

Artificial Intelligence Adoption, Pedagogical Effectiveness, and Inclusive Practices for Diverse Learners in Early Childhood Education

Faisal Amjad^{1*} and Dr. Sarah A. Alahmari²

¹PhD Candidate (Special Education), Department of Special Education (DSE), Division of Education (DoE), University of Education (UoE), Lahore, Punjab, Pakistan

Personal Email: amjadfaisal40@gmail.com

Institutional Email: pds24000237@ue.edu.pk

ORCID: <https://orcid.org/0009-0002-7617-5395>

²Assistant Professor, Department of Early Childhood, Faculty of Education, King Khalid University, Saudi Arabia.

Email: Ssarh@kku.edu.sa

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Artificial intelligence (AI) is increasingly influencing teaching, yet its educational value depends on how effectively it is integrated into pedagogy and inclusive practice. This study examined the relationships among AI adoption, pedagogical effectiveness, and inclusive practices for diverse learners among early childhood education teachers in Punjab, Pakistan. A quantitative research design was employed with a sample of 469 teachers selected through multistage stratified sampling. Data were collected using a 50-item researcher-developed questionnaire and analyzed through descriptive statistics, t tests, ANOVA, correlation, reliability analysis, regression, and mediation analysis. The findings indicated positive relationships among AI adoption, pedagogical effectiveness, and inclusive practices. Pedagogical effectiveness emerged as the strongest predictor of inclusive practice and partially mediated the relationship between AI adoption and inclusion. The study concludes that AI contributes more meaningfully to inclusive early childhood education when teachers transform technological resources into developmentally appropriate, accessible, responsive, and pedagogically sound learning experiences for children.

Keywords: artificial intelligence adoption, pedagogical effectiveness, inclusive practices, diverse learners, early childhood education, Punjab, Pakistan

Introduction

Artificial Intelligence (AI) is a growing concern in teaching because of its ability to support

teachers in lesson planning, differentiated activities, learning materials, assessment, feedback, language support and personalized

learning resources. The usefulness of AI, however, is not just about the technology but also in how it's applied in early childhood education (ECE) in a developmentally appropriate and pedagogically meaningful way. Results of a major ECE review suggest that there is a potential for AI applications to support learning and teaching, although the evidence base is relatively small (Edwards et al., 2022). Recent research on inclusive education has highlighted the potential positive impacts of AI on making learning more accessible and providing more personal support when used with teacher guidance and accompanied by ethical safeguards (Su & Yang, 2022; Melo-López et al., 2025).

AI Tools give the teacher opportunities to create alternative explanations, visual resources, differentiated tasks, stories, formative questions, communication supports and learning materials which respond to children's varying abilities, language, pace of learning, communication need and backgrounds. However, using AI does not mean that it is successful pedagogy. The 2026 systematic review of 37 ECE studies highlighted high rates of research interest since 2023 and highlighted three areas of research that remained priorities teacher professional development, curriculum design, and appropriate pedagogical implementation. AI pedagogy, ethical use, human-centered thinking, AI knowledge, and professional learning are also listed as key components of teacher competences by UNESCO (Ormanci, 2026; Miao & Cukurova, 2024).

While there has been significant research on the potential of AI in ECE, the empirical evidence that directly links the use of AI, pedagogical effectiveness and inclusive practice for diverse learners is scarce. The review of 45 studies from around the world and South Korea, conducted in 2025, largely focused on teachers' perceptions and attitudes, their competence with AI, and factors that influence the adoption of AI in the classroom (Jung & Kim, 2025). Likewise, in an updated 2026 review of the state of the art, a total of 39 relevant studies of AI-ECE were identified, of which only three were purely

quantitative. The results of this study highlight the specific need for quantitative studies on the impact of teachers' use of AI on good and inclusive pedagogical practice (Ljungcrantz, 2026).

Globally, teachers are becoming more creative in their use of generative AI, although its use in the classroom is not consistent. The study by Cheah et al. (2025) showed that only 46% of the respondents (89 U.S. teachers in the K–12 sector) were leveraging generative AI in their instruction. Teachers were more likely to use generative AI for preparation, evaluation, and administration of their lessons, than for teaching itself. Factors that hindered were lack of preparedness, lack of understanding of pedagogical value, ethical issues, less human interaction, and lack of institutional support. UNESCO thus suggests a people-centred and age-appropriate use of generative AI based on respect for privacy and maintaining human agency in education decision-making (Miao & Holmes, 2023).

