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Review article

Critical Success Factors and Challenges of AI Adoption in Higher Institute of Sciences and Technology: A Case Study of Libya

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Abstract
The integration of Artificial Intelligence in technical and vocational education stands as a powerful catalyst for preparing a workforce aligned with the demands of the Fourth Industrial Revolution. In post-conflict Libya, Higher Institutes of Science and Technology (HISTS) face a critical transition: they must recover from systemic geopolitical disruptions while modernizing their pedagogical and administrative frameworks to bridge the gap between academic theory and market realities. This systematic review investigates the critical success factors and structural challenges of adopting Artificial Intelligence in Libyan higher technical institutes. Adopting an integrated framework that synthesizes the Technology-Organization-Environment model, the Diffusion of Innovations theory, and the Technology Acceptance Model, this study analyzes empirical data compiled from multiple academic cohorts across Libya, representing over eight hundred combined institutional stakeholders. The findings reveal a significant dichotomy between user readiness and institutional capacity. While students demonstrate a highly optimistic attitude toward Artificial Intelligence, and pilot programs report academic performance gains such as a fifteen percent improvement in student grades, adoption remains severely constrained by systemic barriers. These barriers include severe technological infrastructure deficits, a sixty percent faculty training gap, linguistic biases in existing software tools, and the absence of a cohesive national regulatory framework. Conversely, proactive administrative leadership, curriculum co-design with local industries, and the localized implementation of institutional governance policies are identified as core success factors. This study synthesizes these dimensions to construct a phased, capacity-driven implementation roadmap designed to facilitate sustainable, equitable, and culturally aligned digital transformation within resource-constrained educational environments
Keywords. Artificial Intelligence, AI Adoption, Technology-Organization-Environment Framework.

Introduction

The global proliferation of generative and adaptive Artificial Intelligence (AI) technologies has initiated a profound paradigm shift in higher education, transforming instructional models, administrative workflows, and research methodologies [1]. Within technical and vocational education and training (TVET), AI-driven tools ranging from sensor-equipped simulators and intelligent tutoring systems to predictive student analytics offer unprecedented opportunities to enhance student engagement, personalize learning pathways, and bridge the gap between academic instruction and real-world application [3]. However, the trajectory of AI implementation reveals a stark geographical divide [2]. In developing and post-conflict nations, the systematic integration of AI into educational infrastructure faces severe structural and socio-political hurdles that are often overlooked in mainstream technological discourse [2].

In the State of Libya, the higher education sector is split into general university networks and specialized technical training pathways [5]. The Ministry of Technical and Vocational Education is responsible for supervising all public and private technical and vocational institutes across the nation, comprising forty-five technical colleges, one hundred and sixty Higher Institutes of Science and Technology, and four hundred intermediate vocational institutes [7]. These higher technical institutes serve a vital socio-economic function by offering specialized three-year programs leading to a Higher Diploma, particularly for secondary school graduates who score below sixty-five percent [6]. These programs span applied engineering, computer science, civil aviation, and medical technology [6]. They aim to supply the local labor market with skilled technicians and applied professionals [8].

Despite their critical mandate, Libyan technical institutes operate within an exceptionally challenging environment [10]. Following the 2011 political transition, the educational landscape has endured severe disruptions, characterized by damaged campuses, dual governance claims between competing regional administrations, and a massive brain drain of academic professionals [5]. Furthermore, technical education in Libya suffers from a persistent negative public perception; students enrolled in vocational tracks are often stigmatized as having failed academic streams, which translates to compressed salary scales and limited career progression [12]. This structural vulnerability is exacerbated by a historical mismatch between TVET curricula and market needs, leaving the domestic economy with a severe shortage of skilled human capital and high youth underemployment [11]. While national initiatives, such as the Government of National Unity's National Strategy for Higher Education and Scientific Research (2025–2035), increasingly emphasize e-learning and AI as core components of national development, actual deployment remains highly uneven [5]. Past digital transformation efforts have frequently faltered, with Learning Management Systems (LMS) turning into simple document repositories rather than interactive learning platforms due to a lack of structured pedagogical frameworks, poor internet connectivity, and low user training [15].

