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Research Article

E-learning and Artificial Intelligence: A Solution to the Limitations of Educational Infrastructure in Afghanistan

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Abstract: Higher education in Afghanistan faces chronic challenges stemming from decades of conflict, political instability, and underinvestment. Universities operate with limited infrastructure, outdated curricula, and overcrowded classrooms, leaving students underprepared for the demands of a competitive global labor market. The COVID-19 pandemic further exposed the fragility of the sector, as efforts to shift toward online learning were hindered by poor connectivity, unreliable electricity, and insufficient institutional readiness. This study investigates the potential of e-learning combined with artificial intelligence (AI) to address these systemic limitations and to provide a sustainable pathway for educational reform in fragile contexts. Adopting a qualitative design, the study draws on documentation analysis, field observations, and semi-structured interviews with lecturers, administrators, and students in Afghan universities. The data were analyzed thematically, focusing on infrastructure barriers, institutional capacity, and perceptions of AI-enhanced e-learning. Findings highlight that while conventional e-learning platforms expanded access during emergencies, they often lacked adaptability, personalization, and effectiveness in sustaining engagement. Participants demonstrated limited technical literacy regarding AI but expressed strong interest in its potential to improve teaching efficiency, student support, and inclusiveness. The absence of coherent policy frameworks and persistent gender and geographic inequalities emerged as critical challenges to equitable implementation. This study contributes to the state-of-the-art by extending discussions of AI in education into a fragile-state context, where assumptions of stable infrastructure and governance do not apply. It also problematizes the universality of technology adoption theories, suggesting the need for adaptations that incorporate structural and socio-cultural variables. AI-enabled e-learning can partially mitigate Afghanistan's educational infrastructure deficits when implemented alongside capacity building, inclusive design, and supportive governance frameworks. These findings hold relevance not only for Afghanistan but also for other fragile states seeking innovative, equitable, and sustainable educational solutions.

Keywords: E-learning; Artificial Intelligence (AI); Higher Education; Educational Infrastructure; Afghanistan.

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1. Introduction

Education in fragile and conflict-affected states such as Afghanistan remains one of the most pressing development challenges of the 21st century. Higher education in particular faces deep structural and institutional constraints, shaped by decades of political instability, underinvestment, and prolonged conflict that have eroded the national capacity to provide equitable and high-quality learning opportunities (Bagherimajd & khajedad, 2025). Universities across the country struggle with inadequate physical infrastructure, outdated curricula, and a lack of modern teaching resources, students leaving underprepared for a competitive global labor market (Emynorane et al., 2025). These deficits are compounded by socio-political disruptions that often force universities to suspend or modify academic programs, disproportionately affecting women and marginalized groups. The result is an

educational landscape that remains far from meeting the aspirations of Afghan youth or the developmental needs of the country (Noori, 2021).

Against this backdrop, e-learning has emerged as a potential mechanism to address some of the chronic barriers to access and quality in Afghan higher education. The COVID-19 pandemic accelerated global adoption of online and distance learning technologies, and Afghanistan was no exception, with universities attempting to migrate to digital platforms under emergency conditions (Katawazai, 2021). Yet, while some progress was made in enabling continuity of learning, serious limitations were also exposed: weak internet connectivity, unreliable electricity supply, digital illiteracy among both faculty and students, and a lack of robust institutional policies to support digital transformation. These constraints limit the reach and effectiveness of e-learning initiatives, especially for students in rural provinces where connectivity and resources remain scarce (Ahmadzai & Ye, 2025). Despite these challenges, the pandemic underscored the necessity of digital readiness and revealed the possibility of leveraging technology as a long-term strategy to improve educational access in Afghanistan (Noori, 2021).

Existing approaches to strengthening Afghan higher education through digital means have relied heavily on conventional e-learning systems and open and distance learning (ODL) platforms. Studies show that these systems provide flexibility, reduce geographic barriers, and support inclusive learning opportunities (Noori, 2021). However, they also face critical weaknesses: static course designs that fail to adapt to learner needs, limited capacity for personalization, and insufficient mechanisms for monitoring student engagement or preventing dropout (Adewale et al., 2024). Moreover, many platforms lack integration with local pedagogical traditions, language preferences, and socio-cultural sensitivities. The absence of adaptive and intelligent features constrains their capacity to respond to the diversity of Afghanistan's student population (Utsumi & Muradi, 2024).

