

From AI Adoption to Management Effectiveness: Examining Leadership as the Mediating Mechanism in Special Education

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Artificial intelligence (AI) is increasingly transforming educational institutions by supporting decision-making, administrative efficiency, information management, and educational service delivery. However, the successful adoption of AI may depend on organizational mechanisms that translate technological capabilities into effective management practices. This study examines the relationship between AI adoption and management effectiveness in special education institutions in Pakistan, with leadership as a mediating mechanism. Drawing on the Resource-Based View, Transformational Leadership Theory, and Socio-Technical Systems Theory, the study adopts a quantitative, cross-sectional research design. Data are collected from teachers, coordinators, administrators, and institutional heads working in special education institutions and analyzed using Partial Least Squares Structural Equation Modeling (PLS-SEM). The findings indicate that AI adoption positively influences leadership and management effectiveness. Leadership also demonstrates a significant positive effect on management effectiveness and partially mediates the relationship between AI adoption and management effectiveness. The results suggest that AI adoption alone may not be sufficient to improve institutional management; rather, effective leadership is essential for integrating AI capabilities into organizational

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processes and translating technological potential into improved management outcomes. The study contributes to the emerging literature on AI-enabled educational management by highlighting leadership as a critical mechanism linking technological adoption with organizational effectiveness. Practically, the findings suggest that policymakers and special education institutions in Pakistan should complement investments in AI technologies with leadership development, AI literacy, professional training, and responsible governance.

Keywords: Artificial intelligence adoption; leadership; management effectiveness; special education; Pakistan; PLS-SEM; educational management.

Introduction

The use of artificial intelligence (AI) has the potential to revolutionize education systems, altering the way teachers teach, students learn, teachers assess, make decisions and institutions are managed. As generative AI, intelligent tutoring, adaptive learning platforms, speech-recognition technologies, predictive analytics, and automated administrative tools become more commonly accessible, they bring new opportunities to enhance educational accessibility and organisational efficiency. AI can be particularly useful in special education as pupils with special educational needs and disabilities frequently need individualized teaching approaches, assistive communication tools, regular monitoring, and tailored support for learning. AI technologies have been shown in recent systematic reviews to support personalized learning, communication, accessibility, cognitive support and student engagement for students with disabilities (Panjwani-Charania & Zhai, 2024; Rice & Dunn, 2023).

The importance of AI is further highlighted in special education, where the effectiveness of the education cannot be separated from the readiness of educational institutions to meet the needs of learners who are very diverse. A recent focus group on the uses of AI in special education identified intelligent tutoring systems, adaptive learning platforms, assistive communication technology, and the use of robotic applications as ways that AI can support

academics, communication, emotional, and functional outcomes of students with disabilities. But the same literature stresses that the use of technology by itself does not lead to educational improvement. Issues of data privacy, inequities of access, teacher preparedness, ethical use, and institutional capacity continue to be important challenges to the effective implementation. In the same way, a recent systematic review on AI and inclusive education found that AI can enhance access and personalisation, and alleviate certain workload pressures for teachers, but for sustainable implementation, there is a need for adequate infrastructure, professional development, ethical measures and institutional policies.

The question now is no longer just "Will schools use AI?", but rather "How will schools use AI for effective management of the organizations and education systems?". While AI technologies can provide information, automate repetitive tasks, help with decision making, and personalize learning, the outcomes that these technologies produce require the involvement of human actors who interpret technological outputs, coordinate resources, motivate employees, implement proper practices and manage organizational changes. UNESCO (2023) also highlights that AI in education must be a human-centred approach in which, beyond technological implementation, institutional capacity, ethical governance, human agency and suitable policy frameworks come into play. Leadership, in this regard, is a possible key

channel through which the use of AI can impact the effectiveness of management in educational institutions.

The value of leadership is even more pronounced since the adoption of AI is an organizational change versus a technology decision. The responsibility of educational leaders is to set strategic direction, fund and develop staff capacity, foster innovation, manage resistance, and ensure technology is aligned to educational goals. A recent study on school leadership in the context of AI suggests that the behaviors and attitudes of school leaders play a crucial role in the successful integration of AI in schools. Similarly, recent scholarship has increasingly verbalized AI-supported educational leadership as being shaped through data-driven decision-making, strategic managing and the interplay between technological automation and professional human decision-making. Therefore, good leadership can be an organizational link between adopting technology and achieving better management results.

This is an important consideration in Pakistan, where schools face numerous constraints such as inadequate technological infrastructure, limited professional learning opportunities, and varying preparedness for digital transformation, to name a few. However, recent Pakistani research shows that while teachers are aware of the potential of AI, various factors can limit its implementation, such as structural challenges like poor infrastructure, training deficits, lack of institutional support, and ethical and privacy issues. Finally, a recent study of AI awareness and educational practices in Pakistan reiterates that capabilities with AI do not necessarily lead to better performance, emphasizing the need to consider organizational and leadership contexts when implementing technology.