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To address these systemic gaps, this systematic review explores the critical success factors (CSFs) and multi-dimensional challenges of AI adoption specifically within Libyan Higher Institutes of Science and Technology. By mapping the unique institutional realities of the post-conflict Libyan TVET landscape against established technology adoption models, this article provides policy-makers, deans, and educators with an actionable, context-sensitive roadmap for sustainable digital integration.

Related Work

Socio-Economic Profile and Structural Challenges of Libyan HISTS

The Higher Institutes of Science and Technology in Libya are uniquely positioned within the national educational structure to offer applied, career-focused training [8]. Spread across diverse geographical and socioeconomic regions including Sirte, Jalu, Raqdaleen, Al-Khums, Bani Waleed, Tajoura, and Ghadamesthese institutes are designed to meet the localized technical needs of urban centers and remote communities alike [8]. However, the TVET sector has historically been constrained by a deeply entrenched hierarchy of academic values [11]. Unlike university tracks that enjoy high social prestige, technical institutes are widely perceived as a safety net for academically lower-performing students, resulting in a marginalized institutional status, poor public funding, and low graduate starting salaries [12]. This societal marginalization is reinforced by a persistent supply-driven educational model [10]. For decades, HISTS have operated in relative isolation from domestic industries, leading to highly outdated curricula, a severe shortage of modern laboratory workshops, and a lack of formal training needs analyses (TNA) among key employers [10]. A study examining technical and vocational curricula in Libyan industrial contexts revealed that only a minor fraction of students (17.7%) believed their courses were well-linked to relevant industries, whereas forty-five percent reported a total disconnect between course design and industry requirements [13]. This mismatch has severely degraded the quality of graduate outputs [11]. While Libyan manufacturing and service sectors suffer from a severe shortage of skilled domestic manpower, technical diploma holders face high underemployment due to their lack of familiarity with modern, automated industrial technologies [11]. Furthermore, the national system lacks advanced postgraduate training pathways [6]. There is currently no domestic provision for doctoral studies in science, technology, or engineering within Libya, forcing specialized technical educators to pursue qualifications abroad and contributing to a persistent deficit of expert academic staff [6],[46],[47].

Baseline Digital and E-Learning Transformation Efforts

Prior to the introduction of AI, digital transformation initiatives at Libyan technical institutes faced significant hurdles, leaving a fragile foundation for advanced system integration [25]. At the Al-Azizia Higher Institute of Science and Technology, researchers evaluated the availability of digital education transformation requirements across four primary dimensions: technical infrastructure, human resources, digital content and curricula, and administrative policies [25]. The study concluded that the availability of requirements across all four dimensions was low and weak, highlighting a lack of systemic readiness for advanced educational technologies [25]. A parallel study at the Higher Institute of Science and Technology – Khoms confirmed these findings, indicating that e-learning implementation was severely impeded by obsolete computer hardware, unstable electricity networks, and an absolute lack of high-speed campus internet access [15]. This systemic unreadiness has historically caused digital learning tools to be heavily underutilized [16],[48]. Empirical evaluations of e-learning platforms across Libyan institutions show that rather than operating as interactive, student-centered environments, LMS tools are quickly reduced to simple repositories of static PDF files [16]. This degradation stems from a lack of structured digital strategies, poor quality assurance standards, and an absence of formal pedagogical training for instructors, who struggle to transition from traditional chalk-and-board lectures to online or hybrid environments [11]. Thus, the literature establishes that the baseline technological infrastructure and human capacity in Libyan HISTS are characterized by severe structural deficits, which directly impede the transition toward advanced, data-intensive AI systems.

Methods

This systematic review employs a descriptive-analytical approach to synthesize the current state of technology adoption and AI feasibility in the Libyan higher technical education sector. To compile a robust and comprehensive empirical foundation, a structured literature search was executed up to the year 2026 across five primary academic databases: Scopus, Google Scholar, the Comprehensive Journal of Science (published by the Raqdaleen Higher Institute of Sciences and Technology), the Taj Al-Ma'rifa Journal (published by the Tajoura Higher Institute of Science and Technology), and the International Science and Technology Journal [17].