In contrast, recent international research points to the transformative potential of Artificial Intelligence (AI) in education. AI-powered tools can enable adaptive learning platforms, automated assessments, intelligent tutoring systems, and predictive analytics to identify at-risk learners and provide timely interventions (Aderibigbe et al., 2025). AI further enhances the capacity of e-learning platforms by personalizing content delivery, optimizing resource allocation, and improving feedback mechanisms in ways that conventional systems cannot (Utsumi, 2022). Within the Afghan context, these applications could compensate for teacher shortages, support students in remote areas, and create scalable models of instruction despite limitations in physical infrastructure (Aderibigbe et al., 2025; Parakh et al., 2025). However, the adoption of AI in education is not without risks. Concerns regarding equity of access, algorithmic bias, data privacy, and the cost of implementation remain unresolved.

The central research problem, therefore, lies in identifying how Afghanistan can leverage AI-enabled e-learning to mitigate its severe infrastructure and institutional deficits while avoiding the pitfalls associated with premature or inequitable technology adoption. This challenge requires not only technological solutions but also careful consideration of socio-political and cultural contexts. Specifically, Afghan higher education institutions must determine how to balance the promise of intelligent digital platforms with the realities of limited connectivity, economic instability, and systemic governance weaknesses. Without addressing these structural barriers, the deployment of AI may reinforce, rather than reduce existing inequalities.

This study proposes that a hybrid model of AI-enhanced e-learning can serve as a viable solution to Afghanistan's educational infrastructure limitations. Such a model would combine the scalability and accessibility of e-learning with the adaptive, personalized, and efficiency-enhancing features of AI systems (Aderibigbe et al., 2025). Building on international evidence and contextualized through Afghan realities, the approach emphasizes three strategic directions: (i) development of lightweight AI-driven learning platforms optimized for low-bandwidth environments; (ii) capacity building for faculty and students to improve AI literacy and digital competencies; and (iii) policy frameworks that promote inclusivity, safeguard data privacy, and ensure affordability. This multi-dimensional strategy not only addresses immediate infrastructure gaps but also creates pathways for long-term resilience and innovation in the Afghan higher education system.

There are three principal contributions derived from this study. First, it provides a comprehensive analysis of the limitations of Afghanistan's higher education infrastructure, integrating perspectives from both institutional and student-level experiences. Second, it synthesizes insights from the growing global literature on AI in education to articulate a context-sensitive framework for Afghan universities, particularly in fragile and resource-constrained environments. Third, it offers practical policy recommendations and technological pathways that can guide stakeholders including the Ministry of Higher Education, university administrators, and international partners in scaling AI-enhanced e-learning initiatives to promote equitable and sustainable access.

This study starts with a review of relevant literature on e-learning and the integration of artificial intelligence in higher education, with particular attention to their application in fragile contexts. It then outlines the qualitative and analytical approaches employed to evaluate both infrastructure challenges and possible technological solutions. The analysis subsequently examines current barriers within Afghanistan's higher education system and explores the potential role of AI-enhanced e-learning platforms in addressing these issues (Utsumi, 2022). The discussion expands on the broader implications of embedding AI in Afghanistan's socio-political and economic landscape, while the conclusion synthesizes key insights and offers recommendations for future policy and practice.

2. Literature Review

Study on e-learning and artificial intelligence (AI) in education has expanded considerably over the past decade, producing a rich body of work that explores technological applications, pedagogical models, and institutional challenges across diverse contexts (Aderibigbe et al., 2025). In fragile states such as Afghanistan, however, the literature remains sparse, with most studies focusing either on the general limitations of higher education infrastructure or the short-term effects of emergency online learning during crises like COVID-19 (Adewale et al., 2024). This section reviews relevant studies on e-learning and AI adoption, outlines key theoretical frameworks, and highlights the gaps that motivate the present research.