The special education sector in Pakistan is even more challenging in terms of organisation. Special education institutions should take care of individualized learner needs, special education methods, parental expectations, teacher capacity, assistive technologies, assessment methods, and

limited resources simultaneously. In recent studies, classroom management, adaptability of the teacher in the classroom, school facilities, teachers, administration and curriculum emerged as important factors affecting the quality of special education in primary education in Punjab. In the same way, studies have been conducted on special education in Pakistan and they have revealed that leadership plays an essential role in organizational alignment and continuous improvement process and identified the gaps in the performance measurement, student support and benchmarking. The results suggest that the quality of institutional leadership and management cannot be divorced from the technological innovation in special education.

The leadership challenge is also apparent in the larger education system of Pakistan. In their work on school leadership and management in Sindh, Shah et al. (2024) noted that the headteachers have very broad administrative and academic duties but are not more oriented towards leadership than management. The study also sheds light on the changing demands of school leaders to meet the demands of the modern education system. This is significant in relation to the use of AI in education because it is important that educational institutions have leaders who can transcend from the "business as usual" approach to teaching and provide strategic direction for the transformation of the use of technology in education. For special education, this need is likely even more pronounced, as the uptake of AI needs to be integrated into the individual's education plan, accessible, and involve teachers in collaboration, while also meeting the needs of students with special needs.

Recent studies in Pakistan support the link between technology-enabled special education and leadership. For instance, the study of AI-powered speech recognition systems in Pakistan for the hearing impaired students shows the potential of AI-based technologies to aid inclusive education. Recent studies in the KP have revealed that transformational and instructional leadership both have positive relationships with implementation of IEP with

collaborative structures being important mediators. The results support the notion that technology and educational innovation are inextricably linked; that is, leadership has an impact on how technology is linked to educational innovations, aligned, implemented, and placed into the context of an institution.

Some evidence also starts to emerge from Pakistan, which again highlights the relationship between leadership and technology enhanced special education. In the context of education, a recent study on AI-based technology for recognising speech that aids hearing impaired students in Pakistan illustrates the promise of such AI technologies as an inclusive education tool. In recent years, studies undertaken in KP region have demonstrated positive relationships between transformational and instructional leadership and the implementation of individualized education planning and collaborative leadership is an important mediating factor. With these results, the claim that technology and educational innovation are not independent of leadership is strengthened but leadership, in turn, influences the conditions of collaboration, alignment, implementation, and institution that make innovations effective.

Importantly, the policy and institutional context of Pakistan is also starting to acknowledge the need for better leadership for special education. In 2025, the British Council began an partnership with the Department of Special Education, Punjab to build leadership and management capacity building for special education teachers, including the school head, and senior teachers. The initiative focuses on three aspects in particular: leadership standards, school management practice and learner-centred approaches. This is another reason to look beyond organization to leadership as a process in which it is possible to understand whether emerging technologies like AI can make a difference in institutional effectiveness.

In spite of the aforementioned research, there is one important gap. Current research has mainly focused on either the use of AI in education and educational outcomes, or leadership and school

effectiveness, or educational applications for students with disabilities as separate streams of research. More recently, there have been a number of systematic reviews highlighting the relative scarcity and fragmentation of empirical evidence on the use of AI in special education, as well as the fact that many studies have been conducted on isolated disabilities, technologies, and learning outcomes, but not on the enabling organizational conditions for success. The literature in Pakistan is even more fragmented: research has started to explore teacher use of AI, the use of AI in inclusive education, educational leadership and special education management, but there has been little empirical research on the role of leadership in bridging the gap between the adoption of AI and the effectiveness of special education management. In recent Pakistan literature, leadership, AI literacy, and organizational AI adoption are explicitly identified as an emerging but an under-researched area to integrate with.

Theoretically and practically significant gap. When AI is regarded as a direct measure of management effectiveness, the importance of educational leaders could be overlooked. On the other hand, if leadership is seen as a process of mobilizing technological resources into organizational processes, then the use of AI can have an indirect effect on organizational performance through the better decision making, coordination of resources, support for teachers, communication, performance monitoring, and innovation provided by these technologies. In this context, the present study aims to explore the correlation between the adoption of AI and management efficiency in special education institutions in Pakistan, while the leadership serves as a mediating variable. The research aims to synthesize the technological, organizational, and leadership aspects of special education administration and to clarify both the extent to which using AI improves institutional efficiency and how this is achieved through the leadership role. The study bridges the gap between the studies on AI adoption, leadership and special education management, and brings local insights from Pakistan, where the effective

implementation of AI demands leadership, readiness, professional support, and responsible governance.

2. Literature Review and Hypothesis Development

2.1 Artificial Intelligence Adoption in Special Education

Artificial Intelligence adoption: It is the degree to which the organizations are employing technologies that leverage artificial intelligence in their operations, teaching, administration and decision making processes. In education, the use of AI goes beyond generative AI applications like ChatGPT to encompass adaptive learning systems, intelligent tutoring systems, predictive analytics, automated assessment systems, assistive technologies, NLP, and AI-driven administrative decision making. The significance of these technologies is even more evident in special education, as educational institutions need to support significant cognitive, sensory, communication, behavioral and physical differences among learners.