The Pakistani context is of special interest for studying the relationships. The study conducted in Punjab with 250 ECE teachers (125 teachers from public school and 125 teachers from private school) found that there were significant differences between the extent to which technology was accessible and integrated, with public school ECE teachers being more limited in technology access and professional preparation (Qayyum et al., 2024a). Similarly, another Pakistani ECE study, involving 30 policymakers, educators, parents, and experts, revealed that significant problems in ECE policy included lack of infrastructure, limited training, cultural issues, data-privacy concerns, and lack of AI provisions (Qayyum et al., 2024b). The National Artificial Intelligence Policy (NAIP) was officially approved at the national level on July 31, 2025 (Ministry of Information Technology and Telecommunication, 2025), enhancing the policy framework for AI capacity building and responsible usage.

While the use of AI is rising among educators in Pakistan, its application is often not effectively

and inclusively. Various studies have been conducted in Pakistan that already documented how teachers use AI tools for educational purposes and the need for improved AI literacy and training among teachers (Ahmed et al., 2024). The central issue is then not just if ECE teachers use AI, but if they can use AI to ensure the developmentally appropriate use of AI in pedagogical practices that enhance accessibility, differentiation, participation, and meaningful learning for diverse children. Until now there was little empirical evidence that has explored this relationship between ECE teachers in Punjab.

1. To determine the levels of AI adoption, pedagogical effectiveness, and inclusive practices among ECE teachers in Punjab.
2. To examine the relationship between AI adoption and pedagogical effectiveness.
3. To examine the relationship between AI adoption and inclusive practices for diverse learners.
4. To determine the relationship between pedagogical effectiveness and inclusive practices.
5. To examine whether pedagogical effectiveness mediates the relationship between AI adoption and inclusive practices for diverse learners.

This study moves beyond measuring whether teachers accept or use AI by examining whether adoption is translated into effective and inclusive pedagogy. Recent evidence indicates that AI may enhance personalization, accessibility, and learner engagement, but successful inclusive implementation depends substantially on teacher competence, institutional support, ethical practice, and appropriate pedagogical integration (Li et al., 2025). The study will provide context-specific evidence for ECE teachers, teacher educators, school leaders, professional-development providers, and Punjab education authorities. It may particularly inform professional training that combines AI competence with differentiated instruction, accessibility, developmentally appropriate practice, and responsible decision-making rather than

promoting technology use as an educational outcome in itself.

Literature Review

Artificial Intelligence Adoption in Education

AI has progressed and evolved from niche tools for education to readily available resources that educators can utilize for their planning, assessment, resources, feedback, differentiation, and professional communication. Researchers completed a systematic review of the literature to explore how AI can be used in the context of teachers and instructional decisions, and they identified three areas in which AI can help teachers support instructional decisions: learner information, instructional implementation, and assessment. The authors found that while AI can support instructional decisions, effective integration depends on teachers' ability to draw meaning from and critically evaluate the AI-supported decisions. This problem has been exacerbated by the rise of generative AI, which has enabled teachers to produce curriculum materials and customize content without the need for extensive technical knowledge, but with continuing concerns about reliability, pedagogical and ethical appropriateness, and professional readiness. Therefore, AI adoption should not just be defined as access to or use of technology, but as a meaningful learning integration (Celik et al., 2022; Yusuf et al., 2024).

Artificial Intelligence in Early Childhood Education

The use of AI in early childhood education is a fairly novel and still underdeveloped area compared to other areas of schooling and higher education. Su and Yang's literature review revealed only 17 studies that met their inclusion criteria and revealed that AI was used to support children's creativity, literacy development, computational thinking, collaborative inquiry, and an understanding of concepts. The field has expanded rapidly as evidenced by the following: Ljungcrantz reviewed 39 AI-ECE studies published between the years 2020 and 2024 and found an unmistakable growth in the field;

Ormanci's systematic review of 37 studies showed an accelerated growth of research after 2023. Both recent reviews highlight the ongoing requirement for improved empirical designs, developmentally appropriate implementation, teacher training, and a focus on the integration of AI into the practice of early childhood pedagogy, not just a technology (Su & Yang, 2022; Ljungcrantz, 2026; Ormanci, 2026).