The first group of studies examined the adoption of e-learning in contexts of limited infrastructure. (Alier et al., 2025) investigated open and distance learning (ODL) systems and found that they expand access by reducing geographic and financial barriers. Similarly, study from Afghanistan during the pandemic revealed that online learning initiatives enabled continuity of instruction despite university closures (Indrawati et al., 2025). Yet these approaches relied primarily on conventional learning management systems (LMS) and video conferencing tools, which were constrained by bandwidth requirements, low levels of digital literacy, and insufficient institutional readiness. The outcomes often include limited student engagement and high dropout rates, pointing to the structural weakness of static e-learning models when applied in fragile environments.

Building on these limitations, a second body of research emphasizes the role of AI in transforming digital education. Studies on AI-enabled adaptive platforms highlight their ability to personalize content, monitor learner progress, and provide automated feedback (Aderibigbe et al., 2025). In addition, multimodal learning analytics have been used to capture complex data on student interaction, offering predictive insights into dropout risks and performance (Emynorane et al., 2024). Comparative studies further show that AI-driven vocational training programs are capable of aligning curricula with labor market demands, thereby enhancing both educational outcomes and economic development (Boaro et al., 2025). Despite these advances, the literature indicates that AI implementation requires careful attention to ethical concerns, data privacy, and algorithmic fairness, areas that are often neglected in resource-constrained settings.

Theoretically, several frameworks have been used to explain adoption and effectiveness of AI in education. The Technology Acceptance Model (TAM) has been widely applied to capture perceptions of usefulness and ease of use as determinants of adoption (Mazı & Yıldırım, 2025). Within the Afghan context, this framework may be too narrow, as structural barriers such as electricity shortages and poor connectivity also determine feasibility. The Unified Theory of Acceptance and Use of Technology (UTAUT2) expand on TAM by incorporating social influence and facilitating conditions, offering a more nuanced lens to

analyze how Afghan faculty and students may engage with AI-based systems (Yue Yim, 2024). More recently, Generalizability Theory has been revisited as a framework for evaluating the reliability and fairness of AI-driven educational tools, focusing on variance decomposition to ensure validity across diverse learning environments (Aderibigbe et al., 2025). Together, these frameworks underline the need for context-sensitive approaches to technology adoption in fragile states.

Empirical work in Afghanistan highlights both opportunities and systemic challenges. (Emynorane et al., 2024) documented how universities attempted to implement e-learning during the pandemic but found limited impact due to infrastructure deficits and governance gaps. Another strand of literature emphasizes the socio-political dimension: gender disparities in access to digital tools, institutional fragility, and insecurity that disrupts learning continuity (Bagherimajd & khajedad, 2025). These findings suggest that while e-learning offers a partial solution, it cannot fully address the entrenched infrastructure and cultural barriers without adaptive, intelligent support mechanisms.

The analysis highlights two primary gaps in existing literature. First, numerous studies have demonstrated the potential of AI to enhance learning outcomes in well-resourced contexts; However, little is known about how such technologies can be adapted for fragile higher education systems such as Afghanistan. Second, existing research on Afghan higher education has primarily examined either conventional e-learning or general infrastructure challenges, but rarely the integration of AI as a strategic response to those deficits. This study, therefore, seeks to fill the gap by exploring how AI-enabled e-learning can mitigate infrastructure limitations while remaining sensitive to Afghanistan's socio-political realities.

3. Method

This study adopts a qualitative research design to explore how e-learning combined with artificial intelligence can serve as a solution to the infrastructure limitations of higher education in Afghanistan. A qualitative approach is particularly suitable because the focus lies not on measuring variables numerically, but on developing a deep understanding of contextual challenges, institutional practices, and stakeholder perceptions. Three complementary methods were employed for data collection: documentation study, observation, and semi-structured interviews. The documentation study involved an extensive review of policy reports, institutional guidelines, and existing academic literature related to e-learning and AI adoption in Afghanistan and comparable fragile contexts. This provided a foundation for situating the study within current debates and identifying structural and policy-level gaps. Observations were then carried out within selected higher education institutions to examine the availability of digital infrastructure, classroom dynamics, and patterns of technology use. These observations offered firsthand insights into the day-to-day challenges and opportunities of implementing digital learning in resource-constrained environments.

