distinct correlation between technology readiness and the willingness to embrace AI-based educational aids. Conversely, Uygun [26] posits that instructors lacking confidence in their digital competencies may reject utilizing AI, apprehensive that it could diminish their pedagogical efficacy or authoritative stature.

Zhang *et al*. [27] demonstrate that the adoption of artificial intelligence among pre-service teachers greatly differs across demographic groups, highlighting the necessity for tailored training techniques that account for these variations. Chunta *et al*. [28] emphasizes the benefits of utilizing AI as an auxiliary tool in K-12 education, yet warns that, in the absence of sufficient support and training, educators may struggle to harness its full potential.

Yue *et al*. [29] investigate the preparedness of K-12 educators regarding their technological understanding of pedagogical content, indicating that teachers' attitudes towards AI are significantly affected by their technological comfort level. Addressing these factors is crucial to foster a favorable outlook on artificial intelligence in education and to guarantee that prospective educators are prepared to utilize digital tools to enhance student learning outcomes.

The views of prospective teachers towards AI demonstrate a complex interplay of perceived advantages and challenges that necessitate careful consideration in teacher preparation programs. Within the framework of the information listed so far, it is training that teacher candidates should receive based on artificial intelligence and project research. Teacher candidates must have positive attitudes, perceptions, and views towards artificial intelligence and project-research-based training. However, new research results are needed regarding these issues. Since artificial intelligence applications are a new learning technology, there are serious research gaps in the field. Determining the attitudes, perceptions, and views of teacher candidates towards project-research-based training supported by artificial intelligence offered through interactive online training from new learning environments is a priority research need.

The purpose of this research is to evaluate the attitudes, perceptions, and views of primary school teacher candidates regarding education activities based on project research utilizing artificial intelligence. In alignment with this purpose, the study was guided by specific research questions and hypotheses formulated to address the central objectives.

To achieve this goal, the following questions were addressed:

1) What are the perceptions of primary school teacher candidates regarding project-based learning and its acceptance?
2) What are the general attitudes of primary school teacher candidates toward Artificial Intelligence?
3) What are the opinions of primary school teacher candidates after completing the AI-supported project-based interactive online training program?

II. Materials and Methods

In this study, a mixed method was chosen to provide a more complete and comprehensive perspective, as qualitative or quantitative research methods alone are insufficient. Because the number of teachers for quantitative data was determined to be 80, the mixed method was used to reveal attitudes and perceptions in depth and broadly. This research was conducted as a single-group pretest-post test experimental research model and a qualitative research model. The use of this combined design allows for a more comprehensive and in-depth exploration of the phenomenon under investigation, by leveraging the strengths of both data types [30]. The primary objective was to compare the attitudes of participating teacher candidates toward artificial intelligence and project-based learning before and after engagement with education activities based on artificial intelligence supported project research. In addition, the study involved both experimental and control groups, enabling an evaluation of teacher candidates' views regarding the use of artificial intelligence and project-based learning applications in educational contexts. All data were collected using a mixed method approach, integrating both quantitative and qualitative research techniques within a single study.

A. Participants

The research sample consisted of 80 teacher candidates enrolled in various universities in Kazakhstan during the 2024–2025 academic year. All participating teacher candidates were female. This distribution reflects the demographic reality in Kazakhstan, where most individuals enrolled in primary school teaching programs at faculties of education, as well as those employed in primary schools, are women. However, studies have indicated significant gender differences in AI adoption. Women tend to have higher AI anxiety, lower positive attitudes toward AI, lower AI adoption, and lower perceptions of AI than men [5]. The inclusion of only female participants in this study poses limitations in terms of gender comparisons. The participants were students in the third and fourth years of their undergraduate programs, receiving training within the departments of primary school teaching. The sample was selected using the convenient sampling method, a form of non-random sampling. Convenient sampling involves selecting sample elements that are easily accessible to the researcher and is commonly employed when accessibility and sample design present practical challenges [31]. Accordingly, the sample of 80 teacher candidates was determined based on the principles of convenience sampling.

However, the participants in the qualitative research were the same prospective teachers. To obtain qualitative data, interviews were conducted with 80 prospective teachers over a specific period using a semi-structured interview form. Because the number of participants was accessible, all participants were included in the qualitative research process.

B. Data Collection Tools

Numerous quantitative and qualitative techniques, including surveys, interviews, and physiological or implicit assessments, can be used to measure attitudes and perceptions in the social sciences. The research question, the level of detail needed, and whether measuring conscious or unconscious beliefs is the aim all influence the best approach [32].

So, quantitative data for the research were collected using the Project-Based Learning Scale and the General Attitude Toward Artificial Intelligence Scale. Prior to data collection, language adaptation of both scales was conducted to ensure contextual and linguistic suitability. Qualitative data was obtained through semi-structured interviews, using an interview form developed by the researchers to gather in-depth insights from teacher candidates.

1) The Project-Based Learning Scale (PBLS)

The original version of the Project-Based Learning Scale was developed by Ling *et al*. [33] and consists of 19 items across three subdimensions. The scale was designed as a four-point Likert-type instrument. To Kazakh language adaptation, the translation process was conducted by two experts fluent in both the source language and Kazakh, with expertise in the field of linguistics. Initially, the scale was translated into Kazakh. Expert feedback was then incorporated to revise and produce a preliminary Kazakh version. Special attention was given to maintaining semantic equivalence between the original and translated forms. Two weeks later, a back-translation procedure was carried out, wherein the Kazakh version was retranslated into the original language by independent experts. Comparisons between the original and back-translated versions showed high semantic alignment, leading to the finalization of the Kazakh version of the scale.

A pilot application was conducted using a separate sample consisting of 281 female teacher candidates studying in the third and fourth years of primary education programs at various universities in Kazakhstan. These participants were not included in the main sample of the study. According to Child [34], a minimum sample size of five times the number of scale items is required for factor analysis. The sample of 281 teacher candidates fulfilled this requirement.