AI Adoption and Pedagogical Effectiveness

Adopting an AI tool does not necessarily improve teaching. The pedagogical effectiveness relies on teachers' ability to link up with the goals of instruction, developmental features of children, curriculum needs, classroom interaction, and suitable modes of assessment, among others, to the capabilities of AI. Research conducted with K–12 educators shows that the extent to which educators are technologically prepared and pedagogically knowledgeable is a critical consideration for meaningful integration of AI. Both Hava and Babayiğit's findings that there was a close relationship between teachers' technological-pedagogical competence on AI and broader technological proficiency, and Cheah et al.'s study on 89 K–12 teachers revealed that less than half of the teachers were currently using generative AI in their classrooms, and that teachers applied the technology more in lesson preparation, assessment, and administrative work than in classroom instruction. The results indicate that while there is an adoption of AI, it is likely to be superficial until teachers acquire the pedagogical skills to transform the outputs of the AI for meaningful learning (Hava & Babayiğit, 2025; Cheah et al., 2025).

Teacher AI Competence and Professional Development

It is becoming more evident that teacher competence is now a key factor for good AI-enabled teaching. In an effort to capture teacher AI competence beyond the ability to use AI tools, Chiu et al. validated a teacher AI competence framework that includes four distinct components: AI knowledge, pedagogical considerations, assessment, ethics, human-centered education, and professional

engagement, with 434 K–12 teachers. UNESCO also lists five areas that are connected and related to teachers: human-centered thinking, ethics, AI foundations and applications, AI pedagogy, and professional learning. In teacher professional development, it is important that educators can assess the information created by AI, recognize inappropriate outputs, relate technology to learning goals, and use professional judgment. Case-based AI professional development also suggests that opportunities for structured discussions of realistic educational problems can enhance AI literacy and promote thoughtful integration strategies (Chiu et al., 2025; Miao & Cukurova, 2024; Ding et al., 2024).

Artificial Intelligence and Inclusive Practices for Diverse Learners

Some of the most important aspects of inclusive education where AI is relevant is related to the ability to produce alternative representations, adapt language, generate visual materials, personalise activities, facilitate communication, and present flexible access to curriculum content. Melo-López et al. conducted a systematic review and identified that AI has the potential to enhance the accessibility of and personalized learning, such as by facilitating the creation of accessible materials for learners with sensory and other learning needs, but that it also presents numerous challenges including lack of infrastructure, limited teacher preparation, privacy issues, and unequal access. Another systematic review of empirical studies also highlighted the potential of AI tools to support inclusive education, while highlighting the need for pedagogical expertise, accessibility-focused design, and suitable institutional conditions to put it into practice. Evidence-based selection, data protection, accountability, monitoring, and human responsibility are also emphasised as essential for the educational benefits of AI according to an OECD analysis of AI for learners with special educational needs (Melo-López et al., 2025; Li et al., 2025; Linsenmayer, 2025).

Ethical, Human-Centered, and Developmentally Appropriate Practice

AI-enabled inclusive pedagogy cannot be isolated from ethical and developmental issues. Young children need social interactions play communication relationship physical movement, and direct interactions with people and object; so, in order for AI to be additive, AI should support the role of teachers rather than displace the human relationship that is essential to young children' learning. Ethical AI research in the field of education identifies several principles including privacy transparency fairness accountability learner control and human oversight that are desirable for educational AI system. An AI literacy also includes the competence to understand use assess and reflect on AI and its ethical implications rather than the skills to use an AI application. Such concern becomes more significant in the domains where AI systems will have access to children's education behaviors communication, disability and family data (Nguyen et al., 2023; Ng et al., 2021).

Evidence from Pakistan and Punjab

Local Pakistani evidence confirms both interest in AI and challenges to implementation. For instance, an increase in the use of ChatGPT and Gemini and of other AI tools by educators was reported by researchers Ahmed et al. While emphasizing this trend, the authors call for increased AI literacy and professional training. An investigation carried out in Punjab revealed heterogeneity in access to technology, teachers' skill, and level of integration into teaching activities and differences between public and private schools, with the former struggling more with resources and training, following an online survey to 250 ECE teachers (125 private and 125 state providers) conducted by Qayyum, Tabassum and Kashif. In another and different Pakistani study Iraqi Pakistani government officials parents teachers and experts explored the availability of infrastructure, the in-service teacher training, teachers' learning privacy cultural issues and policy addressing, as challenges to AI integration in ECE. These data are totally aligned to the Pakistani National Artificial Intelligence Policy 2025, which officially endorses AI preparedness and

development, responsible use, security, and ethics (Ahmed et al., 2024; Qayyum, Tabassum, & Kashif, 2024; Qayyum, Sadiqi, & Abbas, 2024; Ministry of Information Technology and Telecommunication, 2025).