To complement the documentation and observation, semi-structured interviews were conducted with key stakeholders, including university lecturers, administrators, and students. This method allowed the researcher to probe into experiences, expectations, and concerns regarding e-learning and AI, while providing flexibility for participants to elaborate on issues most relevant to their context. The combination of these three methods ensured triangulation of data sources, thus enhancing the credibility of the findings. Data analysis followed a thematic approach, in which transcripts and notes were coded inductively to identify recurring patterns, contrasts, and emerging themes. Particular attention was given to how infrastructure limitations, pedagogical practices, and socio-political conditions influence the feasibility of AI-enhanced e-learning. To ensure data validity, multiple strategies were applied: triangulation across documentation, observation, and interview findings; member-checking by sharing key interpretations with selected participants for confirmation; and maintaining an audit trail of decisions made during data collection and analysis. These procedures strengthened the trustworthiness, credibility, and transferability of the research outcomes, aligning with established qualitative research standards.

4. Results and Discussion

Results

Analysis of the documentation, observations, and interviews revealed four key themes. First, infrastructural limitations remain the most pressing barrier. Participants repeatedly highlighted unreliable electricity, weak internet connectivity, and insufficient access to digital devices as core obstacles to effective e-learning. Institutional reports confirm that rural universities face especially severe resource deficits, which directly translate into unequal access for students depending on geography and socioeconomic status. Second, pedagogical and institutional capacity emerged as a major concern. During the COVID-19 pandemic, certain faculty members experimented with digital platforms, but the majority did not possess adequate training in online instructional design. Observations of classrooms and computer labs showed limited integration of digital tools beyond basic presentation software, indicating that both knowledge and institutional support for e-learning remain underdeveloped. Third, interview data underscored student and faculty perceptions of AI. Although most participants were unfamiliar with the technical details of AI, there was strong interest in the potential for intelligent tutoring systems, automated assessments, and adaptive learning tools to improve educational experiences. Students expressed enthusiasm for the possibility of AI-driven language translation and personalized support, while faculty members emphasized the need for AI systems that reduce workload and help manage large class sizes. Finally, the analysis revealed systemic governance and equity challenges. Documentation review shows that national higher education policy lacks clear frameworks for digital transformation, leaving universities to develop their own ad hoc strategies. Interviews also highlighted gender disparities: female students reported more limited access to devices and social restrictions on technology use. These findings suggest that without careful attention to inclusiveness, AI-enabled e-learning could risk amplifying existing inequalities.

Discussion

The role of e-learning in fragile states has long been debated, but recent scholarship increasingly emphasizes that its transformative potential depends on how effectively it adapts to local constraints. Afghanistan represents one of the most extreme cases of infrastructure fragility, where decades of conflict have left higher education institutions struggling with limited resources, political instability, and uneven access (Bagherimajd & khajedad, 2025). Studies in comparable contexts, such as sub-Saharan Africa and post-conflict Middle Eastern countries, have demonstrated that online education can expand access where physical campuses are limited; However, these efforts are often undermined by weak digital ecosystems (Utsumi & Muradi, 2024). The critical question is thus not whether e-learning can function in Afghanistan, but how it must be reimagined to suit an environment characterized by chronic infrastructure and governance deficits. By situating Afghanistan within this broader body of research, it becomes clear that solutions cannot rely on replicating models developed in stable, well-resourced contexts; instead, they require new frameworks that combine technology with social and institutional adaptation.