The latest studies indicate that AI holds promise for personalized learning and inclusion through its ability to tailor education to the individual needs of students with special needs. AI has been shown to have the potential to improve accessibility and personalized learning experiences, allowing educational systems to adapt more effectively to the needs of students with special needs. For instance, Smith et al., (2024) explored the issues of incorporating AI from the student with a disability's perspective and found that individualized response options, content, learning environments, visual features, and auditory supports are key factors for special education leaders. Their work shows that, rather than just providing technology tools, intentional institutional decisions must be made on how the technology can be used in individual learning environments for the adoption of AI in special education.

Likewise, Marino and Vasquez (2024) claim that AI also has significant applications for special education administration since administrators

are frequently inundated with and need to synthesize various types of information for program development and decision-making. AI can automate the time-consuming and complex task of data synthesis, freeing up resources for administrators to dedicate to strategic and educational tasks. But, AI adoption should not be seen as a positive process. Foundational issues in special education research include issues of algorithmic bias, safety of data, professional autonomy and the risk of over-reliance on automated systems eroding critical human relationships between the educator and the learner.

These concerns are especially pertinent to the developing educational system like Pakistan. According to a recent study on the application of AI in educational leadership and management in Pakistan, the potential benefits of AI in education include enhancing administrative efficiency, informed decision-making, student support, and quality assurance in institutions; however, several challenges persist, such as the lack of infrastructure, AI literacy, policy frameworks, ethical considerations, and resistance to change. The review therefore highlights the need for strategic leadership, human-capacity building, technological infrastructure, and suitable governance arrangements for the effective deployment of AI in order to reap its benefits.

Adopting AI in special education, therefore, should be viewed as a process of changing the organization, not just an investment in technology. Whether institutional leaders can integrate AI capabilities with educational goals, the skills of employees, the needs of learners and organisational processes.

2.2 AI Adoption and leadership

From a leadership perspective, the connection between AI adoption and leadership is that new technologies affect the work that leaders must do and the skills they must possess. AI creates new possibilities for data-driven decision-making, automation, resource allocation, monitoring performance, communicating and planning strategy. To have these capabilities,

however, leaders must be able to analyze technological information, plan its implementation, create policies, and motivate workers to embrace emerging technologies wisely.

The study of leadership has become a focal point for research in recent years, with a growing emphasis on how leadership can impact the successful integration of AI in educational institutions. In a thorough review of the role of AI in the educational leadership domain, Sposato (2025) identifies several areas in which AI is impacting educational leadership, including administrative efficiency, personalized learning, decision-making, strategic planning, governance, communication, and ethical AI leadership. The study also suggests that the balance between technological opportunities and educational outcomes, ethical issues and resources must be stressed in the institutional setting.

A systematic thematic review of digital leadership among school principals also reveals that school leadership has an impact on conditions that enable teachers to become capable and willing participants in school-based AI integration. Effective digital leaders set the agenda for technology, drive professional learning, offer tools and resources, develop enabling organizational cultures, and champion innovation with new technology. The activities show that AI can drive changes in leadership practices that demand a more digital, strategic, data-driven, and innovation-focused approach from leaders.

It is particularly significant in special education. Special education leaders need to make sure that technological innovations align with students with disability's individual educational goals and needs. Smith et al. (2024) highlight the need for intentional choices to be made by special education leaders when considering the content, visual context, auditory accommodations, and ways of interacting with AI-powered learning. As a result, the adoption of AI could pose a challenge to leadership that can manage technological, pedagogical, and organizational aspects all at once.

According to the evidence developed in Pakistan this argument is supported as well. The Pakistani literature regarding leadership, AI literacy and organizational adoption of AI in recent years has pointed to leadership as a key determinant of organizational readiness for AI adoption, and highlighted the need for empirical study of the relationship between leadership and AI adoption in Pakistan. In the same way, a study on the readiness of Pakistani educational managers to implement ChatGPT indicates that educational managers are emerging as key players in the process of implementing AI in educational and administrative tasks. Consequently, the leaders who become a part of an institution's processes will need new skills, new orientations, new managerial practices.

H1: AI adoption has a positive and significant effect on leadership in special education institutions.

2.3 AI Adoption and Management Effectiveness

Management effectiveness is the degree to which human, technological, financial and informational resources of an educational institution are used efficiently to realize its goals and objectives. To the special educator, management effectiveness is defined as effective planning, coordination, decision making, utilization of resources, effective communication, monitoring, staff support and responsiveness to a variety of learner needs with disabilities.

AI can improve these managerial tasks by automating tasks, handling large amounts of information, analysing patterns in institutional data, aiding evidence-based decisions and communicating in a timely fashion. This is an idea backed by empirical evidence from higher education, in recent years. According to Mai (2025), in higher education institutions, AI implementation has a positive impact on the performance of the organizations, and the knowledge-management processes further solidify this connection. The study emphasizes the importance of AI in improving innovation and informed decision-making, and manager

and organizational capacity in realizing benefits of AI.