Search strings incorporated Boolean operators to pair keywords such as "artificial intelligence," "AI adoption," and "digital transformation" with "higher technical institutes," "vocational colleges," "Libya," "TOE framework," and "challenges"[1]. To ensure academic rigor and contextual relevance, the selected literature was subjected to a systematic screening process guided by three core inclusion criteria. First, eligible studies were required to present primary empirical data whether qualitative, quantitative, or mixed-methods or structured policy reviews addressing e-learning, digital transformation, or AI integration within Libyan higher education [1]. Second, the study cohort had to include key academic stakeholders, specifically faculty members, students, and administrative staff representing Libyan universities or technical colleges [20]. Third, the analytical focus was required to investigate technological, organizational, or environmental factors that influence

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technology acceptance or operational implementation [23]. This rigorous selection framework ensured that the reviewed literature was both methodologically sound and directly relevant to the Libyan higher education context, thereby strengthening the validity of the study's findings and interpretations. This systematic selection process identified a core set of empirical studies representing a cumulative cohort of over eight hundred respondents. The data synthesis relies on five key Libyan empirical datasets:

- ***The Benghazi Cohort:*** A qualitative case study conducted at the University of Benghazi involving eighteen semi-structured interviews with faculty lecturers, students, and administrators, focusing on AI-supported course outcomes and connectivity barriers [22].
- ***The Misurata Cohort:*** A quantitative survey administering online questionnaires to three hundred and forty-eight students at Misurata University, utilizing Statistical Package for the Social Sciences (SPSS) tools, Chi-Square tests, and Pearson correlation to evaluate technical efficiency, demographic influences, and ethical concerns [21].
- ***The Tripoli Cohort:*** A descriptive study evaluating AI feasibility in the information technology colleges of Tripoli University and the colleges of Electronic Technology-Tripoli, utilizing Google Form surveys with seventy-six respondents (twenty-four teachers and fifty-two students) to construct a prioritized SWOT matrix [20].
- ***The Al-Azizia and Al-Khums Baseline Studies:*** Analytical investigations measuring the availability of digital transformation requirements (infrastructure, human resources, content, and administration) at the Al-Azizia Higher Institute of Science and Technology and e-learning implementation barriers at the Higher Institute of Science and Technology – Khoms [15].

To synthesize these diverse datasets, this review adopts an integrated theoretical framework that combines the Technology-Organization-Environment (TOE) model [24], the Diffusion of Innovations (DOI) theory [23], and the Technology Acceptance Model (TAM) [26]. The TOE framework provides a robust organizational taxonomy to categorize factors into technological constraints, organizational capabilities, and environmental pressures [24]. The DOI theory explains how system compatibility, complexity, and trialability influence adoption intentions [23]. Finally, the TAM explains individual user acceptance through perceived ease of use, perceived usefulness, and user attitudes [26]. By mapping these integrated constructs against the extracted empirical data, the study identifies second- and third-order systemic implications, ultimately generating an actionable implementation framework.

Results

Academic Performance and Connectivity Bottlenecks: The Benghazi Case Study

At the University of Benghazi, a qualitative field study involving eighteen academic stakeholders explored the practical impact and operational constraints of integrating AI technologies into the curriculum [22]. The findings demonstrated a significant positive outcome, showing a fifteen percent improvement in student grades in courses supported by adaptive, AI-driven learning platforms [22]. However, the study also exposed severe infrastructural dependencies [22]. Ninety percent of the participants identified chronic internet instability as the primary barrier to successful AI integration, while sixty percent reported that they had received insufficient training to use or teach these emerging technologies effectively [22].

Student Perceptions, Barriers, and Demographics: The Misurata University Survey

To establish a broader quantitative baseline, researchers administered an online questionnaire to three hundred and forty-eight students across various faculties at Misurata University [21]. The survey evaluated student awareness, perceived academic benefits, technical challenges, and ethical concerns [21]. Statistically, the findings revealed a highly positive general perception of AI's capacity to support flexible learning, personalize resources, and enhance academic motivation [21]. Crucially, Chi-Square tests of independence demonstrated that student acceptance of AI was highly uniform and did not significantly associate with key demographic variables:

- **Gender:** No statistically significant association ($X^2 = 1.840$, df = 2, p = 0.398) [21].
- **Age:** No statistically significant association ($X^2 = 2.110$, df = 4, p = 0.716) [21].

