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THE IMPACT OF ARTIFICIAL INTELLIGENCE ON EDUCATION: A QUANTITATIVE AND SURVEY-BASED INVESTIGATION

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Abstract

AI is changing education all over the world pretty fast. It brings some good chances for students and teachers, but also a lot of problems. This study looks at how AI tools affect learning for students, how much work teachers have to do, and if schools run better with them. It's mostly for secondary and college levels. The research uses a mix of methods, like numbers and surveys from 450 people in five schools in Punjab, Pakistan. They collected data on things like intelligent tutoring systems or adaptive platforms that change to fit the student. Automated grading and AI for delivering content are part of it too. These tools are shifting old ways of teaching in big ways. From the surveys, about 74 percent of students said they understood stuff better and did better in school after using AI regularly. Teachers, around 69 percent, felt their paperwork and admin stuff went down a bit. It seems like the stats back this up with tests like t-tests and chi-square, plus some regression models. They show real links between using AI and higher GPAs for students, more engagement, and teachers feeling happier. That part stands out, I guess. But there are also issues. Not enough digital setups in some places, no training on how to use AI, and fairness problems—especially in rural areas or for poorer families. Some people might think it's all great, but others see these barriers clearly. The study suggests ways to fix things for policymakers, school leaders, curriculum planners, and teacher training programs. It adds to what we know about tech in education. In South Asia, AI needs to fit the local context and consider ethics. This gets a bit messy because not everything is solved yet. Equity concerns linger without full answers.

Keywords*:* *Adaptive Learning Systems, AI-Assisted Learning, Artificial Intelligence in Education, Digital Transformation, Educational Technology, Intelligent Tutoring Systems, Pakistan Education, Quantitative Research, Student Outcomes, Teacher Workload.*

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1. Introduction

There are major changes to education coming because of AI. I mean since around a decade, advancements in machine learning and NLP are resulting in personalized learning tools that can provide immediate feedback, detect future student performance, and adaptive learning platforms that adapt lessons to an individual's learning level, as well as grammar and plagiarism checking applications. Research is showing enormous progress in AI applications in education from studies that date back to 2016 such as by Luckin and her colleagues or the review by Zawacki-Richter 2019. The global market in AI in education is burgeoning. It stood at approximately $1. 8 billion in 2021, according to HolonIQ, and projected to exceed $30 billion by 2032. Governments and leading corporations are funding these EdTech companies and it is also a component in programs aimed at improving education globally under the United Nation's education agenda. Several countries such as Finland, the US, South Korea, and China have begun adopting AI policy at various stages in their educational systems.

Developed countries, unfortunately, can afford such luxuries. Developing countries too have begun considering AI in their education system but its prevalence can be said to be limited. In the case of Pakistan, the country is facing several challenges in its education system despite an increase in enrollment rates and improved literacy. According to a report from the government, in 2022, the country faces over-population in classrooms, teacher shortages particularly in rural areas, high dropout rates and educational inequalities.

AI may be used to improve a situation such as this but adoption of AI in Pakistan's education sector is very limited. Global research on AI in education largely focuses on Developed countries and lacks sufficient attention in the South Asian context and particularly in Pakistan. Existing research studies on AI and its effects on education systems are limited and lack broad scope or in-depth analysis. The current study aims to contribute to filling these gaps by examining the adoption and impact of AI-tools by collecting empirical data by surveying students and teachers at five schools in Punjab and utilizing structured questions to gather relevant data.

The results obtained will assist in proposing policy interventions suited to the socio-economic and institutional conditions prevalent in Pakistan. I'm pretty new at all of this and so may not have covered everything here, but this feels like a solid starting point.

1.1. Background and Context

AI ideas in education start much earlier. When the early pioneers were exploring human cognition and beginning to build educational computing software in the 70s and 80s, John Anderson at Carnegie Mellon was one among them working to create what he called "intelligent tutoring systems". The research here began with understanding how people learn and how they think about learning. They hoped to program computers that would serve the role of a private tutor that provides customized Feedback for the learner and guides them step by step.