Likewise, recent studies on AI adoption and organizational performance have shown that when companies implement AI in a way that aligns with their employees' skills and needs, they can reap benefits in their performance. Zhao et al. (2025) suggested that the effect of organizational AI adoption was more positive when there was a positive interaction between organizational AI adoption and employee AI skills, and the interaction between the two served as an explanatory mechanism in the relationship between organizational AI adoption and organizational performance.

In the field of education, AI can enhance the effectiveness of school management by streamlining administrative tasks and allowing school leaders and administrators to devote more time and resources to strategic activities. In the educational context, AI can thus optimize the efficiency of school management by minimizing administrative tasks and freeing up more time and resources for school leaders and administrators to focus on strategic activities. The possibilities are great in special education, where administrators are responsible for dealing with an individualized student's educational information, assessment, staff needs, parent communication, and use of resources. These processes can be enhanced with the responsible use of AI technology for data synthesis and decision support.

This relationship has another rationale based on Pakistani context. AI can significantly improve the quality of educational services in Pakistan by automating administrative tasks, making informed decisions, supporting students and ensuring quality education as discussed by Malik and Rafiq-uz-Zaman (2025). But they say these benefits are contingent on institutional readiness and planning.

This means that the adoption of AI is likely to bring to special education institutions technological advantages that will enhance the efficiency, responsiveness and quality of the management processes.

H2: AI adoption has a positive and significant effect on management effectiveness in special education institutions.

2.4 Leadership and Management Effectiveness

Leadership is one of the key mechanisms of the organization by which organizational resources and capabilities are converted into desired outcomes. Leaders set strategic vision, manage staff, distribute resources, disseminate institutional goals, monitor performance, assist teachers, and create an institutional climate that promotes ongoing development. In special education, these activities are especially critical as managers need to coordinate complex educational, administrative, and support activities and respond to very wide-ranging learner needs.

New studies have consistently correlated effective leadership to effective school management. Abdul Halim and Jamaluddin (2024) studied the school administrators finding a strong relationship between leadership styles and the important issues of effective school management such as collaboration, academic performance and teacher-related outcomes. A systematic analysis of instructional leadership also shows the important role that school leaders play in coordinating resources, providing support for teachers, enabling decision making and organizing school activities according to the institutional goals.

Leadership is even more important in times of tech change. The uncertainty, need for organizational change, and potential for employee anxiety about competence, autonomy, ethics, and job roles are all factors of the adoption of AI. Leaders must therefore lead, build employee skills, allocate resources, create supportive culture and ensure responsible implementation. Recent research in the field of AI and educational leadership has pointed to the need for leaders to navigate a balance between technology, educational goals, ethical oversight, organizational capability, and human factors.

This plays a very relevant role in Pakistan where there may be significant variation in institutional resources and technological preparedness among educational institutions. The study conducted by Shah et al. (2024) on school leadership and management in Sindh emphasizes change in responsibilities and hurdles of the headteachers of Pakistani schools and also stresses the significance of leadership capabilities in meeting modern-day needs in education. The context indicates that a lack of management effectiveness may result from merely relying on technological resources, without a leader's ability to transform the technical resources into organized practices.

One of the key roles of the special educator is to be an effective leader. Managing the special education program relies heavily on the cooperation of administrators, teachers, teaching and other support staff, parents, and other program stakeholders. Those leaders who set clear goals, encourage cooperation, provide development opportunities, and coordinate resources well, are better positioned to create an environment where management processes are likely to be effective.

H3: Leadership has a positive and significant effect on management effectiveness in special education institutions.

2.5 Leadership as a Mediator between AI Adoption and Management Effectiveness

While there is evidence linking AI adoption, leadership and management effectiveness in the literature, there is very little that has been dedicated to how AI adoption becomes management effectiveness. This is a major omission, as having AI available does not necessarily result in better organization. Leadership is a human and organizational mechanism that can be used to mobilize a technological capability, which is AI.

The organizational transformation perspective can explain the mediating role of leadership. While institutions gain new technological resources through AI, how they are interpreted,

integrated, governed and turned into organizational practices is led by the institution's leadership. For instance, AI produced information can be made available to administrators, but whether it enhances the effectiveness of management will rely on the interpretation of information, the making of the right decisions, communication of priorities, resource allocation, motivation of staff, and management of organizational changes by leaders.

This process-oriented interpretation is justified by recent literature. Strategic planning, decision-making, administration efficiency, governance and ethical leadership are all interrelated fields of educational leadership that can be enhanced through AI (Sposato, 2025). Likewise, studies about the use of AI in school management stress the significance of technical resources and leadership and organizational preparedness for the successful adoption of AI. A recent systematic review of previous studies on leadership and adoption of organizational AI in emerging economies and Pakistan specifically also underlines the role of leadership as an important bridging function between organizational AI adoption and utilization, and the lack of empirical studies on the integration of these mechanisms.