However, the study identified a statistically significant positive correlation between a student's self-reported technical IT efficiency and their overall favorability toward AI [21]. Furthermore, positive attitudes were significantly associated with enrollment in scientific or technical academic disciplines and higher English language proficiency, as these students could easily access and navigate English-centric AI tools [21]. Despite their optimism, students identified several critical barriers. The specific mean scores (M) and standard deviations (SD) for these technical and social concerns are compiled in (Table 1):

Table 1. Perspectives of Students on Barriers to AI Usages in Libya

Structural Dimension	Survey Variable / Identified Barrier	Mean Score (M)	Standard Deviation (SD)
Technical Challenges	Inadequate campus technological infrastructure	4.40	0.59
	Insufficient user knowledge regarding AI applications	4.35	0.62
	Requirement for specialized training programs	4.11	0.75
	Complexity and difficulty of interacting with AI tools	4.04	0.85

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	Core difficulty in accessing educational AI platforms	2.24	1.22
Social & Ethical Concerns	Widening of the educational inequality gap	4.11	1.04
	Reduction in direct human face-to-face interaction	3.94	1.02
	Personal student data privacy and security vulnerabilities	3.90	0.85
	Risks of cheating, plagiarism, and scientific fraud	3.19	1.44
	Potential loss of critical thinking and independent problem-solving	2.99	1.43

Note: Mean scores are based on a five-point Likert scale, where higher values indicate greater agreement or perceived severity of the barrier [21].

Prioritized SWOT Matrix Analysis: The Tripoli Cohort

To synthesize the internal strengths and external environmental dynamics of AI integration, a study targeted the IT colleges of Tripoli University and the colleges of Electronic Technology-Tripoli [20]. Using Google Forms surveys from 76 respondents (24 teachers and 52 students), the researchers conducted a prioritized SWOT analysis [20]. The top-prioritized factors from this environmental analysis are organized in the matrix shown in (Table 2):

Table 2. SWOT Matrix Analyses of Top Prioritised Factors

Internal Strengths (S)	**Internal Weaknesses (W)**
1. Advanced learning tools (simulations, adaptive tutors) [20] 2. Predictive analytics for student outcomes [20] 3. Data-driven insights for instructional improvement [20] 4. Support for lifelong and self-paced learning [20] 5. Step-by-step problem-solving assistance [20] 6. Explainable AI models (LIME, SHAP) for transparency [20]	1. Absolute lack of standardization in AI applications [20] 2. Severe skill gap in AI literacy among staff [20] 3. Quality and accuracy concerns (grading errors, hallucinations) [20] 4. Lack of funding for research and training centers [20] 5. High risk of student over-reliance on automated tools [20] 6. Sensitive data privacy and security concerns [20] 7. Limited local R&D facilities [20]
External Opportunities (O)	**External Threats (T)**
1. Intelligent systems to optimize resource allocation [20] 2. Virtual classrooms for remote learning [20] 3. Enhanced overall student satisfaction and performance [20] 4. Advanced data analytics supporting decision-making [20] 5. Scientific simulations in virtual laboratories [20]	1. Severe reduction in direct human educational interaction [20] 2. Rapid decline in student critical thinking skills [20] 3. Systemic lack of institutional and structural readiness [20] 4. Onerous financial and budget constraints [20] 5. Growing technical skill gap among student cohorts [20] 6. Chronic telecommunication and internet service interruptions [20]

Note: prioritized SWOT factors are organized and synthesized from the empirical rankings of the Tripoli electronic and IT colleges cohort [20].

Discussion

International TVET Benchmarks in AI Adoption

When compared with international TVET settings, the challenges faced by Libyan technical institutes are both unique and representative of broader global trends [2]. In more stable developing contexts, such as Malaysia, empirical studies show a very high rate of informal AI adoption among students [4]. At Politeknik Melaka, eighty-eight percent of polytechnic students frequently utilize generative AI tools like ChatGPT and QuillBot for academic tasks [32]. However, this rapid adoption has created significant institutional friction, particularly regarding academic honesty and data privacy [32]. TVET researchers warn that excessive reliance on virtual simulations and generative assistants risks degrading hands-on, practical competencies and manual problem-solving skills, which are the core of technical education [32],[45]. Furthermore, global research demonstrates that successful AI integration in technical education requires moving beyond simple software access [4].