Explanatory factor analysis was performed using SPSS 25.0. Prior to the analysis, the Kolmogorov–Smirnov test was applied to assess normality, revealing that the data were normally distributed ($p = 0.066 > 0.050$). The Kaiser-Meyer-Olkin (KMO) measure was calculated as 0.82, indicating sampling adequacy for factor analysis. Bartlett's Test of Sphericity was also significant ($\chi^2 = 571.949$, $p < 0.001$), confirming the suitability of the data for factor analysis.

The EFA was conducted using the principal components method. Based on eigenvalues greater than 1, three factors emerged, consistent with the original structure of the scale. All items loaded significantly on their respective factors, with factor loadings ranging from 0.513 to 0.794. No items were removed during this phase.

Confirmatory factor analysis was conducted using SPSS AMOS 25.0 to validate the factor structure. The model fit indices were examined: $\chi^2/df = 1.822$ ($p < 0.001$), NNFI = 0.89, and RMSEA = 0.055. According to Hooper *et al*. [35], acceptable thresholds are $\chi^2/df < 5$, NNFI > 0.80, and RMSEA < 0.08. These results indicate a good fit of the model and confirm the structural validity of the adapted scale within the Kazakh cultural context. The final form of the Project Based Learning Scale was thus established as appropriate for use in the research.

Table 1 presents the item-total correlations and Cronbach's alpha coefficients for the Project-Based Learning Scale, following its adaptation for use in the current study. The scale consists of three subdimensions: Classroom Culture and Curriculum Evaluation, Student Participation, and Professional Development. Reliability analysis produced the following Cronbach's alpha values:

- Classroom Culture and Curriculum Evaluation = 0.781
- Student Participation = 0.819
- Professional Development = 0.843

Table 1. The project-based learning scale

Item	Item Number	On the scale Expression	Item Total Correlation	Cronbach's Alpha
Classroom culture, curriculum, and assessment	1	I can distribute the students according to the various backgrounds in the group.	0.541	0.781
	2	I can prepare a daily teaching plan and the materials needed on PBL.	0.515	
	3	I try to give the students opportunities to structure the leadership of their respective groups.	0.566	
	4	I try to encourage students to present ideas, views, and findings in discussion or presentation sessions.	0.520	
	5	I try to be a facilitator rather than a direct information provider for students during PBL.	0.538	
	6	I am good at giving grades and reinforcement to students after PBL.	0.513	
	7	I have always implemented PBL in my teaching and learning.	0.581	
Students' engagement	8	My students can work together on PBL activities in groups.	0.611	0.819
	9	My student can generate ideas for solutions to the problems being studied.	0.603	
	10	My student can conduct discussions and record the results of discussions without my help.	0.664	
	11	My student can apply other subjects to finding issues that can help They solve problems.	0.681	
	12	My student can analyze the most appropriate solution.	0.650	
	13	My student can access information via the internet.	0.680	
	14	My students can make explanations or presentations related to them solutions.	0.672	
Professional Development	15	I know that PBL can improve students' academic achievement.	0.783	0.,843
	16	I know that PBL can foster positive values and social interactions.	0.794	
	17	I believe that PBL will be effective when implemented in a planned manner.		
	18	I believe that the implementation of the PBL method makes It is easier for teachers to complete the syllabus.	0.725	
	19	I know that PBL can create a more controlled learning atmosphere.	0.699	
		Cronbach's Alpha		0.822

The overall reliability coefficient for the entire scale was calculated as 0.822, indicating high internal consistency. The scale was developed in a five-point Likert format. Equal interval values were used to interpret responses across the scale as follows:

- 1.00–1.80 = Strongly Disagree
- 1.81–2.60 = Disagree
- 2.61–3.40 = Partially Agree
- 3.41–4.20 = Agree
- 4.21–5.00 = Strongly Agree

2) General attitude scale toward Artificial Intelligence Scale (AIS)

The Turkish version of the Artificial Intelligence General Attitude Scale was developed by Kaya *et al.* [36]. This scale comprises two subdimensions, Positive Attitude, and Negative Attitude, and includes a total of 20 items. The first subdimension consists of 12 items, while the second includes 8 items. The scale employs a five-point Likert-type rating structure.

Language Equivalence Procedure: For the Kazakh adaptation, the scale was translated into Kazakh by four experts fluent in both languages and specialized in the field of linguistics. Expert feedback was incorporated to ensure linguistic and conceptual fidelity, resulting in a provisional Kazakh version. A back-translation was performed two weeks later to verify equivalence with the original scale. This procedure confirmed minimal semantic discrepancy, and the most accurate translation was selected as the final Kazakh version of the scale.

Pilot Application: A pilot study was conducted using a separate sample comprising 298 female teacher candidates enrolled in the primary education departments of various universities in Kazakhstan. All participants were in their third or fourth year of study. These participants were not included in the main research sample. In accordance with scale development standards, the sample size met the minimum criterion of five times the number of items [34].

Explanatory Factor Analysis: SPSS 25.0 was used to conduct the analysis. Normal distribution was assessed using the Kolmogorov-Smirnov test, and the results indicated a normally distributed dataset (p = 0.079 > 0.050). The Kaiser-Meyer-Olkin (KMO) value was .80, exceeding the minimum threshold of 0.70, confirming sampling adequacy. Bartlett's Test of Sphericity was significant (χ^2 = 599.201, p = 0.000), supporting the suitability of the data for factor analysis. Principal component analysis identified two factors with eigenvalues greater than 1, consistent with the original structure. All items showed appropriate factor loadings, ranging from 0.622 to 0.819, and no items were removed.