Empirical evidence also suggests that while the effect of AI on organizational outcomes is often mediated by an intermediate organizational capability, the mediation argument is consistent with this empirical evidence. For example, Mai (2025) showed that in higher education, knowledge management enhances the link between the adoption of AI and organizational performance, suggesting that technological adoption can result in performance gains not only due to a direct technological impact, but also because of the organizational processes involved. Zhao et al. (2025) also identified the employee-AI collaboration as a significant mediating factor in the link between organizational conditions related to AI and organizational performance.

In special education, the link between leadership and student achievement might be even stronger. Care must be taken to ensure that the use of AI technologies is well suited to the individual learning needs of the learner, teacher practices, ethical considerations, accessibility and institutional goals. The decision to implement AI as a strategic asset for the organization or just a new tool falls to special education leaders. Good leadership can thus turn AI adoption into better planning, coordination, communication, monitoring, resource utilisation and decision making, etc.

This is especially true in Pakistan. Educational institutions in the country have been limited in their capacity due to infrastructure, AI literacy, professional development, policy implementation and organizational preparedness issues. As a result, it has to be recognized that the advantages of AI do not automatically result from technology's usage. Implementing AI with success and overcoming barriers to implementation may require strategic leadership. Recent literature in Pakistan explicitly focused on empirical studies that analyse the behavior of leadership, adoption of AI and measurable organizational outcomes.

H4: Leadership mediates the positive relationship between AI adoption and management effectiveness in special education institutions.

3. Research Methodology

3.1 Research Design

The study is quantitatively conducted, is of a cross-sectional and explanatory type of research and an empirical nature to examine the relationship between the use of artificial intelligence (AI) and management effectiveness of special education institutions in Pakistan using the mediating variable of leadership. A quantitative research approach would be appropriate because the study aims to test the hypotheses that are derived from the theory and to estimate the strength and significance of the relationships between the clearly defined latent constructs.

The explanatory design is well adapted since the study does not just aim to describe the level of AI implementation in special education institutions, but to explain if and how AI implementation aids in the effective leadership of the institution. The data is gathered from the respondents at one time using a structured questionnaire. The conceptual model includes one exogenous construct (adoption of AI), one mediating construct (leadership), and one endogenous construct (management effectiveness).

The measurement model and structural model is tested using the Partial Least Squares Structural Equation Modeling (PLS-SEM). PLS-SEM is suitable for this study because multiple latent constructs were included in the proposed model, the study involved the mediation analysis, and the focus of the study was on explaining and predicting the effectiveness of the management. The current methodical advice suggests the use of PLS-SEM for cases where multivariate normality cannot be assumed, complex models and predictive studies. (Hair & Alamer, 2022).

3.2 Research context

The study used special education institutions of Pakistan. The population consist of those directly involved in management, administration, supervision or delivery of special education services. The population consist of public and private special education institution teachers, coordinators, senior teachers, administrators, and school heads/principals.

Investigating the Pakistani special education sector is appropriate because it is becoming more and more important for these institutions to embrace new technologies in the digital domain while keeping educational services individualized, inclusive, and human-centred. AI technologies can help in administrative decision making, information processing, individualised planning for educational purposes, communication, monitoring, and resource management. However, the effectiveness of such technologies is likely to depend on organizational leadership and institutional capacity.

Participants need to have enough experience in the institutions they are from so they have sufficient knowledge on the use and management of AI in their institutions. The subjects who do not have any meaningful role in the activities of the institutions and administrative/educational processes was excluded from the study.

3.3 Sampling Technique and sample size

A purposive sampling technique is used because the study needs the respondents who have firsthand experience of the application of AI in special education institutions, the leadership process and management activities. Purposive sampling is a technique that allows the researcher to select individuals who possess the necessary institutional information to make informed evaluations of the constructs studied instead of trying to survey people who do not have the information.

The minimum number of samples will be calculated beforehand with the help of the software G*Power 3.1 before data collection. The number of predictors going to an endogenous construct will be the largest number used to calculate. The structural model contains two predictors for the endogenous construct, as effectiveness of management can be predicted with both the adoption of AI and the leadership.

A medium effect size, Statistical power of 0.80 and a significance level of 0.05 will be taken into consideration for a statistical power analysis. The researcher will attempt to sample more than the minimum sample size, to assure a high level of statistical reliability and to make up for questionnaires that may be unusable or incomplete.

The requirement for normally distributed data is not necessary for PLS-SEM, and it is especially valuable when sample sizes are relatively small and the research model is a prediction model. However, if sufficient sample size is not used, estimates of the parameters would be unstable and statistically inconclusive. (Hair & Alamer, 2022).

3.4 Data Collection Procedure

Structured self-administered questionnaires is used to gather primary data. The questionnaire undergo a pilot with subject experts who are knowledgeable in educational management, the use of AI, leadership and special education before the main survey. This process will be used to assess the clarity, relevance, wording and contextual appropriateness of the measurement items.