Synthesis of the Literature

The literature reviewed in the column has shown that AI can offer teachers important tools for planning, differentiating instruction, as a means of accessibility, and assessment support, but use of technology is not itself enough to suggest quality. Existing ECE literature is a comparatively small body of research, teacher professional development varies in quality, and inclusive-AI research consistently reveals the important role of pedagogical effectiveness and human oversight as a necessity for responsible use. More exactly under-studied quantitatively is research-to-date examining adoption of AI, pedagogical effectiveness, and inclusive practices for diverse learners all at once within early childhood education. Even more under-studied in Punjab is the literature which to date has addressed access to technology, attitudes toward technology, and policy studies rather than whether pedagogical effectiveness moderates the link between AI Adoption and inclusive practices for diverse learners in early childhood classrooms. Because of this, this is precisely the gap available to investigate the proposed relationship the primary predictor of interest is AI Adoption, the potential mediator is Pedagogical Effectiveness, and the outcome is Inclusive Practices for Diverse Learners in ECE teachers in Punjab, Pakistan (Jung & Kim, 2025; Qayyum, Sadiqi, & Abbas, 2024).

Research Methodology

Research Design

The study used a quantitative research design to examine the relationships among AI adoption, pedagogical effectiveness, and inclusive practices for diverse learners among early childhood education teachers. Quantitative methods were used to measure the study variables and test the proposed relationships statistically (Creswell & Creswell, 2023).

Population and sampling of the Study

Participants consisted of early childhood education teachers working in Punjab, Pakistan in public/private educational institutions. Participants included teachers working with urban and rural learners with various learning developmental linguistic, and educational requirements. The target sample consisted of 469 early childhood education teachers through multistage stratified sampling. I divided Punjab into 3 regions, namely Central, Southern and Northern/Upper, and then stratified based on public/private sector and urban/rural location to ensure representation from within each sector (Creswell & Creswell, 2023).

Instrument Development

A researcher-developed instrument titled the Artificial Intelligence, Pedagogy and Inclusive Practice Questionnaire for Early Childhood Educators (AIPIQ-ECE) was used. It contained 44 items covering AI Adoption (14 items), Pedagogical Effectiveness (15 items), and Inclusive Practices for Diverse Learners (15 items). Responses were recorded on a five-point Likert scale ranging from strongly disagree to strongly agree.

Validity and Reliability of the Research Instrument

The questionnaire was also validated by professionals specialized in early childhood education, inclusive education, educational technology and research method. They analyzed the items within the context of their relevance, mastery of the language used and cultural appropriateness to the targeted population; and, checked the correspondence of the items with the variables to be studied and recommended

Demographic Characteristics of the Participants

there further refinements to the instrument where appropriate (DeVellis & Thorpe, 2021). The instrument was pilot tested on teachers who were not among the study sample. Internal consistency was measured using Cronbach's alpha, an alpha coefficient of 0.70 or higher indicating adequate internal consistency while the validity of the instrument was re-evaluated using the data obtained from the main study (Kline, 2023).

Data Collection and Analysis Procedure

Permission was granted from the appropriate authorities and selected schools/colleges before data collection. Participants were provided with information about the aims of the research, told that participation was voluntary and that their answers would be kept confidential. The questionnaire was administered as either a hard copy or electronic version and the returned questionnaires checked before data analysis. Data were analysed with the Statistical Package for Social Science (SPSS) and analysis of Moment Structures (AMOS). Frequencies percentages means and standard deviations were calculated and t tests, ANOVA used to investigate group differences. Pearson correlation coefficient was used to examine the intercorrelations among the variables. Confirmatory factor analysis and structural equation modelling were utilized to examine the measurement and structural models of the data, respectively. The mediating effect of pedagogical effectiveness was further investigated using 5,000 bootstrapped samples with $p < .05$ as the criterion for significance (Hayes, 2022; Kline, 2023).

Table 1: Demographic and Professional Characteristics of Respondents (N = 469)

Variable	Category	f	%
Gender	Male	142	30.3
	Female	319	68.0
	Prefer not to disclose	8	1.7
Age	20–29 years	141	30.1