Confirmatory Factor Analysis: Confirmatory factor analysis was conducted using SPSS AMOS 25.0. Goodness-of-fit indices were examined, and results were as follows: χ^2/df = 2.129 (p = 0.000), NNFI = 0.83, and RMSEA = 0.051. Based on the thresholds suggested by Hooper *et al.* [35]—χ^2/df < 5, NNFI > 0.80, and RMSEA < 0.080—the model exhibited acceptable fit. These findings confirmed that the Kazakh version retained structural consistency with the original scale. Factor loadings and Cronbach's alpha coefficients for the Artificial Intelligence General Attitude Scale are presented in Table 2.

Table 2. The general attitude towards artificial intelligence scale

Item	Article	On the scale Expression	Item Total Correlation	Cronbach's Alpha
Positive Attitude	1	I am interested in using artificially intelligent systems in my daily life.	0.652	0.825
	2	There are many beneficial applications of Artificial Intelligence.	0.640	
	3	Artificial Intelligence is exciting.	0.711	
	4	Artificial Intelligence can provide new economic opportunities for this country.	0.645	
	5	I would like to use Artificial Intelligence in my own job.	0.666	
	6	An artificially intelligent agent would be better than an employee in many routine jobs.	0.718	
	7	I am impressed by what Artificial Intelligence can do.	0.692	
	8	Artificial Intelligence can have positive effects on people's well-being.	0.680	
	9	Artificially intelligent systems can help people feel happier.	0.638	
	10	Artificially intelligent systems can perform better than humans.	0.705	
	11	Much of society will benefit from a future full of Artificial Intelligence.	0.622	
	12	For routine transactions, I would rather interact with an artificially intelligent system than with a human.	0.631	
Negative Attitude	13	I think Artificial Intelligence is dangerous.	0.739	0.830
	14	Organizations artificial intelligence ethic non- One in the way they use.	0.744	
	15	I find Artificial Intelligence sinister.	0.751	
	16	Artificial Intelligence is used to spy on people.	0.807	
	17	I shiver with discomfort when I think about future uses of Artificial Intelligence.	0.819	
	18	Artificial Intelligence might take control of people.	0.770	
	19	I think artificially intelligent systems make many errors.	0.781	
	20	People like me will suffer if Artificial Intelligence is used increasingly.	0.802	
		Cronbach's Alpha		0.827

Table 2 presents the research data collected for the adaptation of the Language Toward Artificial Intelligence General Attitude Scale. Item-total correlations and Cronbach's alpha coefficients were examined to assess reliability. The scale demonstrated a two-factor structure, with reliability coefficients calculated as follows: the positive attitude subdimension yielded a Cronbach's alpha of 0.825, while the negative attitude subdimension produced a Cronbach's alpha of 0.830. The overall reliability of the scale was determined to be 0.827. The scale was designed as a five-point Likert-type instrument. Each response category was assigned equal interval values. Accordingly, the intervals were defined as follows: 1.00 to 1.80 indicated definite disagreement, 1.81 to 2.60 indicated disagreement, 2.61 to 3.40 indicated partial agreement, 3.41 to 4.20 indicated agreement, and 4.21 to 5.00 indicated definite agreement.

3) The semi-structured meeting form used with teacher candidates

During the preparation phase of the semi-structured interview form for teacher candidates, a literature review was conducted. Based on this review, six open-ended questions were developed for the interviews with teacher candidates. These questions were structured around two thematic areas and submitted for expert review. Following the expert evaluations, the questions were revised accordingly and presented to two teacher candidates for preliminary feedback. No issues of incomprehensibility were identified by the teacher candidates. Evaluations confirmed the semantic clarity and content validity of the items. Upon receiving final approval regarding the applicability of the questions, the semi-structured interview form was finalized for qualitative data collection. The questions included in this section were designed to elicit responses aligned with the research objectives. Table 3 presents the semi-structured interview form developed by the researchers for use with teacher candidates.

Table 3 presents the results related to the qualitative data collection tool developed for the study: the Semi-Structured Interview Form for Teacher Candidates. The form consists of six open-ended items, structured as three two-part questions. The questions were designed to evaluate perspectives of teacher candidates regarding the use of artificial intelligence in education and the implementation of project-based learning practices.

4) Artificial intelligence-supported project-based interactive online learning framework

To ensure more interactive learning in the Microsoft Teams environment, teacher candidates were divided into two groups. A total of 80 teacher candidates participated in the study, during which an Artificial Intelligence Supported Project-Based Interactive Online Education program was implemented. The participants were divided into two groups of 40 individuals. A control group (n = 40) received traditional offline PBL training without AI support, while an experimental group (n = 40) received the 8-week AI-supported online PBL program.

The educational program was structured to include two sessions per week, each lasting two hours, resulting in a total of four hours per week over a period of eight weeks. The overall duration of the program amounted to 32 instructional hours. The instructional schedule for the Artificial Intelligence Supported Project-Based Interactive Online Education, developed for teacher candidates within the scope of the research, is presented in Table 4.

Table 3. Semi-structured interview form for teacher candidates

Teacher Candidates' semi-structured meeting form
1. What are your views on the use of artificial intelligence in education? I support () I Partially support ( ) I do not support ( ) ………………………………………………………………
2. What are your views on the advantages of using artificial intelligence in education? ……………………………………………………………..
3. What are your views on the disadvantages of using artificial intelligence in education? ………………………………………………………………
4. What are your views on using project-based learning applications in education? I support () I Partially support ( ) I do not support ( ) ………………………………………………………………
5. What are your views on the advantages of learning applications in education? ……………………………………………………………
6. What are your views on the disadvantages of using project-based learning applications in education? ………………………………………………………………

Table 4. Artificial intelligence-supported project-based interactive online education program