Artificial intelligence (AI) has emerged as a key element of such frameworks, offering tools that go beyond the static delivery of content typical of conventional online systems (Tian & Zhang, 2025). International studies show that AI can enable adaptive learning pathways, predictive analytics, and intelligent tutoring systems that respond dynamically to student needs. These features are particularly relevant in environments with large class sizes and limited teaching capacity, which are common in Afghan universities. However, the literature also warns against uncritical optimism. The deployment of AI in education has raised ethical questions concerning algorithmic bias, privacy, and fairness, issues that may be magnified in contexts where regulatory oversight is weak (Aderibigbe et al., 2025). What sets Afghanistan apart is not merely the lack of infrastructure but the broader political and social fragility that complicates regulation. Thus, despite its potential, AI needs to be introduced with safeguards that are frequently neglected in low-resource environments. This tension underscores the need for a balance between innovation and caution.

Another dimension worth highlighting is the relationship between technological adoption and institutional capacity. Previous study on Afghan higher education often focuses on hardware deficits, poor connectivity, lack of devices, or unreliable electricity, yet less attention has been paid to the institutional mechanisms that enable or hinder digital

transformation (Espinosa Andrade et al., 2024). Comparative studies from other fragile states demonstrate that governance, faculty training, and leadership commitment are as decisive as technical infrastructure (Katawazai, 2021). The absence of national strategies for digital education in Afghanistan leaves universities to rely on fragmented, ad hoc initiatives. This gap in governance suggests that even well-designed AI systems could fail if not embedded within coherent policies that establish standards, ensure sustainability, and coordinate resources. Importantly, the absence of such framework limits not only implementation but also trust. Faculty and students may hesitate to engage with AI tools if their legitimacy and reliability are not formally endorsed (Noori, 2021). For Afghanistan, therefore, the central issue is not simply technological feasibility but institutional readiness, which must be built alongside any technical intervention.

Socio-cultural factors add another layer of complexity to the discussion. In Afghanistan, access to technology is unevenly distributed along gender, geographic, and socioeconomic lines (Katawazai, 2021). Global literature on the digital divide consistently shows that vulnerable groups are the last to benefit from technological innovations, unless deliberate strategies are adopted to include them. AI has the potential to either widen or narrow these divides (Indrawati et al., 2025). On one hand, personalized learning tools can provide female students or those in remote areas with flexible access to educational resources that might otherwise be unavailable (Fombona et al., 2025). On the other hand, if AI platforms require continuous connectivity or advanced digital literacy, they risk reinforcing exclusion. The challenge, then, lies in ensuring that AI-enhanced e-learning is designed with inclusivity at its core, incorporating offline functionalities, multilingual support, and training initiatives that target marginalized groups. This need for inclusive design resonates with broader theoretical perspectives such as the Unified Theory of Acceptance and Use of Technology (UTAUT2), which stresses the importance of facilitating conditions and social influence in shaping adoption behaviors (Bagherimajd & khajedad, 2025). For Afghanistan, inclusivity is not an optional feature but a determinant of whether AI adoption can be successful at all.

The debate over e-learning and AI in fragile contexts also invites reflection on the nature of resilience in higher education. Education systems in conflict-affected countries are not merely tasked with transmitting knowledge but with rebuilding social capital and fostering stability. AI-enabled e-learning can contribute to resilience by creating continuity of learning in the face of disruptions, whether political, economic, or environmental (Espinosa Andrade et al., 2024). For example, intelligent platforms capable of adapting to sudden shifts in access conditions such as intermittent connectivity can sustain educational processes when traditional modes collapse. Yet resilience must also be understood institutionally: universities require the capacity to integrate technology sustainably rather than as temporary fixes. Here, Afghanistan faces the dual challenge of ensuring continuity at the micro-level of students and teachers while also institutionalizing reforms at the macro-level of policy and governance (Fombona et al., 2025). This dual focus differentiates sustainable resilience from short-term adaptation, and it is precisely this distinction that Afghan higher education must navigate in considering AI adoption.