	30–39 years	169	36.0
	40–49 years	107	22.8
	50 years and above	52	11.1
Academic qualification	Bachelor's	201	42.9
	Master's	206	43.9
	MPhil/MS	53	11.3
	PhD/Other	9	1.9
Professional qualification	ECE/ECCE Diploma	103	22.0
	B.Ed.	151	32.2
	M.Ed.	94	20.0
	Special Education	51	10.9
	Montessori	49	10.4
	Other	21	4.5
Teaching experience	1–5 years	153	32.6
	6–10 years	150	32.0
	11–15 years	96	20.5
	16 years and above	70	14.9
School sector	Public	281	59.9
	Private	188	40.1
School location	Urban	268	57.1
	Rural	201	42.9
Region	Central Punjab	187	39.9
	Southern Punjab	147	31.3
	Northern/Upper Punjab	135	28.8
Teaching level	Nursery	129	27.5
	Kindergarten	151	32.2
	Kachi/Prep	159	33.9
	Other ECE	30	6.4
AI-related training	No training	147	31.3
	Short workshop	158	33.7
	Certificate course	105	22.4
	Formal course/diploma	59	12.6
AI-use frequency	Never	39	8.3
	Rarely	86	18.3
	Monthly	103	22.0
	Weekly	160	34.1
	Daily	81	17.3

Table 1 indicates the most of the participants were females (68.0%) and most of the teachers, 59.9%, taught in public-sector institutions and a slightly lower amount, 57.1%, in urban areas. The dominant age group was 30-39 years (36.0%) and the most common level of

qualification among participants was a bachelor's or master's degree. On AI use, the largest share of participants had received no methodical instruction in AI (31.3%) and the most common AI usage pattern was weekly use (34.1%).

Table 2: Descriptive Statistics and Distribution Characteristics

Variable	M	SD	Skewness	Kurtosis
AI Adoption	3.51	0.51	-0.21	0.16
Pedagogical Effectiveness	3.73	0.50	-0.16	-0.48
Inclusive Practices	3.81	0.51	-0.38	-0.19

Note. Scores ranged from 1 to 5.

Table 2 shows the Inclusive Practices obtained the highest mean ($M = 3.81$), followed by Pedagogical Effectiveness ($M = 3.73$), whereas AI Adoption had the comparatively lowest mean ($M = 3.51$). All three mean scores were above the midpoint of the five-point scale. Skewness and kurtosis values remained within

acceptable limits, indicating no serious departure from normality.

Frequency and Percentage Levels of the Study Variables

For descriptive interpretation, mean scores of 1.00–2.33 were categorized as low, 2.34–3.67 as moderate, and 3.68–5.00 as high

Table 3: Frequency and Percentage Distribution of Construct Levels

Variable	Low f (%)	Moderate f (%)	High f (%)
AI Adoption	3 (0.6)	279 (59.5)	187 (39.9)
Pedagogical Effectiveness	0 (0.0)	210 (44.8)	259 (55.2)
Inclusive Practices	1 (0.2)	176 (37.5)	292 (62.3)

Table 3 describe the most participants demonstrated moderate AI Adoption, with 59.5% falling in the moderate category and 39.9% in the high category. More than half of

the respondents reported high Pedagogical Effectiveness (55.2%). Inclusive Practices showed the strongest distribution, with 62.3% of teachers falling in the high category.

Reliability Analysis

Table 4: Internal Consistency Reliability of the Research Instrument

Scale	No. of Items	Cronbach's α	Interpretation
AI Adoption	16	.862	Good
Pedagogical Effectiveness	17	.876	Good
Inclusive Practices	17	.884	Good
Overall questionnaire	50	.936	Excellent

Table 4 shows the Cronbach's alpha coefficients ranged from .862 to .884 for the three individual

dimensions, indicating good internal consistency. The overall 50-item questionnaire

produced an alpha coefficient of .936, representing excellent reliability. These results indicated that the instrument consistently measured the intended constructs.

Independent-Samples t Tests

Independent-samples t tests were performed for demographic variables containing two meaningful comparison groups: gender, school sector, and school location. Participants who preferred not to disclose gender were excluded only from the gender comparison.

Table 5: Independent-Samples t Tests for Gender, School Sector, and Location

Grouping Variable	Outcome	Group 1 M (SD)	Group 2 M (SD)	t	df	p	Cohen's d
Gender	AI Adoption	Male 3.47 (0.53)	Female 3.53 (0.50)	-1.11	459	.268	-0.11
	Pedagogical Effectiveness	Male 3.72 (0.53)	Female 3.75 (0.50)	-0.49	459	.624	-0.05
	Inclusive Practices	Male 3.86 (0.48)	Female 3.80 (0.52)	1.11	459	.267	0.11
School sector	AI Adoption	Public 3.50 (0.53)	Private 3.51 (0.47)	-0.20	467	.845	-0.02
	Pedagogical Effectiveness	Public 3.77 (0.52)	Private 3.68 (0.48)	1.95	467	.052	0.18
	Inclusive Practices	Public 3.84 (0.53)	Private 3.76 (0.47)	1.67	467	.095	0.16
School location	AI Adoption	Urban 3.54 (0.52)	Rural 3.47 (0.48)	1.53	467	.126	0.14
	Pedagogical Effectiveness	Urban 3.75 (0.51)	Rural 3.71 (0.50)	0.85	467	.393	0.08
	Inclusive Practices	Urban 3.84 (0.50)	Rural 3.77 (0.51)	1.51	467	.133	0.14

Note. Gender analysis included 461 respondents because eight respondents selected “prefer not to disclose.”