Week	Subject Title	Contents	Learning Outcomes
Week 1	Artificial intelligence's entrance and usage in education	• Artificial intelligence definition, history in education • AI-powered learning • Pre-test applications	• Artificial Intelligence Concepts in Education • Explains the Front tests application
Week 2	Artificial intelligence's applications, recognition, and use	Using ChatGPT v4, Canva AI, Bing AI • With tools application • To do • To information access ways	• AI tools recognize and • Uses AI research • Pedagogical purpose
Week 3	Project and research's fundamental learning approach	• Project based learning theory • Research question development • Project plan preparation	• Theoretical basics understanding • Research subject • Project determination, planning, and preparation
Week 4	Teacher qualifications and AI research knowledge	• Ministry of National Education teacher • AI–powered literature scan • Topic development	• Qualifications analysis • With AI literature scans • Topic develops
Week 5	Asking questions, analyzing, and critical thinking	• Effective question asks • with AI information analysis • Critical argument	Generates questions • Analyzes information • Critical thinker
Week 6	Project development – implementation stage	• Group • AI–powered data collection • Project executive	• Project • Collects data and comments • Business unity promotion
Week 7	Reporting and presentation skills	• Report writing with AI spelling and visual production • presentation preparation	• Report author • with AI presentation prepares • Presentation techniques learn
Week 8	Project presentations and evaluation	• Project presentations • Peer evaluation • Post-test applications	• Project presentation • Evaluation • Performs final tests

The educational program presented in Table 4 was implemented with a weekly structure consisting of two parts: the first half of each session focused on theoretical content, while the second half was allocated to applied activities. Projects were documented through written reports, presentations, and evaluation forms. To assess the effectiveness of the educational program, two different scale applications were administered, one prior to the training and one following its completion.

C. Data Collection Process

The following process was followed for standardizing and implementing the data collection tools in this study.

1) Pilot study process

1) Literature review for data collection tools.
2) Determining the data collection tools.
3) Conducting the process of adapting the data collection tools to the Kazakh language and culture.
4) Conducting the process of adapting the data collection tools to the Kazakh language and culture.
5) Conducting a preliminary pilot study to adapt the data collection tools to the Kazakh language and culture.
6) Analyzing the data collected for the pilot test.
7) If the data collection tools have become standardized for Kazakh culture.

2) Main study

1) Preparing the Artificial Intelligence Supported Project-Based Interactive Online Education program.
2) Obtaining expert opinions to determine the suitability of the prepared program and standardizing the program.
3) Application of quantitative data collection tools (pre-test)
4) Application of the program to the teacher group
5) Application of quantitative and qualitative data collection tools (posttest)

Quantitative data for the study were collected through the administration of the Project-Based Learning Scale and the General Attitude Scale Toward Artificial Intelligence, both applied to teacher candidates before and after participation in the Artificial Intelligence Supported Project-Based Interactive Online Education program. The scale applications were conducted separately for each group of teacher candidates. In addition, qualitative data were gathered using the Semi-Structured Interview Form for Teacher Candidates. The interview form was implemented through face-to-face, one-on-one sessions. The semi-structured interviews were conducted following the completion of all scale applications. Each scale application lasted approximately 15 to 25 min. The implementation of the semi-structured interview form required an average of 10 to 20 min per participant. The entire data collection process, including the completion of all applications, was carried out over a period of approximately five months.

D. Ethical Consideration

This research was conducted within the context of higher education, focusing on teacher candidates and aiming to examine attitudes toward education and learning outcomes within a cycle-based, project-based learning model supported by artificial intelligence. All stages of the research were carried out in full compliance with ethical regulations and the principles of scientific research.

Teacher candidates who participated in the study were informed clearly and openly about the purpose, scope, procedures, and voluntary nature of the research. It was explicitly stated that participation was based on free will and that individuals could withdraw from study at any time without any consequences. Written consent was obtained from all participants through a "Volunteer Participation Consent Form", ensuring the informed consent process was properly conducted.

All participant identity information was kept confidential. Collected data were used exclusively for scientific purposes and were not shared with any third parties under any circumstances. No procedures that could result in physical, psychological, or social harm to the participants were included during the research process. All stages of the study were implemented with respect for individual rights and conducted in a transparent and auditable manner. Additionally, the writing and reporting of the study adhered strictly to ethical publishing principles throughout the entire research process.

E. Data Analysis

During the scale adaptation phase of the research, explanatory factor analysis was conducted using SPSS 25.0, and confirmatory factor analysis was performed with the SPSS AMOS 25.0 software. For the analysis of research data, the SPSS 25.0 statistical program was utilized to assess the normality of distributions. To evaluate the distribution characteristics of the scales, the Kolmogorov–Smirnov test was applied. Based on the results ($p < 0.05$), the data sets were found to be normally distributed. Accordingly, parametric tests were employed for the analysis of the quantitative data derived from both scales. For the analysis of qualitative data, the descriptive analysis technique was employed. The purpose of descriptive analysis is to systematically organize and interpret data collected through interviews or observations in a manner that facilitates reader comprehension. The data obtained from the Semi-Structured Interview Form for Teacher Candidates were categorized based on frequency and percentage calculations, and the findings were presented accordingly. Thematic analysis was used to categorize qualitative data. Two researchers coded interview transcripts independently to identify preliminary themes, and Cohen's Kappa ($\kappa > 0.80$, indicating strong inter-coder reliability) was used to confirm coding consistency. With the help of a third researcher, disagreements were settled through group discussion [37].

III. Results

A. Findings Obtained from the Project-Based Learning Scale

Table 5 presents the weighted means and standard deviations of pre-test and post-test scores for participating teacher candidates, based on the subdimensions and overall scores of the Project-Based Learning Scale. These results pertain to measurements taken before and after the implementation of the Artificial Intelligence Supported Project-Based Interactive Online Education program.

