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Abstract

The integration of Artificial Intelligence (AI) in education offers transformative opportunities for personalized learning and efficient instructional practices. However, the successful adoption of AI in classrooms is contingent upon teachers' preparedness, technological literacy, and understanding of ethical considerations. This study examined how these factors alongside professional development and access to technology influence the effective implementation of AI tools in classrooms. A quantitative research design involved 210 teachers from nine schools in Punjab, Pakistan, was employed, utilizing structured questionnaires to collect data on these variables. The findings revealed significant positive correlations between technological literacy, professional development, and access to technology with the effective use of AI tools. Ethical considerations, while moderately correlated, showed lower statistical significance, underscoring the need for more focus in this area. Access to technology emerged as the strongest predictor of successful AI implementation, highlighting disparities in infrastructure as a critical barrier, particularly in under resourced schools. The study underscores the necessity of holistic strategies to empower educators through targeted training, ethical literacy, and equitable resource allocation. By addressing these factors, schools can unlock AI's potential to enhance teaching and learning while promoting inclusivity and innovation in education. The findings provide actionable recommendations for policymakers and educators to bridge gaps in preparedness and equity.

Introduction

The integration of Artificial Intelligence (AI) into educational settings has revolutionized the way teaching and learning occur, offering unprecedented opportunities for personalization, engagement, and efficiency. AI-integrated classrooms provide teachers with tools to analyze student performance, adapt curriculum dynamically, and deliver tailored instruction that meets the unique needs of each learner. However, the success of such transformative potential depends largely on the preparedness and technological literacy of teachers who serve as the facilitators of these innovations (Bitar & Davidovich, 2024). Educators must not only understand the functionality of AI tools but also possess the pedagogical competencies to integrate these technologies effectively into their teaching practices. The rapid adoption of AI in education has created a pressing need for teacher training

programs that address both technological and pedagogical dimensions. While AI tools like intelligent tutoring systems, predictive analytics, and chatbots can streamline administrative tasks and enhance instructional quality, their effectiveness hinges on teachers' ability to use these tools strategically (Praveenkumar et al., 2024). Inadequate training or a lack of familiarity with AI technologies can lead to suboptimal utilization, perpetuating inequities rather than addressing them.

Teacher preparedness in AI-integrated classrooms involves more than mere technical proficiency; it also requires an understanding of ethical considerations, data privacy, and the implications of AI-driven decision-making (Kayal, 2024). For instance, educators must navigate the potential biases embedded within AI algorithms and ensure that data-driven insights are applied in a manner that supports equity and inclusivity. This dual focus on technical and ethical literacy underscores the complexity of equipping teachers for AI-enhanced education. Despite the growing importance of AI literacy, studies suggest that many educators feel unprepared to integrate these technologies effectively into their classrooms. Surveys indicate that a significant percentage of teachers lack confidence in their ability to leverage AI tools, often citing insufficient professional development opportunities and limited access to resources as barriers (Alwaqdani, 2024). These challenges are particularly pronounced in under-resourced schools, where disparities in access to technology can exacerbate existing educational inequities.

Addressing these gaps in preparedness requires a multidimensional approach that includes pre service and in-service training programs, collaborative professional learning communities, and partnerships between educational institutions and technology developers. Teacher training programs must move beyond traditional models to incorporate hands-on experiences with AI tools, fostering a deeper understanding of their practical applications and potential pitfalls (Kotsis, 2024). Furthermore, ongoing support and mentorship are critical to ensuring that teachers can adapt to the evolving landscape of AI technologies. The need for teacher preparedness in AI-integrated classrooms is not only a pedagogical imperative but also a societal one. As AI becomes increasingly prevalent in all facets of life, schools play a crucial role in preparing students to navigate a future shaped by these technologies. Teachers, as the architects of this preparation, must be equipped to model critical thinking, ethical reasoning, and adaptability skills that are essential in an AI-driven world (Isaacs et al., 2024; Walter, 2024).

By fostering technological literacy among educators, schools can bridge the gap between the potential of AI and its practical implementation, ensuring that all students benefit from the opportunities it offers. Teacher preparedness and technological literacy are foundational to the successful integration of AI in education. Equipping teachers with the skills, knowledge, and ethical understanding needed to navigate AI technologies is essential for realizing their transformative potential. As educational institutions, policymakers, and technology developers collaborate to address this challenge, the focus must remain on empowering educators to harness AI as a tool for equity, innovation, and lifelong learning.