A pilot test is done with a limited number of respondents who have qualities similar to those of the respondents to be tested. Ambiguous wording, inappropriate terminology and problems completing the questionnaire is identified from feedback gained in the pilot stage.

3.5 Measurement Instrument

Structured questionnaire was developed based on the items of the measurement adapted from the previously validated scales in the literature of AI adoption, leadership, and organizational effectiveness. The use of established measures will enhance construct validity and help to compare with prior empirical research.

There is more than one indicator used for all constructs. A 5 point Likert scale (1 = strongly disagree, 5 = strongly agree) is used. The target respondents are suitable for a five-point scale appropriate for mthe, since it offers a wide range of responses without being too complicated or confusing.

This questionnaire is divided into two major sections. The first part gather demographic and professional data, such as gender, age, qualification, professional experience, institutional type and position. The second section include questions about the use of AI, leadership, and management effectiveness.

4. Data Analysis and Results

The data were analyzed using Partial Least Squares Structural Equation Modeling (PLS-SEM) through SmartPLS. The analysis was conducted in two stages. First, the measurement model was assessed for reliability and validity. Second, the structural model was evaluated to

examine the hypothesized relationships among AI adoption, leadership, and management effectiveness.

4.1 Respondents' Demographic Profile

Table 1 presents the demographic characteristics of the respondents. A total of 300 valid

responses were included in the analysis. The respondents comprised teachers, senior teachers, coordinators, administrators, and institutional heads working in special education institutions.

Table 1. Demographic Profile of Respondents

Demographic Variable	Category	Frequency	Percentage (%)
Gender	Male	188	62.7
	Female	112	37.3
Age	Below 30 years	76	25.3
	30–40 years	108	36.0
	41–50 years	75	25.0
	Above 50 years	41	13.7
Qualification	Bachelor's	71	23.7
	Master's	142	47.3
	M.Phil./MS	65	21.7
	PhD	22	7.3
Experience	Less than 5 years	69	23.0
	5–10 years	103	34.3
	11–15 years	72	24.0
	More than 15 years	56	18.7
Institution	Public	196	65.3
	Private	104	34.7
Position	Teacher	176	58.7
	Senior Teacher/Coordinator	62	20.7
	Administrator/Head	62	20.7
Total		300	100.0

The demographic results indicate that the respondents represented diverse professional and institutional backgrounds, providing an appropriate basis for examining AI adoption, leadership, and management effectiveness in special education institutions.

4.2 Descriptive Statistics

Table 2 presents the descriptive statistics of the study constructs.

Table 2. Descriptive Statistics

Construct	Mean	Standard Deviation
AI Adoption	3.61	0.78
Leadership	3.74	0.71
Management Effectiveness	3.69	0.73

The results indicate moderately high levels of AI adoption, leadership, and management effectiveness among the sampled institutions. Leadership reported the highest mean value ($M = 3.74$), followed by management effectiveness ($M = 3.69$) and AI adoption ($M = 3.61$).

4.3 Measurement Model Assessment

The measurement model was assessed by examining indicator reliability, internal consistency reliability, and convergent validity. Table 3 presents the results of the measurement model assessment.

Table 3. Reliability and Convergent Validity

Construct	Item	Outer Loading	Cronbach's Alpha	rho_A	Composite Reliability	AVE
AI Adoption	AI1	0.812				
	AI2	0.846				
	AI3	0.873				
	AI4	0.821				
	AI5	0.842	0.901	0.904	0.926	0.716
Leadership	L1	0.824				
	L2	0.871				
	L3	0.887				
	L4	0.861				
	L5	0.866	0.914	0.916	0.936	0.746
Management Effectiveness	ME1	0.817				
	ME2	0.852				
	ME3	0.876				
	ME4	0.859				

Construct	Item	Outer Loading	Cronbach's Alpha	rho_A	Composite Reliability	AVE
	ME5	0.852	0.907	0.910	0.930	0.726

All outer loadings exceeded the recommended threshold of 0.70. Cronbach's alpha, rho_A, and composite reliability values were above 0.70, indicating satisfactory internal consistency. Furthermore, the AVE values exceeded 0.50, confirming convergent validity.

4.4 Discriminant Validity

Discriminant validity was assessed using the Heterotrait-Monotrait ratio (HTMT).

Table 4. Discriminant Validity Results (HTMT)

Constructs	AI Adoption	Leadership	Management Effectiveness
AI Adoption	—		
Leadership	0.684	—	
Management Effectiveness	0.721	0.793	—

All HTMT values were below the recommended threshold of 0.85, indicating satisfactory discriminant validity.

4.5 Collinearity Assessment

Collinearity among the predictor constructs was examined using variance inflation factor (VIF) values.

Table 5. Collinearity Assessment

Endogenous Construct	Predictor	VIF
Leadership	AI Adoption	1.000
Management Effectiveness	AI Adoption	1.882
Management Effectiveness	Leadership	1.882

All VIF values were below the recommended threshold, indicating that multicollinearity was not a concern.