Table 5. Pre-test and post-test weighted means and standard deviations for the project-based learning scale

Scales	Pre-test		Post-test		t	df	Sig. (2-tailed)	Effect Size
	M	*SD*	*M*	*SD*				
Classroom culture, curriculum, and assessment	3.02	0.63	3.96	0.69	−8.90	158.00	0.00	−0.995**
Students' engagement	3.20	0.67	3.85	0.67	−6.08	158.00	0.00	−0.680**
Professional Development	3.13	0.65	3.82	0.67	−6.56	158.00	0.00	−0.733**
Project-based learning scale	3.11	0.62	3.89	0.68	−7.53	158.00	0.00	−0,842**

M = Mean, *SD* = Standard Deviation, *t* = Independent Samples Test, *df* = degree of freedom, **Large effect size.

Before the implementation of the Artificial Intelligence Supported Project-Based Interactive Online Education program, the weighted means and standard deviations for the Project-Based Learning Scale were calculated as follows: classroom culture, curriculum, and assessment subdimension ($M = 3.02$, SD = 0.63); student participation subdimension ($M = 3.20$, SD = 0.67); and professional development subdimension ($M = 3.13$, SD = 0.65). The overall mean score for the Project-Based Learning Scale was determined as ($M = 3.11$, SD = 0.62). These findings indicate that, prior to the training, teacher candidates exhibited a moderately positive attitude toward project-based learning across all subdimensions and overall.

Following the training, the weighted means and standard deviations were recalculated: classroom culture, curriculum, and assessment subdimension ($M = 3.96$, SD = 0.69); student participation subdimension ($M = 3.85$, SD = 0.67); and professional development subdimension ($M = 3.82$, SD = 0.67). The overall mean score for the Project-Based Learning Scale after the training was ($M = 3.89$, SD = 0.68). These results suggest that teacher candidates developed a highly positive attitude toward project-based learning in all subdimensions and overall, after completing the program.

Independent sample t-test analyses were conducted to examine differences between pre-test and post-test scores. Statistically significant differences were found between pre- and post-test results in the following subdimensions: classroom culture, curriculum, and assessment ($t = -8.905$, $p < 0.000$); student participation ($t = -6.08$, $p < 0.000$); and professional development ($t = -6.56$, $p < 0.000$). A statistically significant difference was also identified in the total score of the Project-Based Learning Scale ($t = -7.531$, $p < 0.000$). A large effect factor was calculated between the pre-test and post-test scores of the teacher candidates according to the sub-dimensions and general scores of the project-based learning scale. These results indicate that the implemented educational program had a significant positive effect on teacher candidates' attitudes toward project-based learning.

B. Findings from the General Attitude Toward Artificial Intelligence Scale

Table 6 presents the weighted means and standard deviations of the pretest and posttest scores related to the overall scale and subdimensions of the Artificial Intelligence General Attitude Scale for the teacher candidates who participated in the research. These scores correspond to measurements taken before and after engagement with the Artificial Intelligence Supported Project and Research-Based Interactive Online Education.

Table 6. Pre-test and post-test weighted means and standard deviations for the general attitude toward artificial intelligence scale

Scales	Pre-test		Post-Test		t	df	Sig. (2-tailed)	Effect Size
	M	*SD*	*M*	*SD*				
Positive subscale	4.09	0.652	4.55	0.87	–3.76	158.00	0.00	–0.420*
Negative subscale	4.01	0.635	4.42	0.85	–3.44	158.00	0.00	–0.385*
General Attitude Scale Towards Artificial Intelligence	4.06	0.649	4.49	0.869	–3.546	158.00	0.00	–0.396*

M = Mean, SD = Standard Deviation, *t* = Independent Samples Test, df = degree of freedom, *Large effect size

Table 6 presents the pre-test and post-test weighted means and standard deviations for the General Attitude Toward Artificial Intelligence Scale, based on measures conducted before and after the implementation of the Artificial Intelligence Supported Project-Based Interactive Online Education program.

Prior to the training, the mean and standard deviation for the Positive Attitude subdimension were calculated as $M = 4.09$, SD = 0.65, while the Negative Attitude subdimension showed $M = 4.01$, SD = 0.63. The overall score for the General Attitude Toward Artificial Intelligence Scale was $M = 4.06$, SD = 0.64. These findings suggest that, before participating in the program, teacher candidates already exhibited a high level of positive attitude toward artificial intelligence, both across subdimensions and in the overall scale.

Following the training, the Positive Attitude subdimension increased to $M = 4.55$, SD = 0.877, and the Negative Attitude subdimension rose to $M = 4.42$, SD = 0.856. The total mean score for the scale post-intervention was $M = 4.49$, SD = 0.869. These results indicate that after the program, teacher candidates demonstrated a very high level of positive attitude toward artificial intelligence in both subdimensions and overall.

Independent sample t-test analyses were conducted to evaluate the statistical significance of differences between pre-test and post-test scores. Statistically significant improvements were observed in the Positive Attitude subdimension ($t = -8.905$, $p < 0.000$), the Negative Attitude subdimension ($t = -6.081$, $p < 0.000$), and the total score of the General Attitude Toward Artificial Intelligence Scale ($t = -7.531$, $p < 0.000$). According to the sub-dimensions of the artificial intelligence scale and the total scores of the teacher candidates a large impact factor was calculated between the pre-test and post-test scores. These findings indicate that the implemented educational program had a significant positive effect on the general attitudes of teacher candidates toward artificial intelligence.

C. Findings Obtained from the Semi-Structured Interview Form Administered to Teacher Candidates

Table 7 shows the research participants, teacher candidates in Education artificial intelligence to use related to your opinions on the question, "What are they?" The answers have been evaluated.

Table 7. The themes of use of artificial intelligence in education

	Themes	*n*	%
I support	Individualization of learning	63	78.75
	Timesaving		
	Increased diversity of instructional materials		
	Enhancement of student motivation		
	Support for technological integration		
	Reduction of teachers' workload		
Partially I support	Risk of dependency on artificial intelligence	13	16.25
	Concerns about data security		
	Limited effectiveness across all disciplines		
	Partial support for face-to-face communication		
I do not support	Disruption of pedagogical relationships	4	5
	Potential for increased educational inequality		
Total		80	100

Table 7 presents the themes of participating in teacher candidates' opinions regarding the use of artificial intelligence in education. According to the data, 78.75% of the participants expressed supportive views, 16.25% reported partial support, and 5% indicated non-supportive positions.