Table 5 describe the there is no statistically significant differences by gender, public-private or urban-rural distinctions at p.05 emerged for the three broad constructs; public school teachers scored slightly higher on Pedagogical Effectiveness, and urban teachers scored slightly higher on AI Adoption, but both differences

had small effect sizes. Although the data hinted at potential differences in these broad demographic variables, they did not give rise to dramatic distinctions in teachers' integrative and AI-related approaches.

One-Way ANOVA for Demographic Variables

One-way ANOVA was used for demographic variables containing three or more categories.

Table 6: One-Way ANOVA for Selected Demographic and Professional Variables

Demographic Variable	df	AI Adoption F (p), η^2	Pedagogical Effectiveness F (p), η^2	Inclusive Practices F (p), η^2
Age	3, 465	0.81 (.488), .005	0.72 (.541), .005	0.70 (.551), .005
Academic qualification	3, 465	0.75 (.524), .005	1.44 (.229), .009	0.97 (.408), .006

Professional qualification	5, 463	0.44 (.821), .005	0.16 (.976), .002	0.09 (.994), .001
Teaching experience	3, 465	0.46 (.710), .003	1.74 (.159), .011	1.10 (.347), .007
Region	2, 466	0.31 (.736), .001	0.03 (.971), <.001	0.20 (.822), .001
Teaching level	3, 465	1.86 (.136), .012	1.62 (.184), .010	0.54 (.655), .003
AI-related training	3, 465	9.12 (<.001), .056	5.07 (.002), .032	2.63 (.050), .017
AI-use frequency	4, 464	2.40 (.049), .020	2.56 (.038), .022	0.74 (.563), .006

Note. η^2 = eta squared. Bold values indicate statistically significant omnibus tests at $p < .05$.

Table 6 describe that age, years of qualifications, teaching experience, region, and teaching level were not statistically significant differentiators among the three variables of this study. Though, findings of nearly statistically significant difference for Inclusive Practices, and statistically significant differences for the other two variables of the study indicated there was a statistically significant difference between those with and without AI-associated training for all three variables of this study with the largest effect size for AI Adoption (.056 for 2). For frequency of AI-use, statistically significant

differences were evident for AI Adoption and Pedagogical Effectiveness but with small effect sizes.

Tukey post-hoc tests revealed that formally trained teachers endorsed more AI Adoption than teachers with no post-qualification education and those who had only been through 1-2 day courses in this area. Teachers with certificate/formal training were also found to be more Pedagogically Effective than no AI trained teachers.

Pearson Correlation Analysis

Table 7: Pearson Correlations Among the Study Variables

Variable	1	2	3
1. AI Adoption	—		
2. Pedagogical Effectiveness	.555***	—	
3. Inclusive Practices	.490***	.666***	—

Note. *** $p < .001$.

Table 7 shows the AI Adoption was positively and significantly associated with Pedagogical Effectiveness ($r = .555$) and Inclusive Practices ($r = .490$). The strongest relationship occurred between Pedagogical Effectiveness and Inclusive Practices ($r = .666$). Thus, teachers reporting more effective pedagogical practices also tended to report stronger inclusive practices for diverse learners.

Predictive Analysis

Regression/path analysis was conducted to determine the predictive relationships among AI Adoption, Pedagogical Effectiveness, and Inclusive Practices.

Table 8: Standardized Predictive Path Estimates

Predictive Path	β	SE	p	Decision
AI Adoption → Pedagogical Effectiveness	.555	.038	<.001	Significant

AI Adoption → Inclusive Practices	.173	.041	<.001	Significant
Pedagogical Effectiveness → Inclusive Practices	.570	.041	<.001	Significant

Note. R^2 for Pedagogical Effectiveness = .308; R^2 for Inclusive Practices = .465.

Table 8 shows the AI Adoption significantly predicted Pedagogical Effectiveness ($\beta = .555$), explaining approximately 30.8% of its variance. When both predictors were included, Pedagogical Effectiveness emerged as the stronger predictor of Inclusive Practices ($\beta = .570$) compared with AI Adoption ($\beta = .173$). Together, AI Adoption and Pedagogical Effectiveness explained approximately 46.5% of the variance in Inclusive Practices.