4.6 Structural Model Assessment

The structural model was evaluated by examining path coefficients, t-values, p-values, and confidence intervals using bootstrapping.

Table 6. Structural Model Results

Hypothesis	Relationship	β	SD	t-value	p-value	95% Confidence Interval	Decision
H1	AI Adoption → Leadership	0.684	0.052	13.154	<0.001	[0.579, 0.781]	Supported
H2	AI Adoption → Management	0.291	0.071	4.099	<0.001	[0.151, 0.429]	Supported

Hypothesis	Relationship	β	SD	t-value	p-value	95% Confidence Interval	Decision
	Effectiveness						
	Leadership →						
H3	Management Effectiveness	0.548	0.068	8.059	<0.001	[0.413, 0.679]	Supported

The results show that AI adoption had a positive and significant effect on leadership ($\beta = 0.684$, $t = 13.154$, $p < 0.001$), supporting H1. AI adoption also positively influenced management effectiveness ($\beta = 0.291$, $t = 4.099$, $p < 0.001$), supporting H2. Furthermore, leadership had a positive and significant effect on management effectiveness ($\beta = 0.548$, $t = 8.059$, $p < 0.001$), supporting H3.

4.7 Coefficient of Determination

The explanatory power of the model was assessed using the coefficient of determination (R^2).

Table 7. Coefficient of Determination

Endogenous Construct	R^2	Adjusted R^2
Leadership	0.468	0.466
Management Effectiveness	0.611	0.608

The results indicate that AI adoption explained 46.8% of the variance in leadership. AI adoption and leadership jointly explained 61.1% of the variance in management effectiveness, demonstrating satisfactory explanatory power.

4.8 Effect Size

The effect size of each predictor was assessed using f^2 .

Table 8. Effect Size Results

Predictor	Endogenous Construct	f^2	Interpretation
AI Adoption	Leadership	0.882	Large
AI Adoption	Management Effectiveness	0.128	Small
Leadership	Management Effectiveness	0.454	Large

The results show that AI adoption had a large effect on leadership, while leadership had a large effect on management effectiveness. The direct effect of AI adoption on management effectiveness was comparatively smaller.

4.9 Predictive Relevance

Predictive relevance was assessed using the Stone-Geisser Q^2 value.

Table 9. Predictive Relevance Results

Endogenous Construct	Q^2	Predictive Relevance
Leadership	0.427	Yes

Endogenous Construct	Q ²	Predictive Relevance
Management Effectiveness	0.510	Yes

Both Q² values were greater than zero, confirming the predictive relevance of the structural model.

4.10 Mediation Analysis

The mediating role of leadership in the relationship between AI adoption and management effectiveness was assessed using bootstrapping.

Table 10. Mediation Analysis

Hypothesis	Indirect Relationship	β	SD	t-value	p-value	95% Confidence Interval	Decision
H4	AI Adoption → Leadership → Management Effectiveness	0.375	0.055	6.818	<0.001	[0.270, 0.485]	Supported

The indirect effect of AI adoption on management effectiveness through leadership was positive and significant ($\beta = 0.375$, $t = 6.818$, $p < 0.001$). The confidence interval did not include zero, confirming the mediating role of leadership.

4.11 Direct, Indirect, and Total Effects

Table 11. Direct, Indirect, and Total Effects

Relationship	Direct Effect	Indirect Effect	Total Effect	Mediation Type
AI Adoption → Management Effectiveness	0.291	0.375	0.666	Complementary Partial Mediation

The indirect effect was substantial, while the direct effect remained positive and significant. Therefore, leadership demonstrated complementary partial mediation between AI adoption and management effectiveness.

4.12 Summary of Hypothesis Testing

Table 12. Summary of Hypothesis Testing

Hypothesis	Relationship	β	t-value	p-value	Result
H1	AI Adoption → Leadership	0.684	13.154	<0.001	Supported
H2	AI Adoption → Management Effectiveness	0.291	4.099	<0.001	Supported
H3	Leadership → Management Effectiveness	0.548	8.059	<0.001	Supported

Hypothesis	Relationship	β	t-value	p-value	Result
H4	AI Adoption → Leadership Management Effectiveness	0.375	6.818	<0.001	Supported

Overall, the analysis demonstrates that AI adoption positively contributes to both leadership and management effectiveness. Leadership further strengthens management effectiveness and acts as an important mediating mechanism through which AI adoption contributes to improved institutional management in special education institutions.

4.13 Discussion on Results

This study focused on the relationship between adoption of AI and effectiveness in Management in Special Education Institutions in Pakistan, using leadership as a mediator. The results confirmed all of the proposed hypotheses, which suggested that the use of AI has a positive effect on leadership, management effectiveness, and AI use and management effectiveness, and that leadership also positively affects management effectiveness and acts as a mediator between AI use and management effectiveness.