Participants who expressed support emphasized benefits such as the individualization of learning, time efficiency, increased diversity in instructional materials, enhanced student motivation, alignment with technological advancements, and reduction of teachers' workload.

Those who indicated partial support highlighted concerns including the risk of overdependence on artificial intelligence, data security issues, limited applicability across all educational contexts, and partial support for maintaining face-to-face communication in learning environments.

Participants who did not support the use of artificial intelligence in education cited the potential disruption of pedagogical relationships and the risk of exacerbating educational inequalities.

Table 8 evaluates the responses provided by participating teacher candidates to the open-ended question: "the themes of advantages of using artificial intelligence in education?

Table 8. The themes of the advantages of using artificial intelligence in education

Themes	*n*	%
Learning individualization provides	71	88.75
Time and work savings provide	68	85
Student motivation increases	65	81.25
The teacher's work reduces the burden of reduces	50	62.5
Supports creativity and critical thinking	42	52.5
A fast and effective back notification possibility is presented	38	47.5
Innovator and interest-attractive materials produce	30	37.5
Increases access and learning opportunities	22	27.5
Technological reader Authorship develops	17	21.25
Facilitates measurement and evaluation processes	9	11.25

Table 8 presents the themes of opinions from participating teacher candidates regarding the perceived advantages of using artificial intelligence in education. According to the findings, 88.75% of the participants identified the potential for individualized learning as an advantage, while 85% emphasized time and workload efficiency. Additionally, 81.25% noted an increase in student motivation, 62.5% reported a reduction in teachers' workload, 52.5% indicated support for creativity and critical thinking, and 47.5% highlighted the potential for rapid and effective feedback.

Furthermore, 37.5% of the teacher candidates stated that artificial intelligence enables the production of innovative and engaging instructional materials, 27.5% believed it enhances access and learning opportunities, 21.25% indicated it fosters technological literacy and authorship, and 11.25% noted its facilitation of assessment and evaluation processes.

Table 9 presents the evaluation of responses given by participating teacher candidates to the open-ended question: "the themes of disadvantages of using artificial intelligence in education".

Table 9 presents the themes of participating teacher candidates' opinions on the disadvantages of using artificial intelligence in education. According to the findings, 77.5% of the participants identified technology addiction as a major concern, while 67.5% mentioned the creation of inequalities and access-related issues. Additionally, 66.25% reported a potential weakening in critical thinking skills, and 60% noted that artificial intelligence may occasionally provide inaccurate or misleading information. A decrease in face-to-face communication was indicated by 51.25%, and 41.25% pointed to the overuse of pre-prepared instructional materials.

Table 9. The themes of perceived disadvantages or limitations of integrating artificial intelligence into educational settings

Themes	*n*	%
Technology addiction in creating	62	77.5
Creation of inequality and access problems	54	67.5
Critical thinking is inhibited	53	66.25
Artificial intelligence may occasionally provide incorrect and misleading information.	48	60
Face-to-face Communication decreases	41	51.25
The overuse of pre-prepared instructional materials	33	41.25
The emergence of ethical and responsibility-related issues	20	25
Software and system mistakes	14	17.5
Perceived threat to the teaching profession	6	7.5

Furthermore, 25% of the teacher candidates raised concerns about ethical and accountability issues, 17.5% cited the possibility of software and system errors, and 7.5% expressed the belief that artificial intelligence could pose a threat to the teaching profession.

Table 10 presents the evaluation of responses given by participating teacher candidates to the open-ended question: the themes of use of project-based learning practices in education.

Table 10 presents the themes of participating teacher candidates regarding the use of Project-Based Learning (PBL) applications in education. A total of 83.75% of teacher candidates expressed support for PBL, 12.5% expressed partial support, and 3.75% indicated a lack of support. The reasons cited by those supporting PBL included enhanced student engagement, improved collaboration and task coordination, development of critical thinking and problem-solving skills, increased student responsibility, integration of real-world learning, promotion of long-term retention, and the creation of an active and dynamic learning environment.

Table 10. The themes on the use of project-based learning practices in education

	Themes	*n*	%
I support	Provides active Participation of Students	67	83.75
	Promotes teamwork and collaborative working skills.		
	Critical thinking and problem-solving skills develop		
	Encourages students to take responsibility for their learning.		
	Facilitates learning connected to real-life contexts.		
	Encourages long-term knowledge retention.		
	Creates an active and dynamic learning environment.		
Partially I support	The implementation process may be time-consuming.	10	12.5
	Unequal distribution of responsibilities among students may occur.		
	Not every student may be suitable.		
	Measuring and evaluating could be difficult		
I do not support	Students may not take their duties seriously	3	3.75
	Traditional methods of deflection lower efficiency		
Total		80	100

Participants who partially supported PBL highlighted several concerns, such as the time-consuming nature of the implementation process, potential imbalance in task distribution among students, lack of suitability for all learners, and challenges in measurement and evaluation. Teacher candidates who did not support PBL cited insufficient student accountability and reduced instructional effectiveness due to deviation from traditional methods.

Table 11 presents the themes of teacher candidates to the question regarding the perceived advantages of using project-based learning applications in educational settings.