"Early models even though they are nowhere comparable to our current technology represent the groundwork that still stands tall today like personalization/adaptation, interactivity and evidence based approaches", says Dr Lalan. It looks like the pace has accelerated exponentially in the past few years mainly because of availability of vast data generated by schools coupled with advances in the cloud and deep learning approaches allowing AI to undertake much sophisticated applications. Khan Academy's Khanmigo, Duolingo's tutor, Carnegie Learning's MATHia or Google's tools- they all move beyond simple rule-based systems to building sophisticated probabilistic models of learners, taking the nuances of emotions into account, employing reinforcement learning strategies. "Number of AI in Education research papers have jumped 350% from 2010-2023", he says.

But "Concerns have been raised by researchers regarding the problem of inbuilt bias of the algorithms, data privacy of learners" as well as how AI would commoditize and displace teachers in relationships with learners. This is especially concerning in developing countries with weak regulations on data collection and where existing inequalities could be amplified. "The key here for the research agenda on AI and education should be to balance the various aspects, going beyond mere product performance to take ethical considerations and systemic implications into account," he concludes. It seems personalization will continue to play a significant role.

1.2. Research Objective

The research purpose of this project, in short, can be summarized in the following statement. To determine the quantitative impact of AI - enabled learning technology on the performance of secondary and higher-level students, load of teachers, and productivity of selected institutions at the secondary and higher levels in Punjab Province of Pakistan and to identify limiting factors as well as influencing factors on its use in a successful way.

2. Literature Review

2.1. AI Technologies in Educational Settings

In education the domain of Artificial Intelligence in Education (AIED) is growing constantly. According to Holmes, et al. (2019) and Zawacki-Richter et al. (2019) , scholars have identified six types of AIEd applications, including intelligent tutoring systems (ITS), adaptive learning systems, AI assessment and evaluation systems, conversational systems and chatbots, AI-enabled learning analytics systems, and AI-based content creation or content curation systems.

Among these, the application area with the greatest amount of research is intelligent tutoring systems. For instance, an analysis of 107 experiments by Ma et al. (2014) has estimated that the effect of using ITS was approximately 0.66 standard deviations higher than traditional methods of teaching. An analysis by Kulik and Fletcher (2016) of 50 experiments in a more or less similar range concluded that the effect ranged from 0.3 to 0.6 standard deviations and this was more substantial for STEM subjects and for younger learners. Automated learning platform applications – learning environments that dynamically change the level of content, order of topics, or the methods of content presentation in accordance with learning progress of learners – is another rapidly developing research area. For example, a randomized control study in 147 high schools with Cognitive Tutor Algebra I showed that students utilizing the AI software performed better than the control group in the end; and even better when low-income students utilize it, thus questioning the argument that these benefits would affect only privileged students. Automated writing evaluators or, more broadly speaking, AI assessment and evaluation systems represents the third research cluster that has experienced tremendous development. In an early article, Dikli (2006) reviewed the literature on automated essay scoring (AES), noting its potential to offer objective, instant and scalable assessments of learning. More recent studies in this field focused on AES systems built with neural networks which can evaluate writing surface-level attributes such as surface text, argument structure, and stylistic features (Ke & Ng, 2019), however authors noted major drawbacks such as vulnerability to the system-gaming techniques, insensitivity to the non-standard writing (Cressy, 2017).

2.2. Impact on Student Learning Outcomes

Most studies on how AI affects student achievement tend to show positive results. But those findings come with important caveats and limitations. The evidence is encouraging, though not without its complications. In particular, according to a systematic meta-analysis by Steenbergen-Hu & Cooper (2013) that involved 26 K-12 ITS interventions, there was an average positive effect on learning with an effect size of d = 0.42. In turn, another meta-analysis conducted by Steenbergen-Hu & Cooper (2013) for the higher education sector involved 65 ITS-related studies, demonstrating a similar positive outcome of d = 0.35, although, apparently, the effect might be more pronounced among K-12 learners.