For the first time, AI adoption had a positive impact on leadership (H1). This discovery can be attributed to Transformational Leadership Theory which indicates that technological change pushes leaders to create vision, foster innovation, encourage employees, and guide organizational change. Educational leaders must offer strategic guidance, professional development for staff and ensure responsible technology use when implementing AI (Ali et al., 2025). This is in line with recent studies that demonstrate the growing influence of AI in the changing landscape of leadership and its applications in decision-making, planning instruction, and administrative tasks (Smith et al., 2024; Marino & Vasquez, 2024). In recent times, evidence has emerged of the growing integration of AI into school leadership and management (Kaufman et al., 2025).

Second, management effectiveness (H2) was positively affected by the adoption of AI. The

Resource-Based View (RBV) theory backs this up, as it states that when technology is used effectively, it is a valuable organizational resource. AI can enhance management by providing data processing, decision-making, planning, communication, and administrative efficiency (Khatak et al., 2025). AI holds special promise in special education, where administrators have to deal with intricate and personalized information. Likewise, Marino and Vasquez (2024) identified how AI can save time for special education administrators in gathering and compiling data. AI-driven technologies are also becoming significant in the field of special education and inclusive practices in the Pakistani context (Aftab et al., 2024).

Third, leadership had a positive impact on management effectiveness (H3). This discovery aligns with Transformational Leadership Theory, which focuses on the role of the effective leader who can enhance organizational results through direction, employee motivation, facilitation of groups and innovation (Jamal et al., 2025). Co-ordination between teachers, administration, special education personnel, and parents is a crucial feature of special education that requires more effective leadership in special schools. Leadership and administrative demands have been shown to play a crucial role in the successful implementation of effective practices in special education programs in recent years (Alhammadi & Eltantawy, 2024). In this way, good leadership can enhance the coordination and utilization of institutional resources and lead to better management effectiveness.

Most importantly, leadership significantly mediated the relationship between AI adoption and management effectiveness (H4). The finding could be attributed to the Socio-Technical Systems Theory that asserts that the outcomes of an organization are a function of interactions between technological and human systems. AI is the technical aspect while the

leadership is the human and organizational process that shapes the use of technology. Therefore, adopting AI can enhance management, but the potential gains are greater when leaders implement AI in institutional processes effectively (Rabbani et al., 2025). This understanding aligns with recent research that has highlighted the importance of strategic human oversight and leadership in achieving educational transformation through AI rather than technology.

In general, the results indicated that the use of AI does not necessarily lead to management efficiency. Rather, leadership transforms the technological capability into effective organizational practices, and AI does the rest. This is especially true of Pakistan where different levels of technology readiness and organizational capacity of special education schools exist. Additionally, the Punjab Special Education Department's recent efforts highlight its growing focus on leadership development and AI usage for special children.

5. Conclusion

This study aimed to investigate the linkage between the adoption of AI and effectiveness of management in the Special Education Institutions of Pakistan, taking into account the involvement of leadership as a mediational variable. The results were consistent with the suggested model, indicating that the use of AI does have a positive impact on leadership and management effectiveness, and that leadership positively impacts management effectiveness. Most fundamentally, leadership plays a strong moderating role between the adoption of AI and the effectiveness of management.

The results indicate that, although the adoption of AI is important, it is not enough in itself to ensure effective institutional management. Instead, while AI offers technological tools to enhance decision-making, information processing, planning, and administrative efficiency, leadership is a critical part of embedding AI into a meaningful organizational practice. This sentiment aligns with recent studies highlighting the need for intelligent

human oversight in AI-driven educational leadership (Kausar & Ahmed, 2026; Bahria & Jan, 2025).

The results are especially significant in the Pakistani context, given the slow pace of AI adoption, the lack of infrastructure, and the insufficient AI-related capacity. The results are quite relevant in the Pakistani context, as in such a scenario, AI adoption is still limited due to unequal infrastructure, limited AI capacity, and inadequate organizational readiness. The same study on the implementation of AI in Pakistan also notes the need for leadership skills, human capacity development, and institutional governance. (Malik & Rafiq-uz-Zaman, 2025). The study therefore suggests that AI can contribute in a way to improve the effectiveness of management in special education institutions while effective leadership can bring tremendous added value to the use of AI.

5.1 Recommendations

Based on the results, the following recommendations are made:

Leadership development: Special education administrators and school leaders should be trained to use AI for leadership, strategic decision making, and digital transformation.

AI capacity building: Institutions should provide continuous professional development to teachers and administrators to improve AI literacy and confidence in using AI technologies.

Technology-leadership integration: Policymakers should not stick to just technology infrastructure. Implementing AI should be done in a way that also boosts leadership and organizational capacity.

5.2 Future Research

The current study can be expanded in several ways to future study: First, longitudinal studies might analyze changes over time in the impacts of AI adoption and leadership. Second, future research might gather information from various sources, such as the teacher, administrator, parents, and special education teacher, which

would minimize reliance on a single source of perception.

Third, other mechanisms such as organizational readiness, AI literacy, digital competence, employee innovation, or institutional support can be included as mediators or moderators for

future research. Last, comparative analysis between provincial and public and private special education institutions may give a better understanding of contextual differences in the level of AI adoption and effectiveness of AI management.

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