Novelty of the Study

This study uniquely addresses the intersection of teacher preparedness and technological literacy in the context of AI integrated classrooms, an area that remains underexplored despite the rapid adoption of AI technologies in

education. Unlike existing research that often focuses on the technical capabilities of AI or its impact on student outcomes, this study shifts the lens to the educators themselves, investigating how their readiness and understanding of AI influence the successful implementation of these tools. Additionally, it considers the dual dimensions of technical and ethical literacy, recognizing the broader implications of AI on issues such as equity, data privacy, and algorithmic bias. The study's emphasis on practical solutions such as targeted training programs and sustainable support mechanisms further distinguishes it by offering actionable recommendations for bridging the gap between AI potential and classroom realities.

Statement of the Problem

Despite the increasing integration of AI tools in education, many teachers feel unprepared to utilize these technologies effectively. Limited access to professional development, insufficient resources, and a lack of understanding about the ethical and pedagogical implications of AI exacerbate these challenges. This lack of preparedness poses significant risks, including suboptimal implementation of AI tools, perpetuation of inequities, and potential misuse of data-driven insights. The problem is particularly acute in under-resourced schools, where disparities in technology access and training opportunities are more pronounced. This study seeks to address the critical gap in understanding how teacher preparedness and technological literacy impact the adoption and effectiveness of AI in classrooms.

Purpose of the Study

The purpose of this study is to examine the role of teacher preparedness and technological literacy in the successful implementation of AI technologies in educational settings. By exploring the relationship between educators' technical and ethical competencies and their ability to integrate AI tools, the study aims to identify key factors that contribute to effective adoption. Furthermore, it seeks to develop evidence-based recommendations for designing training programs and support systems that empower teachers to harness AI for enhancing teaching and learning. The findings will be contribute to the broader discourse on AI in education, offering insights into how to bridge gaps in preparedness and promote equitable access to AI-driven innovations. Based on the previous studies four hypothesis formulated.

Hypotheses

H1: Teachers with higher levels of technological literacy are more likely to effectively implement AI tools in their classrooms.
H2: Participation in professional development programs significantly improves teachers' effective implementation of AI tools.
H3: Teachers with a strong understanding of ethical considerations are more likely to implement AI tools in ways that promote equity and inclusivity.
H4: Greater access to technology is positively associated with the effective implementation of AI tools in classrooms.

Literature Review

The integration of AI in education has been lauded for its potential to enhance personalized learning, optimize administrative processes, and provide data-driven insights to improve student outcomes (Takona, 2024; Vashishth et al., 2024). AI tools such as intelligent tutoring systems, learning analytics platforms, and predictive assessment tools allow for real time tracking of student performance, helping educators tailor their approaches to meet individual needs. However, the successful implementation of these technologies is contingent on the users' understanding and ability to leverage AI effectively (Du & Lv, 2024; Yang et al., 2024).

Research highlighted a significant gap between the availability of AI tools and teachers' readiness to adopt them, often due to a lack of technological literacy and professional development (Yue et al., 2024; Zhang & Zhang, 2024). Technological literacy is fundamental for teachers to integrate AI into their classrooms meaningfully. It includes understanding the functionality of AI tools, their pedagogical relevance, and their potential for improving learning outcomes (Ding et al., 2024; Stolpe & Hallström, 2024). The Technological Pedagogical Content Knowledge (TPACK) framework underscores the importance of balancing technical knowledge with pedagogical and content expertise (Li & Li, 2024; Ning et al., 2024). For AI tools, this balance becomes even more critical, as they often require teachers to rethink traditional instructional methods. Empirical studies demonstrated that teachers with primary technological literacy are more likely to experiment with and effectively implement innovative tools (Stumbrienė et al., 2024).

Professional development is a key enabler for enhancing teacher preparedness in AI integrated classrooms. Effective training programs should go beyond basic technical skills to include hands-on experiences, collaborative learning opportunities, and ongoing mentorship (Abedi, 2024). A study by Ding et al. (2024) found that teachers who participated in AI-focused workshops reported increased confidence and a greater ability to align AI tools with their pedagogical goals. However, professional development initiatives often fall short in addressing ethical considerations and the broader implications of AI in education, leaving teachers ill prepared to handle issues such as data privacy and algorithmic bias (Farooqi et al., 2024). Ethical issues are central to the discourse on AI in education, particularly regarding data privacy, algorithmic bias, and equitable access. Teachers must understand how these tools collect, analyze, and use data to ensure they are applied responsibly (Kooli, 2023).

Studies highlighted that biased algorithms can reinforce existing inequalities, disproportionately impacting marginalized student groups (Kordzadeh & Ghasemaghaei, 2022). Educators' awareness and ability to critically evaluate AI outputs are crucial for mitigating such risks and promoting inclusive practices. Moreover, disparities in access to AI tools exacerbate existing inequities, particularly in under-resourced schools where technology infrastructure is often inadequate (Mahapatra et al., 2024). Teachers' attitudes toward AI play a significant role in determining its adoption in classrooms. Resistance to change, skepticism about AI's capabilities, and fear of being replaced are common concerns among educators (Ayanwale et al., 2022). Research shown that these attitudes are often rooted in a lack of understanding or experience with AI tools. Addressing these concerns through targeted training and awareness programs can help build trust and foster a positive mindset toward AI adoption (Ayanwale et al., 2022).