Longitudinal studies have started exploring not only short-term learning advantages but also their long-lasting impacts and sustainability. Thus, according to Roschelle et al. (2016), who carried out a longitudinal study of mathematics ITS implementation among middle schoolers, students demonstrated statistically significant improvement in standardized math test performance two and three years after receiving initial training. On the other hand, some researchers note that AI technology benefits are moderated by student motivational and self-regulation abilities, which indicates that appropriate pedagogy plays a crucial role in learning outcomes (Huang et al., 2020).However, research conducted within the context of low- and middle-income countries, although limited compared to that from high-income settings, may be especially useful to our current project. For example, studies such as those of Bowen et al. (2014), which assessed hybrid teaching using AI in Colombian institutions, discovered a significant yet small improvement in the success rate of students enrolled in AI-infused courses. Similarly, Jita and Munje (2021) reported the beneficial impact of mobile learning applications infused with AI in rural schools in South Africa.

2.3. Impact on Teacher Workload and Professional Practice

Apart from the impacts on the learners, other studies have investigated the effect of AI on the professional life of teachers. The reduction of administrative work by AI and its ability to enable teachers to engage in more complex teaching practices have been identified as key themes. According to Luckin et al. (2016), the use of AI would be considered an "empowerment tool" for teachers, as it will automate processes like attendance taking, marking assignments, and reporting progress to allow teachers to access more data about learners.The literature supporting this perspective is inconclusive. The survey-based studies conducted on AI adoption reveal that time devoted to routine administrative activities is lower among teachers who use AI technology (Chai et al., 2021). On the other hand, qualitative evidence shows that time savings through automation may be partially or fully neutralized by time losses due to learning, troubleshooting, and integrating new technologies in instructional processes, commonly referred to as "technoference" (McDaniel & Radesky, 2018). Furthermore, AI may become burdensome to use in the environments with inadequate technology infrastructure since teachers are concerned about the lack of adaptation of tools to the linguistic and cultural context. There is also a body of literature dedicated to studying the effect of AI on teachers' professional identity, autonomy, and job satisfaction. Thus, Selwyn (2019) raised the issue that increasing presence of AI in assessment and planning would result in decreased sense of agency and devaluation of human pedagogical knowledge. However, Voogt et al. (2015) found that professional satisfaction of teachers increased when AI helped them to get the data regarding individual students.

2.4. Barriers to AI Adoption in Education

Various barriers that impede the adoption of artificial intelligence in education have been found throughout the literature. The technological barriers are related to the fact that institutions may be lacking an appropriate infrastructure, devices and connectivity, or face compatibility problems when trying to integrate AI platforms within their existing structures (Ertmer et al., 2012). This is especially true for developing countries, which have not yet invested enough in infrastructure development.The literature has shown that the adoption of artificial intelligence can be affected by various pedagogical and professional development barriers as well. For example, teachers may lack sufficient experience working with AI technology, know nothing about evidence-based strategies of integrating it into learning activities, or fail to create appropriate professional learning communities to facilitate this process (Chai et al., 2021).

Equity-based barriers require special focus. Several studies show that AI tools and their proper usage have been largely limited to students and schools coming from more affluent social strata (Warschauer & Matuchniak, 2010). The real risk is that uneven access to AI tools could widen gaps in learning. Schools need to pair new technology with clear plans for fairness. Without that, students who already have less might fall even further behind. But it doesn't have to be that way. When teachers get proper training and resources are shared evenly, AI can actually help level the playing field. Still, this won't happen by accident — it takes deliberate effort to make sure every student benefit. This is particularly relevant for Pakistan due to its uneven distribution of educational resources between rural and urban communities and public-private schooling sectors.

3. Methodology

3.1. Research Design

A quantitative cross-sectional survey design with aspects of comparative research was used in this research. Quantitative research method was applied as it helps measure systematically the extent and level of penetration of the use of AI tools and test statistically the existence of relationships and impacts between the use of AI and learning outcomes, as well as provides generalizable conclusions about the phenomenon. The chosen research design allows making a comparison of several institutions at once and collecting cross-sectional data in terms of time and available resources. Two main sources of data were utilized in the course of the study, namely, (1) structured survey questionnaire for teachers and students and (2) institutional documents, such as GPA statistics and technological equipment inventory from the involved schools and universities. Thus, the triangulation method that uses both self-report data and objective documents was implemented here.

3.2. Sample and Sampling Procedure

The sample was made up of students who were studying at grades 9 to 12 (Secondary Education Level) and years 1 to 4 (Higher Education Level), along with teaching faculty, of educational institutes situated in the Gujrat, Gujranwala, and Sialkot districts of Punjab Province, Pakistan. The five educational institutes which were purposefully selected for conducting the research comprised of two public secondary schools, one private secondary school, one public university, and one private university.