Mediation Analysis

Bootstrapping with 5,000 resamples was conducted to examine whether Pedagogical Effectiveness mediated the relationship between AI Adoption and Inclusive Practices.

Table 9: Bootstrapped Mediation Analysis

Effect	Standardized Effect	Bootstrap SE	95% CI	Result
Total effect: AI Adoption → Inclusive Practices	.490	.040	—	Significant
Direct effect: AI Adoption → Inclusive Practices	.173	.041	—	Significant
Indirect effect: AI Adoption → Pedagogical Effectiveness → Inclusive Practices	.317	.029	[.261, .378]	Significant

Note. Bootstrap samples = 5,000. CI = confidence interval.

Table 9 describe the indirect effect of AI Adoption on Inclusive Practices through Pedagogical Effectiveness was significant because the 95% bootstrap confidence interval did not include zero. The direct effect of AI Adoption remained significant after the mediator was introduced, indicating **partial mediation**. The results suggested that AI Adoption was related to stronger Inclusive Practices largely when AI use was translated into effective pedagogical practice.

Discussion

The study explored the relationships between Artificial Intelligence Adoption, Pedagogical Effectiveness, and Inclusive Practices for the Diverse Learners among the early childhood education teachers in Punjab and the identilustrative results revealed that the early childhood education teachers were a little bit moderate in their AI Adoption ($M=3.51$) but

Pedagogical Effectiveness ($M= 3.73$) and inclusive practices for the diverse learners ($M=3.81$) were higher comparatively. It implies that the teachers might practice good pedagogical and inclusive pedagogical practices and pre-existing teaching abilities even when AI was still developing among them. Recent studies affirms that AI adoption among the early childhood education teachers is increasing but it should focus on teacher training, curriculum integration and developmentally appropriate pedagogy as they may not merely revolve around use of technology (Ormanci, 2026).

Electively, looking at the background variables of gender, public/private school sector, and urbanrural, no statistically significant differences were found on the three variables studied. Other background variables of age qualification teaching experience, region, and level of teaching, found no statistically significant

differences, unlike the length of your training, which did, with sustainable teachers A lot better than those with less sustained training. This finding supports current conceptions of teacher's AI competence which consist of AI knowledge pedagogy assessment ethics humancentered education and professional engagement rather than technological skill alone (Chiu et al., 2025).

Frequency of AI use was the only demographic characteristic that much differentiated AI Adoption and Pedagogical Effectiveness but not Inclusive Practices. This is important as it shows that frequency of AI use does not mean effective and inclusive use. Teachers may be frequent users of AI for tasks like lesson planning, administrative work, and generation of resources without changing their usual responses to learner diversity much. Evidence from K12 education was similar, showing that teachers were frequent users of generative AI in preparing lessons and activities, assessments, and administrative tasks, but real classroom embedding of AI was limited by pedagogical concerns readiness ethical issues, and lack of institutional guidance (Cheah et al., 2025).

The correlation analysis revealed statistically significant positive correlations between AI Adoption and Pedagogical Effectiveness ($r=.555$), AI Adoption and Inclusive Practice ($r=.490$), and Pedagogical Effectiveness and Inclusive Practice ($r=.666$). The strongest correlation was between pedagogical effectiveness and inclusive practice. This finding suggests that AI is potentially more educationally useful, when teachers have the pedagogical knowledge about how to select, adapt, and implement technology in ways that meet learners' needs. More recent studies about AI-TPACK has also shown that teachers' ability to integrate AI meaningfully is strongly correlated with their overall TPACK (Hava & Babayit, 2025).

The findings from the predictive analysis supported this conclusion. AI Adoption appeared as a significant predictor of

Pedagogical Effectiveness ($=.555$), and Pedagogical Effectiveness ($=.570$) became a much more powerful predictor of Inclusive Practices over the simple effect of AI Adoption ($=.173$). The combined effects of AI Adoption and Pedagogical Effectiveness explained roughly 46.5% of the variance in Inclusive Practices. These results aligned with the current inclusive-AI literature in demonstrating how AI can play a role in facilitation of personalization, accessibility, and learner engagement, even if its success ultimately relies on pedagogy, the teacher, the infrastructure, and responsible implementation (Li et al., 2025).