The theoretical framework Figure 1 for this study is grounded in the Technological Pedagogical Content Knowledge (TPACK) Framework, Constructivist Learning Theory, and principles from the Diffusion of Innovations Theory. The TPACK Framework, developed by (Shambare & Simuja, 2024), emphasized the seamless integration of technology, pedagogy, and content knowledge as essential for effective teaching in technology-enhanced classrooms. This framework provides a valuable lens for understanding how educators combine AI tools with instructional strategies and subject matter expertise to create meaningful learning experiences (Alam & Mohanty, 2023; Shankar et al., 2024). Complementing Le and Nguyen (2024) Constructivist Learning Theory, which underscores the importance of experiential, hands-on engagement in the learning process. This theory supports the notion that teachers must actively interact with AI technologies to build the confidence and competence needed to integrate them effectively. Furthermore, Uzumcu and Acilmis (2024) Diffusion of Innovations Theory offers insights into how new technologies, such as AI, are adopted within educational communities. This theory decorated the critical role of opinion leaders and early adopters in influencing broader acceptance, as well as the need for targeted strategies to address resistance and foster sustainable implementation. Together, these frameworks provide a robust foundation for analyzing the interplay between teacher preparedness, technological literacy, and the successful integration of AI in educational settings.

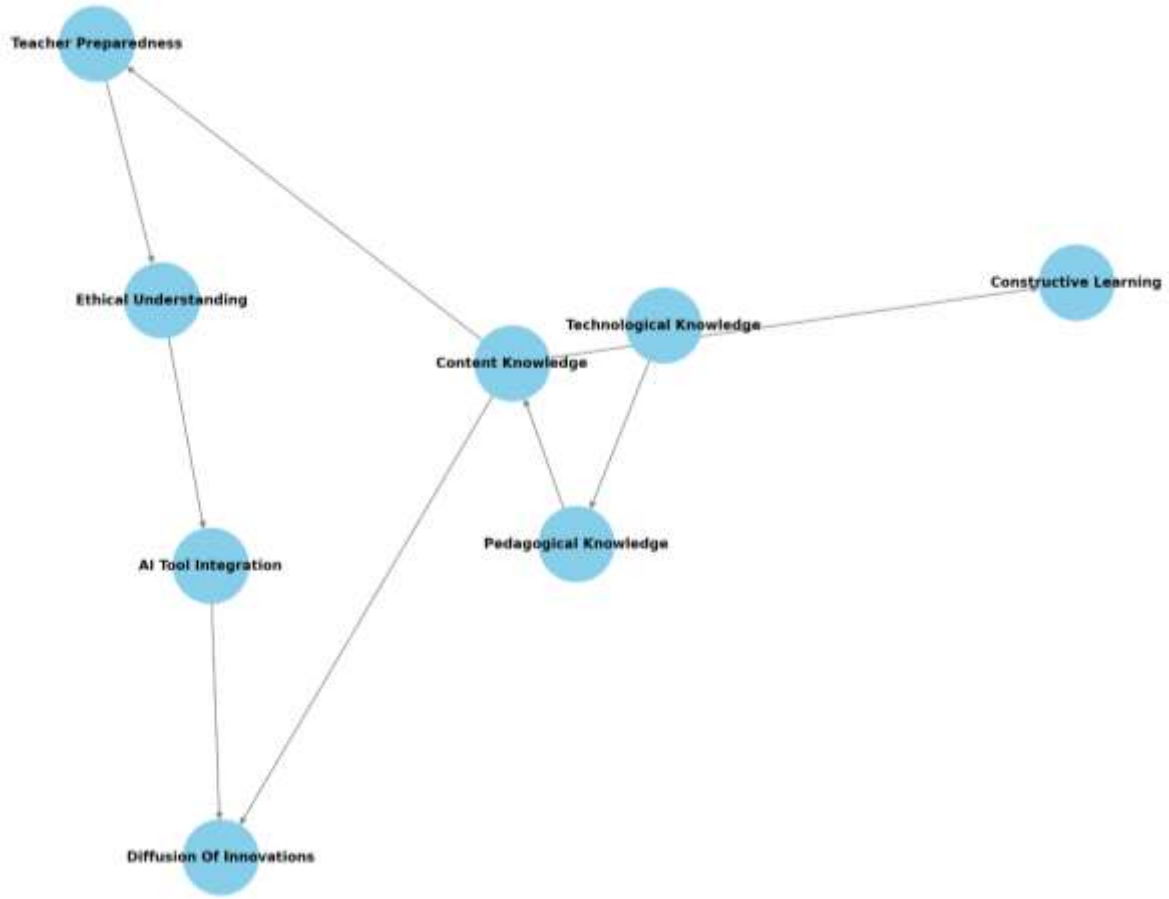

Figure 1. Theoretical Framework for Teacher Preparedness in AI-Integrated Classrooms