Sampling within each institution was done using the technique of stratified random sampling. Overall, 450 questionnaires were distributed; out of which 300 were given to the students while 150 were handed to the teachers. Out of these, 23 questionnaires were excluded due to incompleteness, leaving a sample size of 427 individuals consisting of 283 students and 144 teachers. The demographic data of the respondents is given in Table 1.

Table 1 Demographic Profile of Study Sample (N = 427)

Category	Subcategory	Frequency (n)	Percentage (%)
Gender	Male	241	56.4
	Female	186	43.6
Respondent Type	Students	283	66.3
	Teachers	144	33.7
Education Level	Secondary (Grades 9-12)	198	46.4
	Higher Education (UG)	229	53.6
Institution Type	Public	254	59.5
	Private	173	40.5
AI Tool Experience	Regular Users (≥3×/week)	187	43.8
	Occasional Users (1-2×/week)	134	31.4
	Rare/Non-Users (<1×/week)	106	24.8

3.3. Instrumentation

The main method of collecting data was the use of questionnaires that were drawn up based on existing scales that have been used and validated in the fields of educational technology and AIED. The questionnaire for students consisted of 42 questions divided into five sub-scales: (1) access to the AI tool and its frequency of use; (2) the effect on academic achievement; (3) engagement and motivation; (4) attitudes towards AI in education; and (5) barriers to the use of the AI tool. The questionnaire for teachers included 38 questions about: (1) their own experience in using AI tools professionally; (2) their workload; (3) the effect of AI on their teaching and student outcomes; (4) their professional development; and (5) institutional barriers.The survey questions were measured using either a 5-point Likert Scale (1= Strongly Disagree, 5=Strongly Agree) or frequency scales (1=Never, 5=Daily). Questionnaire development was started in English, and then professionally translated into Urdu language, followed by back translation to maintain semantic equivalence. Preliminary testing was done with a different group of 45 respondents, out of which 30 were students while 15 were teachers. Internal consistency was assessed with the help of Cronbach's alpha. Cronbach alpha values for all subscales were above 0.70 and ranged from 0.74 to 0.89.

3.4. Data Collection Procedure

The data collection process spanned duration of six weeks from February to March 2026. The questionnaires were distributed personally during classroom and staff meeting times, and a researcher or an assisting researcher was always there to help in answering any query. The institutional GPA records from the years 2024-2025 and 2025-2026 were retrieved from the academic registry offices of all the three institutions in the form of institutional agreements. Written informed consent forms were signed by all subjects before the start of the study, and students below 18 years of age provided their assent after obtaining permission from their parents.

3.5. Data Analysis Strategy

The quantitative data were analyzed using IBM SPSS Statistics Version 27. Data analysis had employed the following statistical methods: (1) Descriptive Statistics The study begin the analysis of the data by calculating the frequencies, percentages, and the mean and standard deviations for all of the collected data. These statistics describe the sample to the reader and reveal the incidence with which the AIs were incorporated in the classroom, their effects on attitudes toward the AIs and where and how they were employed. (2) inferential Statistics In order to determine the extent that AI had effected student performance, an Independent- Samples t-test was conducted and compared the score on standard achievement test for students using AIs and non-users of AI. Relationships between categorical variables (e.g., usage group versus classroom type) and continuous variable were analyzed using Chi-squares tests of independence and the Pearson product-moment coefficient of correlation respectively (3) Multi- linear Regression Analysis To determine whether AIs could be predictive of student success (e. g. (a) GPA change & (b)) teachers job satisfaction an application of the multiple- linear regression analysis was applied.

All of the following tests had an application of. 05 on the significance level (alpha); the significance level for calculating a measures effect size: Cohen's, Crammer's VandR2.

4. Results and Discussion

4.1. Prevalence and Nature of AI Tool Use

In terms of results of the survey, we note that the presence of AI tools within the target group of schools and institutions exist, however, the adoption of tools and their application vary depending on the level and nature of the institution, the roles and position of the respondents and geographic area. Our study on the respondents of the total 213 student respondents and 103 teachers' respondents we show that about75. 2% of all students surveyed, respectively, and about71. 5% of all teachers surveyed use AI-powered learning tools at least once per week this school year. Table 2 presents the frequency distribution of AI tool types used by students and teachers.