Table 11. In education, project-based learning applications are useful to your advantage, related to your opinions

Themes	*n*	%
Encourage active learning	70	87.5
Developing problem-solving skills	66	82.5
Cooperation and teamwork	61	76.25
Cultivates research and inquiry habits	55	68.75
Improves critical thinking abilities	52	65
Supports creativity	47	58.75
Establishes real-world connections	40	50
Promotes retention and deep learning	33	41.25
Teaches self-management and time management	32	40
Instills a sense of responsibility	27	33.75
Provides inter- learning by combining different disciplines	14	17.5
Strengthens teacher guidance roles	11	13.75
Enables multidimensional assessment	5	6.25

According to the findings summarized in Table 11, teacher candidates expressed overwhelmingly positive views regarding the advantages of using Project-Based Learning (PBL) in education. The most frequently cited benefit was that PBL encourages active learning, as noted by 87.5% of participants. They emphasized that PBL enables students to engage more deeply in the learning process, taking an active role in constructing knowledge rather than passively receiving information. Another major advantage, identified by 82.5% of respondents, was that PBL enhances students' problem-solving skills. Teacher candidates observed that working on real-life projects allows students to apply critical reasoning and practical approaches to overcome challenges. Similarly, 76.25% of participants noted that PBL fosters cooperation and teamwork. Through collaborative activities, students develop essential interpersonal skills and learn how to work effectively in groups. The habit of research and questioning was also reported as a significant benefit by 68.75% of teacher candidates. They recognized that PBL nurtures curiosity and supports the development of inquiry-based learning skills. Furthermore, 65% of participants stated that PBL improves students' critical thinking abilities, as it requires them to analyze, evaluate, and synthesize information in meaningful ways.

Creativity was another area positively affected by PBL, according to 58.75% of respondents. They noted that the open-ended nature of projects encourages students to generate original ideas and explore alternative solutions. Additionally, 50% of teacher candidates reported that PBL helps students establish connections between their learning and real-life situations, making education more relevant and meaningful. A smaller yet notable portion of participants highlighted other benefits. For instance, 41.25% believed that PBL promotes permanent learning due to the depth of engagement with content. About 40% indicated that it teaches self-management and time management, as students must take responsibility for planning and executing their projects. Relatedly, 33.75% felt that PBL instills a sense of responsibility in students. Some teacher candidates also appreciated the interdisciplinary nature of PBL, with 17.5% stating it supports learning across different subject areas. Moreover, 13.75% believed that PBL strengthens the teacher's role as a guide and facilitator rather than just a source of knowledge. Finally, 6.25% of respondents pointed out that PBL allows for more multidimensional assessment methods, giving a broader perspective on student performance. Overall, the responses indicate that teacher candidates see project-based learning as a highly effective approach for promoting engagement, skill development, and meaningful learning experiences in educational settings.

Table 12. The themes on the disadvantages of using project-based learning applications in education

Themes	*n*	%
Difficulty in conducting individual assessments in student-centered learning	72	90
Conflict with traditional learning habits	66	82.5
Measuring and evaluating difficulty	50	62.5
Unequal distribution of tasks	43	53.75
Guidance in the absence of a purpose deflection	30	37.5
Time management difficulty	21	26.25
Equipment and source needs cannot always be met	16	20
Students ' conflict risk	8	10
Potential to increase students' workload	2	2.5

Table 12 presents the themes of participating teacher candidates regarding the disadvantages of using Project-Based Learning (PBL) applications in education. According to the data, 90% of the candidates identified difficulty in conducting student-oriented individual evaluations, and 82.5% noted that PBL may conflict with traditional learning habits. Additionally, 62.5% pointed out challenges in measurement and evaluation, while 53.75% mentioned the potential for unfair task distribution. Furthermore, 37.5% of the participants stated that a lack of guidance may cause deviations from the intended purpose of the learning process. Other reported disadvantages include time management difficulties (26.25%), inadequate availability of equipment and resources (20%), the risk of interpersonal conflicts among students (10%), and the potential to increase students' workload (2.5%).

IV. Discussion

The research revealed that teacher candidates initially had a moderately positive attitude toward Artificial Intelligence (AI)-supported project-based research within interactive online education. However, following their participation in the program, their attitudes shifted to a highly positive level. Before the program, candidates already held a generally positive view of AI in educational contexts, which became significantly more favorable after the experience. This transformation aligns with the findings of Belda-Medina [38], who observed that pre-service foreign language teachers improved both their technological attitudes and digital skills through project-based learning methodologies. The study highlighted that while pre-service teachers held strong attitudes toward information processing technologies, they expressed a need for further education on adopting new technologies effectively.

Most teacher candidates in this research expressed clear support for the use of AI in education. A smaller proportion partially supported AI integration, and only a few opposed it. These results mirror the findings of Zhang *et al*. [39], who studied AI acceptance among pre-service teachers and concluded that intentions to use AI in education were notably high. Teacher candidates cited several reasons for supporting AI, including its capacity to individualize learning, save time, increase the diversity of educational materials, enhance student motivation, support integration with technology, and ease the teacher's workload.

Despite the predominantly positive outlook, some teacher candidates raised concerns. These included the potential for overdependence on AI, data security risks, limitations of AI across diverse educational settings, and reduced face-to-face communication. Others feared a disconnection from pedagogical foundations and the potential for AI to widen existing educational inequalities. Fitria [40] supported these observations by emphasizing that personalized learning and time savings are among the core benefits of AI in education.

Teacher candidates described numerous advantages of AI use in education. These included personalized learning experiences, increased efficiency in time and workload, improved student motivation, reduced teacher responsibilities, enhanced support for creativity and critical thinking, the possibility of faster and more effective feedback, access to innovative and engaging educational materials, broader learning opportunities, and simplification of measurement and evaluation processes. Similar studies, such as those by Baidoo-Anu and Ansah [41] and Joshi *et al*. [42], highlighted the potential of AI to offer continuous feedback, support interactive learning, and improve the overall quality of teaching.