Previous studies from countries leading in AI education integration, such as Singapore and Finland, provide valuable insights. These nations have invested heavily in teacher training, resource allocation, and research partnerships to support AI adoption in schools (Rigley et al., 2024). Finland's teacher education programs,

emphasized both technical and ethical dimensions of AI, equipping educators with a comprehensive understanding of its applications. Such initiatives serve as models for other countries aiming to scale AI integration in education.

Method

This study employed a quantitative research design to explore the relationship between teachers' technological literacy, professional development programs, and their ethical considerations in effectively integrating AI tools in classrooms. Conducted in Punjab, Pakistan, the study targeted 210 teachers from nine schools, encompassing private institutions and grade levels from 1 to 10. A cross-sectional survey design was adopted, enabling data collection at a single point in time to assess these relationships. The sampling strategy used was stratified random sampling, ensuring a representative sample across diverse districts, school types, and grade levels. Data were collected through a structured questionnaire, developed using validated instruments from prior studies and adapted to suit the local context. The questionnaire included sections measuring technological literacy, professional development experiences, awareness of ethical considerations, and the effective implementation of AI tools. Responses were captured on a 5-point Likert scale, with sample items assessing AI-related competencies, training participation, understanding of data privacy and bias, and the practical use of AI tools in instructional and administrative tasks. The questionnaire underwent pilot testing with 20 teachers, achieving a Cronbach's alpha of 0.85, demonstrating high reliability. Permission for data collection was obtained from school administrations and educational authorities, ensuring ethical considerations such as informed consent, participant confidentiality, and anonymity. Surveys were administered electronically via Google Forms, supplemented by physical distribution in schools lacking digital access. Teachers were provided with two weeks to complete the survey, with reminders sent to enhance response rates.

Data analysis was performed using SPSS, incorporating both descriptive and inferential statistical techniques. Descriptive statistics summarized participant demographics and response patterns, while inferential analyses tested the study's hypotheses. Pearson correlation analysis examined the relationship between technological literacy and effective AI implementation, a paired-sample t-test assessed the impact of professional development on teacher preparedness and confidence, and multiple regression analysis determined the influence of ethical considerations on equitable AI use. All tests were conducted at a 95% confidence level ($p < 0.05$). The study was carried out over four months. During the first month, the questionnaire was developed, pilot tested, and finalized. Data collection was completed in the second month, followed by data entry, cleaning, and analysis in the third month. The final month focused on interpreting the results and report writing. This methodological approach provided a comprehensive understanding of the factors influencing teachers' effective adoption of AI tools in the context of Punjab's schools.

Results

The reliability analysis of the questionnaire, as shown in Table 1, demonstrated strong internal consistency across all constructs. The Cronbach's Alpha values for the individual sections Technological Literacy (0.85), Professional Development (0.86), Ethical Considerations (0.82), Access to Technology (0.79), and Effective

Implementation of AI Tools in Classrooms (0.84) are all above the commonly accepted threshold of 0.70, indicating reliable measurement scales. The overall Cronbach's Alpha for the entire questionnaire is 0.88, signifying high reliability and consistency of the instrument as a whole. These results suggest that the questionnaire is well-suited for assessing the study variables with confidence in the consistency of the responses.

Table 1. Reliability Analysis of Questionnaire

Questionnaire	Cronbach's Alpha
Technological Literacy	0.85
Professional Development	0.86
Ethical Considerations	0.82
Access to Technology	0.79
Effective Implementation of AI Tools in Classrooms	0.84
Overall	0.88

Table 2 presented the demographic statistics of the study participants. Among the 210 teachers surveyed, 61.9% were female, while 38.1% were male. The majority of participants (44.8%) were aged 20–29, followed by 33.8% aged 30–39, 13.3% aged 40–49, and 8.1% aged 50 and above, with a mean age category of 1.85 (SD = 0.941). Regarding grade levels taught, 61.9% of the teachers worked at the primary level (Grades 1–5), 32.9% at the middle level (Grades 6–8), and only 5.2% at the secondary level (Grades 9–10), with a mean grade level of 1.43 (SD = 0.593). Subject specialization showed that 71.9% of teachers taught Mathematics, 11.9% taught Science, and 16.2% taught Languages, with a mean subject specialization category of 1.44 (SD = 0.757). In terms of teaching experience, the largest group (58.1%) had 6–10 years of experience, followed by 19.0% with 1–5 years, 12.4% with over 15 years, and 10.5% with 10–15 years, with a mean experience level of 2.16 (SD = 0.876). These statistics reflected a diverse participant group in terms of gender, age, grade level taught, subject specialization, and teaching experience.