Table 2 Frequency of AI Tool Use by Type and Respondent Category

AI Tool Type	Students (n=283)	%	Teachers (n=144)	%
AI Writing Assistants (e.g., ChatGPT, Grammarly)	198	69.9	87	60.4

Adaptive Learning Platforms (e.g., Khan Academy AI)	156	55.1	61	42.4
AI-Powered Search & Research Tools	214	75.6	109	75.7
Automated Grading/Feedback Tools	67	23.7	98	68.1
AI-Based Translation Tools	172	60.8	76	52.8
Intelligent Tutoring Systems	89	31.4	44	30.6
AI Video/Content Generation Tools	143	50.5	52	36.1
Chatbot-Based Study Assistants	118	41.7	38	26.4

The most widely used tool category among the participants was AI-powered search and research tools, with 75.6% of students and 75.7% of teachers reporting using them regularly. Second-most popular were AI writing assistants used by 69.9% of students, while for teachers, it was automated grading and feedback tools used by 68.1% of educators. It is important to note that the lowest level of usage was demonstrated by intelligent tutoring systems – one of the most researched categories of AIED tools. Only 31.4% of students and 30.6% of teachers used intelligent tutoring systems on a regular basis. Respondents from private institutions used more AI tools across all tool categories compared to respondents from public institutions. 87.3% of private school and university students used AI tools at least once a week, compared to 65.8% of public institution students ($\chi^2 = 21.34$, df = 1, $p < .001$, Cramer's V = 0.27). The most noticeable differences could be observed for the usage of adaptive learning platforms and intelligent tutoring systems, with the former being utilized twice as much by private institution students, and the latter three times as often.

4.2. Impact on Student Academic Performance

Performance of students academically was done via self-rated GPA improvement and also via comparison of GPAs from institutional sources. In the case of students who reported themselves as frequent AI tool users (those who utilized AI tools three or more times each week, n=187), 74.2% (n=139) claimed to have noticed an improvement in their academic performance since being frequent users of AI tools. Eight percent (n=15) admitted to having a negative experience, while 17.8% (n=33) had not noted any difference. Institutional GPAs are given in Table 3.

Table 3 Comparative GPA Data: AI Users vs. Non-Users by Academic Year (Institutional Records)

Group	N	Pre-AI GPA (M ± SD)	Current GPA (M ± SD)	Change (Δ)	t-value	p value
Regular AI Users	187	2.81 ± 0.43	3.24 ± 0.39	+0.43	12.67	<.001
Occasional AI Users	134	2.79 ± 0.47	2.98 ± 0.44	+0.19	5.34	< .001
Rare/Non-Users	106	2.83 ± 0.44	2.86 ± 0.45	+0.03	0.79	.432
Full Sample	427	2.81 ± 0.44	3.06 ± 0.44	+0.25	10.23	< .001

The results from an independent samples t-test conducted to compare the GPAs between regular users of AI tools and infrequent/non-users of AI tools showed that there was a significant difference: $t(291) = 8.94$, $p < .001$, $d = 0.98$, where there was a large effect size. Regular AI users had a mean GPA of 3.24 (SD = 0.39) compared to rare/non-users who had a GPA of 2.86 (SD = 0.45). Significantly, before intervention GPA was not significantly different between the groups (t (291) = 0. 34, p =. 733). Further insight into the GPA predictors was found from a multiple linear regression: The total multiple linear regression with changes in GPA as dependent variable and frequency of use of AI tool, institution type, gender, academic level and existing academic level as predictors, revealed that together the variables predicted 41.

3% of the variation in changes in GPA ($R2 = 0. 413$, $F (5, 421) = 59. 2$, $p <. 001$). Frequency of AI tool usage ($\beta = 0.487$, $p < .001$) and institutional affiliation ($\beta = 0.213$, $p < .001$) were found to be the strongest predictors, while gender ($\beta = 0.038$, $p = .412$) did not emerge as a significant predictor.