Finally, the broader implications of integrating AI with e-learning in Afghanistan extend beyond the education sector. Higher education plays a pivotal role in preparing human capital for national development, and failures in this sector risk perpetuating cycles of poverty and instability (Emynorane et al., 2025). By enabling more efficient and personalized learning, AI could contribute to workforce readiness, skill development, and alignment with labor market demands, echoing findings from vocational education research (Yue Yim, 2024). However, such benefits will only materialize if technology adoption is coupled with investments in infrastructure, training, and governance. In fragile contexts, there is a temptation to treat technological innovation as a shortcut to development, but the evidence suggests that without systemic reforms, technology alone cannot deliver sustainable outcomes. For Afghanistan, the significance of AI lies not in replacing traditional education but in augmenting and extending it, making learning more accessible, resilient, and equitable (Espinosa Andrade et al., 2024). This discussion thus points to a strategic vision: AI-enabled e-learning should be understood not as an isolated intervention but as part of a holistic reform agenda aimed at transforming Afghan higher education into a driver of long-term national resilience and growth.

5. Comparison

Recent international research on e-learning and artificial intelligence has primarily been conducted in relatively stable or moderately resourced environments, where institutions possess the baseline infrastructure required to deploy and evaluate advanced technologies. For example, bibliometric reviews of AI in vocational and higher education emphasize its potential for personalization, automation, and alignment with Sustainable Development Goals, while systematic analyzes of adaptive platforms showcase promising outcomes in terms of student engagement and performance (Adewale et al., 2024). These studies, however, typically presuppose consistent access to electricity, reliable internet, and established digital ecosystems. In contrast, Afghanistan operates under conditions where these assumptions do not hold, making direct transfer of such models problematic. By investigating AI-enhanced e-learning in a context characterized by chronic infrastructure fragility, this study contributes a novel perspective that extends the relevance of state-of-the-art research to environments where technological deployment must contend with instability, inequality, and institutional weakness.

Equally significant is the way this research problematizes the universality of theoretical frameworks commonly applied in educational technology studies. The Technology Acceptance Model (TAM) and the Unified Theory of Acceptance and Use of Technology (UTAUT2) have been widely validated in diverse contexts, emphasizing perceptions of usefulness, ease of use, and social influence as drivers of adoption (Aderibigbe et al., 2025; Parakh et al., 2025). Yet, these models rarely account for systemic fragility, governance deficits, or socio-cultural barriers such as gender restrictions. By applying these frameworks in Afghanistan, the study highlights their limitations and suggests the need for context-sensitive adaptations that integrate structural and cultural variables. This comparative lens not only underscores the originality of the research but also makes a measurable contribution: it bridges the gap between global debates on AI in education and the realities of conflict-affected higher education systems (Boulhrir & Hamash, 2025). In doing so, Afghanistan's position is not as an outlier, but as a critical case that tests the boundaries of current theories and challenges their applicability in fragile contexts.

6. Conclusion

This study explored the potential of e-learning supported by artificial intelligence to address the persistent limitations of higher education in Afghanistan, where decades of conflict and underinvestment have left universities struggling with inadequate infrastructure, weak institutional capacity, and fragmented policy frameworks. Using documentation analysis, observation, and interviews, the research found that while conventional online learning initiatives have expanded access, they remain constrained by poor connectivity, limited training, and lack of supportive governance. At the same time, both students and faculty demonstrated openness to adopting AI-driven tools that can personalize learning, automate routine tasks, and provide support in contexts of scarce resources. These findings suggest that AI-enabled e-learning can play a meaningful role in reducing inequities and fostering resilience, particularly if designed with inclusivity and low-resource adaptability in mind. The study contributes to broader debates by highlighting the limitations of mainstream technology adoption theories when applied to fragile states, emphasizing the need to integrate structural and cultural considerations into existing models. For Afghan policymakers and educators, the results underscore the importance of coupling technological investment with faculty development, institutional support, and equity-focused policies. Nevertheless, the study is limited by its qualitative scope and concentration on selected institutions, leaving questions of scalability and cross-context generalization for future studies. Further research should examine regulatory and ethical dimensions of AI deployment in higher education, while also exploring comparative cases in other fragile states. Taken together, the study illustrates that with careful planning and inclusive design, AI-enhanced e-learning can contribute to sustainable educational reform in Afghanistan and beyond.

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