Table 2. Participant Demographic Statistics

Variables	Options	F	(%)	M	SD
Gender	Male	80	38.1	1.62	0.487
	Female	130	61.9		
	Total	210	100.0		
Age	20-29	94	44.8	1.85	0.941
	30-39	71	33.8		
	40-49	28	13.3		
	50Plus	17	8.1		
	Total	210	100.0		
Grade Level Taught	Primary (1–5)	130	61.9	1.43	0.593
	Middle (6–8)	69	32.9		
	Secondary (9–10)	11	5.2		
	Total	210	100.0		

Variables	Options	F	(%)	M	SD
Subject Specialization	Mathematics	151	71.9	1.44	0.757
	Science	25	11.9		
	Languages	34	16.2		
	Total	210	100.0		
Teaching Experience	1-5 years	40	19.0	2.16	0.876
	6-10 years	122	58.1		
	10-15 years	22	10.5		
	15 above	26	12.4		
	Total	210	100.0		

Table 3 presented the itemized and overall mean scores, standard deviations, and statistical test results for teachers' responses across the study variables, aligned with the four hypotheses. For H1, the analysis of Technological Literacy items (TL1-TL5) revealed a high overall mean score (M = 19.95, SD = 2.93) with significant results (p = 0.000, t = 5.147). This indicates that teachers with higher levels of technological literacy are indeed more likely to effectively implement AI tools, supporting the hypothesis. For H2, Professional Development (PD1-PD5) also yielded a strong overall mean score (M = 19.40, SD = 2.55) with significant results (p = 0.000, t = 7.627). These findings confirm that participation in professional development programs significantly improves teachers' preparedness and confidence in using AI technologies, thereby supporting effective implementation. Regarding H3, Ethical Considerations (EC1-EC5) had an overall mean score of 18.57 (SD = 2.71). Although the mean score was moderately high, the results were not statistically significant (p = 0.105, t = 1.621), suggesting that while understanding ethical considerations may influence equity and inclusivity in AI tool use, the relationship was not strongly evident in this sample. For H4, Access to Technology (AT1-AT5) displayed an overall mean score of 17.58 (SD = 2.75), with significant results (p = 0.001, t = 3.429). This supports the hypothesis that greater access to technology positively correlates with the effective implementation of AI tools in classrooms. Finally, the dependent variable, Effective Implementation of AI Tools in Classrooms (EIATC1-EIATC5), had an overall mean score of 15.73 (SD = 3.55) and was highly significant (p = 0.000, t = 28.363), reinforcing the central importance of these factors in AI integration. These findings collectively validate three of the four hypotheses (H1, H2, and H4) and provide partial support for H3.

Table 3. Each Item and Overall Mean Scores and Standard Deviation, P, t Values of Schools Teachers' Responses

Variables		N	M ± SD	Overall M ± SD	p	t
Technological Literacy	TL1	210	4.42 ± 0.824			
	TL2	210	3.94 ± 0.642			
	TL3	210	3.86 ± 0.840			
	TL4	210	3.98 ± 0.911			
	5L5	210	3.95 ± 0.732	19.95 ± 2.93	0.000	5.147
Professional Development	PD1	210	4.01 ± 0.704			
	PD2	210	3.93 ± 0.651			

Variables		N	M ± SD	Overall M ± SD	p	t
	PD3	210	3.82 ± 0.674			
	PD4	210	3.87 ± 0.576			
	PD5	210	3.76 ± 0.750	19.40 ± 2.55	0.000	7.627
Ethical Considerations	EC1	210	3.71 ± 0.718			
	EC2	210	3.58 ± 0.806			
	EC3	210	3.61 ± 0.773			
	EC4	210	3.83 ± 0.671			
	EC5	210	3.84 ± 0.650	18.57 ± 2.71	0.105	1.621
Access to Technology	AT1	210	3.83 ± 0.578			
	AT2	210	3.53 ± 0.891			
	AT3	210	3.77 ± 0.743			
	AT4	210	3.74 ± 0.778			
	AT4	210	2.70 ± 0.832	17.58 ± 2.75	0.001	3.429
Effective Implementation of AI Tools in Classrooms	EIATC1	210	3.38 ± 0.985			
	EIATC2	210	2.97 ± 0.860			
	EIATC3	210	3.01 ± 0.901			
	EIATC4	210	3.34 ± 0.902			
	EIATC5	210	3.04 ± 0.966	15.73 ± 3.55	0.000	28.363

Figure 2 depicts the relationship between various independent variables (Technological Literacy, Professional Development, Ethical Considerations, and Access to Technology) and the dependent variable (Effective Implementation of AI Tools in Classrooms) based on their mean scores.