4.3. Impact on Student Engagement and Motivation

However, besides academic outcomes, the study investigated the impact of AI on students' engagement and intrinsic motivation. As seen in Table 5, the differences in students' engagement were significant at $p<.001$ with a very large effect size ($d = 1.34$), t (291) = 10.38, where frequent users scored higher on the Likert scale (M = 3.89, SD = 0.67) than occasional and non-users (M = 2.97, SD = 0.71).

Table 4 Mean Engagement and Motivation Scores by AI Tool Use Frequency (1–5 Likert Scale)

Survey Item	Regular Users	Occasional Users	Rare/Non-Users	F-value	p-value
I find learning more interesting with AI tools	4.12 ± 0.61	3.74 ± 0.72	2.93 ± 0.84	78.4	< .001
AI tools help me stay focused during study	3.98 ± 0.64	3.52 ± 0.78	2.81 ± 0.90	67.2	< .001

I feel more confident in my studies with AI support	4.01 ± 0.59	3.61 ± 0.69	2.88 ± 0.83	72.8	< .001
AI tools help me understand difficult concepts	4.23 ± 0.55	3.87 ± 0.66	3.11 ± 0.79	82.1	< .001
Using AI motivates me to complete assignments	3.76 ± 0.72	3.44 ± 0.81	2.72 ± 0.91	54.6	< .001

Results of one-way ANOVA showed significant differences in all items of engagement and motivation based on frequency of AI tools use (all $p < .001$). Post-hoc Tukey test results proved the significance of differences between all group pairs in all items, thus demonstrating the existence of a dose-response relationship between frequency of AI tool usage and level of student engagement. Students who used the tools regularly had higher mean levels of engagement and motivation, than students who used them occasionally, and the latter had higher engagement levels, compared to those who seldom used the tools or never did. The item "AI tools assist me to comprehend difficult concepts" had the highest mean in the regular category (M = 4.23).

4.4. Impact on Teacher Workload and Professional Satisfaction

The data from teachers provided a slightly different perspective. Of those teachers who made use of AI technology on a regular basis in their profession, 68.9% (n = 71) felt they had less workload due to the technology. However, 42.7% (n = 44) felt they were initially working harder because of the amount of time needed to learn how to use the AI technology efficiently. The average scores of selected teacher workload and satisfaction scales are provided in Table 5.

Table 5 Teacher Perceptions of Workload and Professional Satisfaction (n = 144)

Survey Item	M	SD	Min	Max
AI tools have reduced my grading and assessment time	3.82	0.74	1	5
AI tools have reduced my administrative burden overall	3.61	0.81	1	5
Learning to use AI tools has required significant time investment	3.94	0.69	1	5
AI tools have improved my ability to personalize instruction	3.74	0.77	1	5
I feel more professionally satisfied since using AI tools	3.48	0.89	1	5

AI tools provide useful data about student learning	3.89	0.71	1	5
I am concerned AI will undermine my professional role	2.87	1.02	1	5
My institution provides adequate support for AI tool use	2.61	0.94	1	5

The statement "AI tools have useful information on student learning" was rated with the highest mean score by teachers (M = 3.89). In other words, teachers appreciate how AI can assist with learning analytics and data-based teaching. Moreover, the statement "It takes substantial time to learn how to work with AI tools" was highly endorsed (M = 3.94), supporting the finding regarding the learning curve mentioned above. Finally, it is important to note that the statement expressing concern about AI posing a challenge to professional role received low endorsement (M = 2.87).Pearson's correlation between the average use of AI tools and teachers' job satisfaction scores indicated a moderate positive correlation: r(142) = 0.41, p < .001. The link between job satisfaction and school sector also held up with teaching years and disciplines included as covariates in partial correlation: β= 0. 37, p < 0. 001. Job satisfaction was higher among private school teachers (M = 3.72, SD = 0. 81) than for teachers from public schools (M = 3. 29, SD = 0. 88), t (142) =3.17, p=. 002, d = 0. 52 (medium effect size).

4.5. Barriers to AI Adoption

The question concerning the barriers that exist that prevent the use of artificial intelligence tools effectively was posed to the respondents, and a variety of structural, educational, and personal obstacles were listed. These responses are presented in Table 6 below.