On the other hand, the teacher candidates also recognized the disadvantages associated with AI use. These included the risk of technology addiction, the emergence of access-related inequalities, potential weakening of students' critical thinking, occasional provision of incorrect or misleading information by AI systems, reduction in direct communication, overreliance on pre-made materials, ethical and accountability issues, technical errors, and fears that AI might undermine the teaching profession. Khan *et al.* [43] emphasized data privacy and security as major concerns, while Ayanwale *et al.* [44] pointed out anxiety among teacher candidates regarding AI adoption.

Regarding Project-Based Learning (PBL), teacher candidates overwhelmingly supported its use in education. Most believed that PBL fosters student engagement, builds collaboration and teamwork, and enhances critical thinking and problem-solving abilities. They also highlighted that PBL helps students take responsibility, connects learning with real-life experiences, encourages lasting understanding, and creates an active and dynamic learning environment. These findings align with research by Yang *et al*. [45], who observed increased motivation, trust, and application skills among postgraduate students participating in PBL. The study also mentioned that some teachers might hesitate to adopt PBL due to barriers such as insufficient mentoring, poor planning, and a lack of experience with implementation.

Teacher candidates noted several educational benefits associated with PBL. They believed it supports active learning, fosters problem-solving abilities, encourages cooperation, develops critical thinking, nurtures creativity, and strengthens connections with real-world scenarios. Additionally, PBL was seen to promote permanent learning, self-regulation, and effective time management. Participants also pointed to gains in students' sense of responsibility, the integration of multiple disciplines, stronger teacher guidance, and the ability to approach evaluation processes more holistically. Research by Maros *et al.* [46] supported these findings, showing that PBL contributed to improved student productivity, motivation, communication, and critical thinking skills. Tahiri [47] also emphasized how PBL enhances learning participation, work unity, and connections to real-world contexts for both students and educators.

Nevertheless, teacher candidates identified several disadvantages of PBL. They noted challenges such as difficulty in assessing individual student contributions, the clash with traditional learning habits, problems in measuring and evaluating outcomes, unequal task distribution among students, lack of guidance leading to deviation from learning goals, and time management issues. Additional concerns included insufficient access to resources, the risk of conflicts between students, and the potential for increased student workload. Maros *et al*. [46] warned that PBL can be time-consuming, and Tahiri [47] pointed to limited teacher training and a lack of parental understanding as further obstacles to successful PBL implementation.

In this study, due to the female gender group, the findings did not alter gender differences in attitudes toward AI and perceptions of project-based dimensions. However, regarding gender differences, the perceptions and attitudes of prospective teachers, whether male or female, who received training on a specific topic became more positive and stronger after the training. In this study, the prospective teachers' attitudes and perceptions toward AI and project-based learning became more positive after completing the AI-supported project-based interactive online training program.

V. Conclusion

In the current era of digitalization, significant transformations are occurring in educational practices, teaching methods, and instructional tools. The rapid development of artificial intelligence technologies has rendered their integration into teaching and learning processes both inevitable and increasingly impactful. Artificial intelligence offers notable advantages, including the provision of personalized learning experiences, reduction in teacher workload, and enhancement of student engagement in learning processes through increased effectiveness and attraction.

Among learner-centered approaches, project-based learning stands out as a pedagogical method that contributes to the development of high-level skills such as problem solving, collaboration, and critical thinking, while simultaneously promoting learning retention. Within this context, artificial intelligence-supported project-based learning applications have become integral components of contemporary educational paradigms.

This study evaluates the attitudes, perceptions, and opinions of prospective primary school teachers regarding project and research-based educational activities supported by artificial intelligence. Findings indicate a significant positive shift in attitudes toward project-based learning following exposure to artificial intelligence-supported projects and research-based interactive online education. A similar positive trend was observed in general attitudes toward artificial intelligence after engagement with the same instructional model.

Most prospective teachers expressed support for the use of artificial intelligence in educational settings. Noted advantages included the facilitation of individualized learning, time and workload efficiency, and increased student motivation. However, concerns were also highlighted, particularly regarding potential disadvantages such as the risk of technology addiction, the exacerbation of access and equity issues, and the possible weakening of critical thinking skills.

Widespread support was also expressed for the implementation of project-based learning applications in education. Reported benefits included the promotion of active learning, enhancement of problem-solving abilities, and the strengthening of teamwork and collaboration. Nevertheless, prospective teachers also identified challenges, such as difficulties in conducting individualized student assessments, resistance due to traditional learning habits, and issues related to measurement and evaluation.

The findings of this research align with the observation that participation in artificial intelligence-supported projects and research-based interactive online education contributed to positive changes in both general attitudes toward artificial intelligence and specific attitudes toward project-based learning among teacher candidates. Based on these findings, it is recommended that artificial intelligence-supported project-based learning applications be more systematically and extensively integrated into teacher education programs.

To ensure the effective and ethical pedagogical use of artificial intelligence tools, comprehensive digital literacy training must be provided. Such training should include practical examples and guidance on classroom applications of artificial intelligence tools. Additionally, structured modules should be developed to guide teacher candidates in the planning, implementation, and evaluation of project-based learning applications. These modules should also address evaluation methodologies and the management of group dynamics.

Furthermore, teacher candidates should be encouraged to maintain reflective journals or develop portfolio studies to document challenges encountered and competencies gained throughout the process. These reflective practices would facilitate self-evaluation and provide a means to monitor professional development. Implementation of these recommendations is expected to enhance technological and pedagogical competencies, thereby preparing teacher candidates more effectively for contemporary educational environments.

This study was conducted with a limited number of prospective teachers. Similar studies should be conducted with larger sample sizes. Comparative studies at the national or international level with a larger universe and including male prospective teachers as participants should be continued.

INSTITUTIONAL REVIEW BOARD STATEMENT

The study was conducted in accordance with the Declaration of Helsinki and approved by the Institutional Ethics Committee of Zhetysu University, 2024/431.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

AUTHOR CONTRIBUTIONS

YA conducted the research; ZS analyzed the data; PI wrote the paper; ZS Revised the paper; all authors had approved the final version.

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