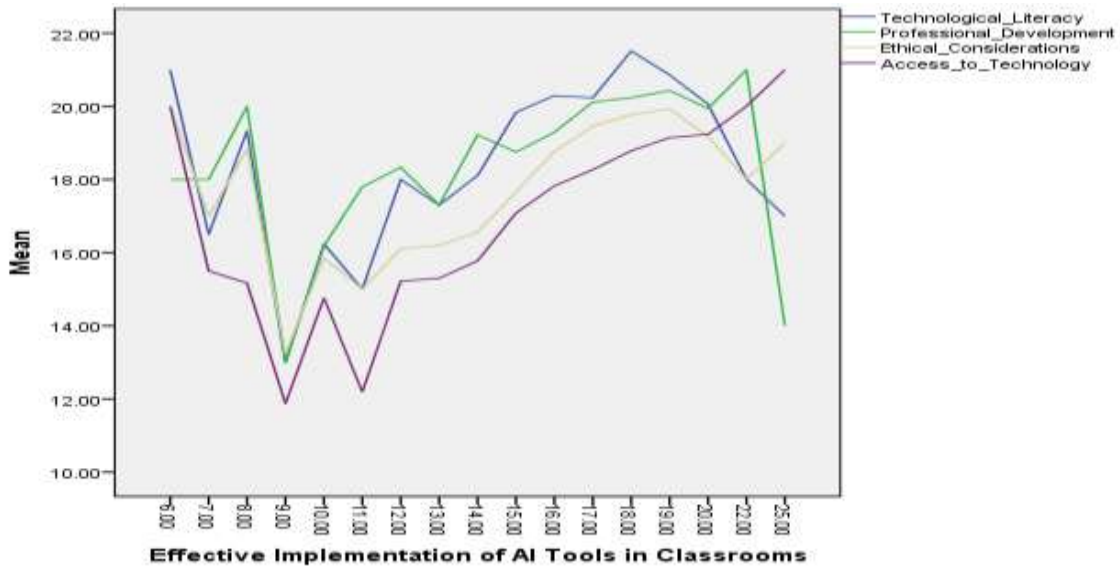

Figure 2. Depicts the Relationship between IV & DV

The trends indicate that Technological Literacy and Professional Development exhibit higher mean values,

suggesting that these factors are strongly associated with the effective use of AI tools in classrooms. Meanwhile, Ethical Considerations and Access to Technology show slightly lower, more variable trends, though still positively correlated with effective AI implementation. The dips in the graph may reflect areas where certain conditions (e.g., lower access to technology or less emphasis on ethical considerations) negatively impact implementation. The overall rising trends across most variables toward higher effective AI implementation underscore the importance of these factors, particularly technological literacy and professional development, in enhancing teachers' ability to use AI tools successfully in educational settings.

Table 4 presents the Pearson correlation coefficients among the variables, highlighted their relationships and statistical significance.

Table 4. Correlation among Each Variables

Correlations		TL	PD	EC	AC	EIATC
Technological Literacy	Pearson Correlation	1				
	Sig. (2-tailed)					
	N	210				
Professional Development	Pearson Correlation	.795**	1			
	Sig. (2-tailed)	.000				
	N	210	210			
Ethical Considerations	Pearson Correlation	.691**	.684**	1		
	Sig. (2-tailed)	.000	.000			
	N	210	210	210		
Access to Technology	Pearson Correlation	.656**	.607**	.772**	1	
	Sig. (2-tailed)	.000	.000	.000		
	N	210	210	210	210	
Effective Implementation of AI Tools in Classrooms	Pearson Correlation	.507**	.441**	.486**	.616**	1
	Sig. (2-tailed)	.000	.000	.000	.000	
	N	210	210	210	210	210