Table 6 Perceived Barriers to AI Tool Adoption (% Endorsing as "Major" or "Significant" Barrier)

Barrier	Students %	Teachers %	Combined %
Inadequate/unreliable internet connectivity	71.4	68.1	70.3
Insufficient device access (smartphones/computers)	64.3	52.1	59.7
Lack of training or guidance on AI tool use	58.7	74.3	64.2
AI tools not available in Urdu/Punjabi language	61.5	56.9	59.8
Concerns about academic dishonesty/cheating	43.1	79.2	56.2
Institutional policies restricting AI use	37.8	48.6	41.7

Concerns about data privacy and security	29.7	41.7	33.7
High cost of premium AI tool subscriptions	53.9	34.7	46.8
Insufficient institutional technical support	44.5	63.2	51.2

Insufficient internet connectivity was the most common barrier identified by students (71.4%) and teachers (68.1%) alike, matching with the reported lack of infrastructure in the government educational institutions of Punjab province in Pakistan (Government of Pakistan, 2022). Language barrier in terms of unavailability of AI technologies in Urdu or Punjabi was mentioned by 61.5% of the respondents amongst the students and 56.9% of those belonging to the teacher demographic. Academic dishonesty was identified by 79.2% of the teachers as a major or significant barrier, being the most endorsed item by the teachers compared to 43.1% endorses by the students. A chi-square analysis indicated that there were differences in the distribution of barriers endorsed by the participants from public and private institutions in a few items. Internet inadequacy was identified by 84.3% of the participants from public institutions compared to 50.3% from private institutions ($\chi^2 = 47.8$, df = 1, $p < .001$, Cramer's V = 0.33). This suggests the existence of infrastructure disparity between the two sectors. Academic dishonesty was not significantly different among institutional categories ($\chi^2 = 1.23$, df = 1, $p = .267$).

4.6. Attitudes toward AI in Education

In general, the attitude towards AI in education was moderately positive but with mixed opinions about particular aspects. Respondents' attitudes to AI in education were measured by means of a composite variable, with ten items included in the scale and an internal consistency value $\alpha = 0.82$. The mean of the variable was equal to 3.64 (SD = 0.71) on a 5-point Likert scale, implying a moderately positive attitude. Figure 1 (below) presents the results, according to which the difference between student attitude and teacher attitude towards AI is statistically significant: M = 3.79 (SD = 0.67) vs. M = 3.35 (SD = 0.73); $t(425) = 5.12$; $p < .001$; $d = 0.63$.

In relation to the students' sample, 81.3% concurred that "AI tools should be more accessible in Pakistani educational institutions," while 76.4% were of the opinion that "teachers need to be trained in the effective use of AI tools." In respect to the teacher sample, 83.3% concurred that "institutional policies on proper AI tool usage should be developed," and 77.1% of teachers agreed that "AI literacy should be included in teacher professional development."

5. Recommendations

5.1. For Educational Policymakers and Government Agencies

There are several implications of the findings of this study that can inform policymakers on what measures can be taken in order to ensure successful introduction of the technologies in question into Pakistani schools and universities. First of all, it is important to stress out that one of the largest barriers to effective use of AI for improving education in Pakistan is digital infrastructure deficiency in terms of connectivity and devices available to students. The Higher Education Commission of Pakistan and respective local authorities need to focus their efforts on development of digital infrastructure in public institutions.Another recommendation for the policymakers involves the creation of an overall strategy for using AI in Pakistan's education sector. In fact, there is already such a document created by the authorities (Government of Pakistan, 2022), but its effectiveness needs to be improved. This new strategy should take into account views of teachers and students from rural areas and disadvantaged families who will be disproportionately affected by potential negative effects (see Warschauer & Matuchniak, 2010; Government of Pakistan, 2022).Third, there is a need for the development of policy incentive frameworks aimed at encouraging the creation of educational tools in Urdu and Punjabi languages by AI developers. This is because the language barrier highlighted in this research study, which about 60 percent of the sample size considered as a major hurdle, is an inherent structural barrier to market mechanisms alone cannot be expected to overcome.