Most importantly pedagogy as a partial mediating factor played a major role, partially mediating the 2 relations above, with a big magnitude of indirect effect ($=.317$). This proposed indirect effect (AI use in classroom->teacher pedagogy->inclusion) thrived on the remaining direct path between AI adoption and inclusion ($=.173$) indicated that the path via AI use in the classroom may work importantly through the transformation of AI use into supported learnings. AI offers content differentiation, alternative graphics/states of operation, flexible learning activities, linguistic allocation, individualization etc. Yet, only when teachers purposefully bridge and use such options to break barriers to learning and participation, inclusion can emerge. Recent systematic data also concludes that personalized AI support and accessibility, but also teacher preparation and ethical considerations are key implementing factors toward inclusive education (Melo-Lpez et al., 2025).

The research also has implications for Punjab and Pakistan, where Punjabi teachers and educators are already adopting similar applications like ChatGPT Gemini etc. towards their academic work. This shows that AI is being adopted already to some extent in the education sector. But, the existing research on Pakistani ECE has found differences in technology availability, professional preparation, and institutional capacity, in particular in public versus private schools. So, merely enabling

teachers with access to AI may not be enough without concurrently enhancing their pedagogical knowledge and skills (Ahmed et al., 2024; Qayyum, Tabassum, & Kashif, 2024).

These findings advocate for a humanist approach to AI in ECE. These concluded about 2 'in preschool classroom teaching, AI does not equate to replacing the vital professional tasks and practices of (i) observation, (ii) teacher child interaction, play, and communication, (iii) the warm relationships among classroom actors, and (iv) teachers' knowledge of individual children' to be used to... rather 'to support teachers' preparations of and adaptations to learning experiences, but to have teachers making the call about whether AI-produced materials are suitable for an individual child's developmentally level, culturally relevant, accessible and educationally meaningful and content.' UNESCO identified human-centered thinking, AI pedagogy, ethical responsibility and CPD as key ingredients of teachers' AI 3 competence (Miao & Cukurova, 2024).

Conclusion

Based on the results, the study found that AI Adoption, Pedagogical Effectiveness and Inclusive Practices were positively related to each other among early childhood ECE teachers. Yet, the results indicated that AI adoption alone was not enough to promote inclusive instruction. Pedagogical Effectiveness was the strongest predictor of Inclusive Practices and provided a significant mediating (indirect) effect between the use of AI in teaching and inclusive classroom practice. It further supports the argument that educational AI should be assessed based on the degree to which pedagogical pedagogical effectiveness in teaching outcomes is supported rather than by frequency of usage.

The mediation results spelt out the author's main finding: that a strong linkage between AI adoption and inclusive practice emerged as AI capabilities were translated into effective pedagogy by teachers. AI can help designing tailored differentiated tasks feedback

accessibility, lesson planning and learner responsiveness, yet professional judgment remains crucial. In ECE, technology should complement rather than substitute developmentally appropriate experiences, human connections, child's active engagement and teachers' knowledge of a child in context.

Within the Punjab context, the findings pointed toward shifting from a generic promotion of AI toward a more intentional professional development. The teachers need to be trained not only on how to use AI applications but how and when to use them, and when not to use them, so that they know when using AI with varying groups of young learners will be advantageous. In Pakistan, some existing research have also highlighted issues like infrastructure, professional development, privacy and security, local relevance, and policy guidance as key factors for effective responsible integration of AI in early childhood education.

Recommendations

Following recommendations are made based on findings of research:

1. Early childhood teachers would benefit from ongoing professional development that combines teaching AI skills with lesson planning differentiation assessment, accessibility, and developmentally appropriate teaching rather than will only self-focused tools for operating AI.
2. Teachers must be trained in how to use the application for adapting the language, developing alternative representations, providing differentiated learning activities, supporting communication or improving participation for children with different learning needs.
3. Schools should not evaluate AI integration merely according to how often teachers use AI. Evaluation should consider whether AI-supported practices improve instructional quality, accessibility, learner engagement, and meaningful participation.
4. Educational institutions should establish procedures concerning data privacy, verification of AI-generated content, cultural and linguistic appropriateness, bias, ethical use,

and teacher responsibility, particularly when technology is used with young children.

5. Education authorities should provide appropriate digital infrastructure, approved AI resources, and continuing professional learning, with particular attention to institutions where technological access and teacher preparation remain limited.

6. AI resources applied to early childhood classrooms in Punjab to align with the local

curriculum, cultural norms, and use languages such as Urdu English Punjabi, and Saraiki rather than generic globally developed resources.

7. The AI should use as an assistant resource rather than an autonomous decision-maker in instruction. Play communication peer interaction, teacher observation, hands-on learning and teacher-child relationship as the core of early childhood education.

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