**. Correlation is significant at the 0.01 level (2-tailed).

Technological Literacy (TL) demonstrates a strong positive correlation with Professional Development (PD) ($r = .795$, $p < .01$) and moderately strong correlations with Ethical Considerations (EC) ($r = .691$, $p < .01$) and Access to Technology (AC) ($r = .656$, $p < .01$). Professional Development (PD) is also strongly correlated with Ethical Considerations (EC) ($r = .684$, $p < .01$) and moderately with Access to Technology (AC) ($r = .607$, $p < .01$). In terms of the dependent variable, Effective Implementation of AI Tools in Classrooms (EIATC), it has a moderate positive correlation with Technological Literacy ($r = .507$, $p < .01$), Professional Development ($r = .441$, $p < .01$), and Ethical Considerations ($r = .486$, $p < .01$), and a relatively stronger correlation with Access to Technology ($r = .616$, $p < .01$). These results indicate that all independent variables are significantly associated with the effective implementation of AI tools, with Access to Technology having the strongest influence. Overall, the correlations suggest that higher levels of technological literacy, participation in professional development, understanding of

ethical considerations, and access to technology positively contribute to the successful implementation of AI tools in classrooms.

Discussion

The findings of this study provided critical insights into the factors influencing the effective implementation of AI tools in classrooms, specifically focusing on teachers' technological literacy, participation in professional development programs, understanding of ethical considerations, and access to technology. This discussion evaluated the results in light of the study's hypotheses, aligns them with existing literature, and explored their implications for educators and policymakers.

The results revealed a significant positive correlation between teachers' technological literacy and their ability to effectively implement AI tools in classrooms ($r = .507$, $p < .01$). This finding supports H1 and aligns with prior studies emphasizing the critical role of technological proficiency in adopting and integrating educational technologies (Nurhidayat et al., 2024; Theodorio, 2024). Technological literacy equips teachers with the skills and confidence to use AI tools for instructional and administrative purposes, enabling them to harness the full potential of these innovations. The high mean scores for technological literacy items ($M = 19.95$, $SD = 2.93$) suggested that teachers who are technologically literate are more adept at tasks such as lesson planning, data analysis, and personalized feedback through AI tools. These results are consistent with the TPACK Framework, which underscores the importance of combining technological, pedagogical, and content knowledge for effective teaching (Li & Li, 2024; Luo & Zou, 2024). However, the moderate correlation value indicates room for improvement, particularly in providing teachers with hands on training to enhance their practical use of AI technologies. This finding underscores the need for schools and training institutions to emphasize AI-specific technological literacy in teacher development programs.

The results also confirmed H2, indicated that participation in professional development programs significantly improves teachers' preparedness and confidence in using AI tools ($r = .441$, $p < .01$). Teachers who attended such programs demonstrated higher effectiveness in integrating AI tools ($M = 19.40$, $SD = 2.55$, $p < .01$), reinforcing the importance of continuous training. This finding is consistent with studies by Liu et al. (2024) and Chiu et al. (2024), which highlighted the transformative impact of professional development on educators' ability to navigate complex technologies. Professional development programs offer opportunities for experiential learning, enabling teachers to familiarize themselves with AI tools in real-world contexts. The relatively moderate correlation suggested that the quality and accessibility of professional development programs vary across schools (Fütterer et al., 2024; Richter & Richter, 2024). Some teachers may lack access to well-structured training, especially in under-resourced schools. This disparity highlighted the need for equitable distribution of professional development opportunities, ensuring that all teachers, regardless of their school's resources, can benefit from AI training programs.

Although H3 was partially supported, the correlation between ethical considerations and the effective implementation of AI tools was moderate ($r = .486$, $p < .01$) and not statistically significant in some analyses (p

= .105). This result suggested that while teachers' understanding of ethical considerations, such as data privacy and algorithmic bias, is important, it is not yet a strong driver of AI integration in classrooms. The overall mean score for ethical considerations (M = 18.57, SD = 2.71) indicated moderate awareness, which is consistent with findings from Del Becaro (2025) that highlighted gaps in teachers' understanding of ethical AI use. One possible explanation for this result is the limited inclusion of ethical topics in professional development programs (Asad & Ajaz, 2024; Krishnan et al., 2024). Teachers may receive training focused on technical skills but lack exposure to the ethical implications of AI tools. This finding underscores the importance of integrating ethical literacy into teacher training programs, as highlighted by Gustian et al. (2024). Schools and policymakers should prioritize ethical education to ensure that teachers can critically evaluate AI tools and use them in ways that promote equity and inclusivity.

The study found that access to technology had the strongest correlation with the effective implementation of AI tools ($r = .616$, $p < .01$), supporting H4. Teachers with greater access to AI tools and infrastructure reported significantly higher effectiveness in using these tools ($M = 17.58$, $SD = 2.75$, $p < .01$). This finding aligns with research by Kelso (2024), which emphasized that technological infrastructure is a prerequisite for successful AI integration in education. The significant influence of access to technology highlighted the challenges faced by under-resourced schools, where limited infrastructure hinders teachers' ability to use AI tools effectively. These disparities exacerbate existing inequities in education, as schools with better resources are more likely to leverage AI technologies to improve learning outcomes by Tang et al. (2024). Through Mwangi (2024) Policymakers must addressed these disparities by investing in technology infrastructure, particularly in rural and low-income schools. This finding also underscored the importance of providing teachers with not only access to technology but also ongoing support to troubleshoot technical issues and optimize AI used (Abulibdeh et al., 2024; Murtaza et al., 2024).