5.2. For School and University Administrators

On an institutional level, policy-making should be conducted, taking into account evidence-based criteria for appropriate and unacceptable uses of AI software that would help reconcile issues regarding maintaining academic integrity and at the same time recognize the pedagogical potential of AI technology in education. The result of the study that shows teachers' approval of clear institutional guidelines for AI use suggests high professional awareness of teachers towards such policy implementation. Such guidelines should identify acceptable and non-acceptable uses of AI in various types of assessments, clearly communicate guidelines to students and establish academic integrity procedures regarding AI without criminalizing the AI-assisted learning process.Professional development for teachers that could include AI literacy training, as well as learning ways to effectively incorporate AI tools into educational practice, should become a priority. As the results show, almost three-quarters of the respondents see a lack of training as a considerable obstacle, and job satisfaction is directly related to frequent use of AI tools. It indicates professional development that has the capacity to improve teachers' skills and ability to handle the AI based products may add value to both student and the teacher via higher level of work satisfaction of teacher. Some level of back up facilities must be available within institution for managing the unnecessary problems caused while use of new IT applications. That the item on institutional support, which received the lowest score of 2.61 out of 5, indicates the need for this suggestion. Technical assistance should be prompt, knowledge-based, and provided in the Urdu language.

5.3. For Curriculum Developers and Teacher Educators

The developers of curricula in schools and universities need to incorporate the acquisition of AI literacy, which includes the ability to critically comprehend, analyze, and utilize AI tools, into learning goals throughout various disciplines. The teaching of AI literacy should not be limited to computer science or technology-related subjects alone. It needs to be taught in subjects such as literacy, math, social sciences, and more, as artificial intelligence applies to all disciplines. Besides learning the use of AI tools, students must also develop an understanding of how to critically assess their results and identify their limitations and biases. The pre-service and in-service courses offered by teacher education institutions such as universities and teacher training colleges must undergo significant changes to ensure that AI literacy is included in the curriculum. Future teachers must be able to make informed decisions about which AI applications can be used for instruction and how those applications can be used in practice. In light of the rapid advancement of AI technology, teacher education institutions must also nurture future teachers' willingness to learn continuously and critically adapt to new technologies.

5.4. For Researchers

There are a number of areas in which future research on AI tools for learning should explore, based on the results of this study. There is need for longitudinal research that will enable identification of the impact of AI tools use over the course of more than one year of study. The value of experimental and quasi-experimental research designs that enable establishing causal relationship is critical as far as making empirical case for policies in education is concerned.

Further research should also investigate the pedagogic effects of using AI tools, i.e., what makes certain AI tool effective in some cases and not effective in others; when, for whom, and how AI tools promote learning. Research design that includes disaggregation of outcomes by student subgroups according to socio-economic background, presence or absence of disability, first-time college student or not, and urban or rural background, will be especially helpful in identifying equity considerations. Finally, qualitative and ethnographic research is required to complement quantifiable results from surveys and help uncover other, non-measurable ways in which using AI tools changes the educational process.

6. Conclusion

Despite this evidence of student academic success, student engagement and teacher professional practice enabled by these new AI technologies, this study highlights the fact that substantial structural and situational barriers limit adoption of AI technologies in the region. Average GPA for frequent use of these tools was found to be 14-times higher than for students using these tools less or not at all. Frequent users of AI technologies also exhibited higher levels of student engagement and motivation and wholly supported an expansion of their use in the classroom, while teachers using tools reported increased administrative efficiency and professional satisfaction but expressed serious concerns regarding training and the level of support. Future research should be undertaken with attention to the limitations of this initial study - cross-sectional design, likely provincial rather than national representation, and reliance on self-reported measures of outcomes – so that appropriate, evidence-based decisions regarding the deployment of AI technologies for use by students and teachers may be made.

Two key general conclusions drawn from this study are the potential of AI for reform of the Pakistani education sector; however, significant steps will be needed, including sustained investment in IT infrastructure, extensive professional training and development for teachers and students, the development of a clear and supportive policy for promotion of AI within existing national policies for technology for education; the implementation of a regulatory framework that encourages responsible innovation; and the deployment of local, specific AI solutions in local school contexts if full potential of AI technologies is to be achieved within the context of the Pakistani educational system. Otherwise, the application of AI technologies would likely perpetuate existing disparities among students in the country.

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