The dependent variable effective implementation of AI tools, was significantly correlated with all independent variables, indicated a multifaceted relationship. The highest correlation was observed with access to technology ($r = .616$), followed by technological literacy ($r = .507$), ethical considerations ($r = .486$), and professional development ($r = .441$). These results highlighted that the successful integration of AI tools in classrooms depends on a combination of factors, rather than any single determinant. The relatively lower correlation values for professional development and ethical considerations suggested that these areas require further attention. For instance, professional development programs should focused on practical, hands on training while also incorporating modules on ethical considerations.

Similarly, improving teachers' access to AI tools should be accompanied by training on how to use these tools effectively and responsibly. For instance, professional development programs often serve as a catalyst for improving technological literacy and raising awareness of ethical considerations. Similarly, access to technology enables teachers to apply what they learn in training programs, reinforcing their confidence and skills. These findings underscored the need for a holistic approach to AI integration in education. Isolated interventions may have limited impact if not accompanied by complementary efforts to address other factors. As Hall (2024) suggested a systems-level perspective is crucial for creating sustainable change, involving collaboration among

educators, policymakers, technology developers, and researchers.

Conclusion

This study contributed to the growing body of research on AI integration in education by identifying key factors that influence teachers' ability to use AI tools effectively. Technological literacy, professional development, ethical considerations, and access to technology all play significant roles, with access to technology emerging as the strongest predictor. These findings underscored the need for a holistic, equity-focused approach to AI integration, addressing both technical and ethical dimensions while prioritizing infrastructure and training. By investing in these areas, educational institutions can empower teachers to harness the potential of AI, ultimately enhancing teaching and learning outcomes.

Based on the findings, it is recommended that educational institutions prioritize comprehensive teacher training programs that address both technical and ethical dimensions of AI integration, ensuring that educators are well-prepared to apply AI tools in practical classroom settings. Investments should be made to improve infrastructure, particularly in under-resourced schools, by providing reliable access to technology, technical support, and maintenance. Professional development initiatives should incorporate hands-on experiences, peer collaboration, and mentorship to foster ongoing learning and confidence among teachers. Additionally, clear guidelines and resources must be developed to help educators navigate ethical challenges such as data privacy and algorithmic bias, while advocating for the ethical design of AI tools by developers. A holistic and equity-focused approach is essential to ensure that the benefits of AI are accessible to all educators and students, promoting innovation and inclusivity across diverse educational contexts.

Implications for Practice

The findings of this study suggested several practical implications for the effective integration of AI tools in education. Training programs for teachers should focus on both technical and ethical dimensions of AI use, ensuring that educators are equipped with the skills and knowledge to apply AI tools effectively in practical classroom settings. Incorporating peer collaboration and mentorship into these training initiatives can further enhance their impact by fostering shared learning and ongoing support among educators. Moreover, equitable access to technology must be prioritized, especially in under-resourced schools where disparities in infrastructure can hinder the adoption of AI tools. Investments in infrastructure should extend beyond the provision of hardware to include comprehensive technical support and maintenance, ensuring sustainable use of AI technologies. Addressing ethical concerns is another critical area for improvement. Teachers require greater support in navigating ethical challenges such as data privacy, algorithmic bias, and equitable AI use. This can be achieved by providing clear guidelines, practical tools, and transparent AI systems, as well as advocating for the ethical design and deployment of AI tools by developers. Lastly, a holistic approach to AI integration is essential, considering the interplay between technological, pedagogical, and ethical factors. Efforts must focus on promoting equity and inclusivity, ensuring that AI benefits all students and supports broader educational goals. By addressing these areas, educational institutions can empower teachers to leverage AI tools effectively and responsibly.

Limitations and Future Research

This study has several limitations that should be addressed in future research. First, the reliance on self reported data may introduce bias, as teachers' perceptions may not fully reflect their actual practices. Future studies could incorporate classroom observations or student feedback to triangulate findings. Second, the study's focus on schools in Punjab, Pakistan, limits its generalizability to other contexts. Comparative studies across regions or countries could provide broader insights into the factors influencing AI integration. Furthermore, while this study focused on teacher-related variables, other factors, such as school leadership, policy support, and student engagement, may also play critical roles. Exploring these dimensions could provide a more comprehensive understanding of the challenges and opportunities associated with AI in education.

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