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Case studies of European TVET leaders (such as TU Dublin in Ireland and SFUVET in Switzerland) emphasize that AI must be integrated with robust local governance, continuous staff training, and deep curriculum alignment with changing labor market demands [34]. The OECD's guiding principles for AI in vocational development highlight that because VET has unique hands-on characteristics, general university AI policies are insufficient [33]. Instead, institutions require targeted capacity-building, clear data-sharing agreements, and structured human-in-the-loop validation to maintain educational quality and trust [33].

Theoretical Synthesis of the Integrated TOE Framework

By synthesizing the empirical findings from Benghazi, Misurata, Tripoli, Al-Azizia, and Al-Khums against international benchmarks, this review maps the multi-dimensional dynamics of AI adoption in Libyan technical institutes [20]. The integrated TOE-DOI-TAM model explains how technological limitations, organizational capacity, and environmental pressures interact to influence actual adoption outcomes [23].

Technological Context: The Infrastructure-Sovereignty Paradox

The technological dimension of AI adoption in Libyan HISTS is shaped by a profound paradox: while advanced AI models possess a demonstrated capacity to improve academic grades by fifteen percent, their operational dependency on constant, high-bandwidth connectivity renders them highly vulnerable in Libya's unstable telecommunications landscape [22]. The quantitative data showing that ninety percent of Benghazi participants identify internet instability as a primary barrier, and that Misurata students rate campus infrastructure deficits as their most severe challenge ($M = 4.40$, $SD = 0.59$), indicate that cloud-dependent AI tools are highly impractical for daily instruction [21]. Furthermore, because technical institutes require heavy data loads to run advanced engineering, grid-connected solar carport simulations, and predictive maintenance software, legacy computer networks in HISTS are quickly overwhelmed [25]. This technological vulnerability is compounded by severe linguistic biases in modern AI architectures [2]. Because the majority of leading generative tools are trained on English-language datasets, their processing accuracy, contextual understanding, and speed drop dramatically when handling Arabic, particularly local Libyan dialects [20].

The Misurata survey confirms a statistically significant association between English language proficiency and a positive student attitude toward AI [21]. Students with poor English skills face a double barrier: they must struggle with technical subject matter while simultaneously navigating a foreign-language software interface [20]. Additionally, because Libyan technical institutes lack localized, on-premise servers and high-quality Arabic educational corpora, they are forced to rely on external cloud platforms, which exposes sensitive institutional and student data to international security risks ($M = 3.90$, $SD = 0.85$) [20].

Organizational Context: Leadership Support and Faculty Friction

At the organizational level, successful AI integration depends on institutional readiness and administrative commitment [38]. However, quantitative modeling (PLS-SEM) of HEI technology adoption reveals that while individual user attitudes are driven by perceived ease of use, overall institutional readiness is heavily dependent on external environmental factors and structured administrative support [26]. In Libyan HISTS, this organizational readiness is currently very low, characterized by obsolete administrative policies, limited R&D funding, and a massive sixty percent faculty training deficit [20]. This human capital gap creates significant instructional friction; while students are highly motivated and rapidly adopt informal AI tools, faculty members often lack the technical expertise or pedagogical guidelines required to integrate these tools into their teaching or assessments [21]. To resolve this imbalance, proactive institutional leadership and targeted capacity-building are critical success factors [39]. When administrators actively commit resources and establish structured support systems, faculty anxiety and resistance to change decrease [39]. In Libya, some technical institutes are beginning to demonstrate this proactive leadership [41]. In December 2025, the Higher Institute of Science and Technology – Sirte officially inaugurated a dedicated, state-of-the-art Artificial Intelligence Laboratory, establishing a localized center for practical learning and faculty professional development [41]. At the national level, collaborations like the July 2024 partnership between the Islamic World Educational, Scientific, and Cultural Organization (ICESCO) and the Libyan Ministry of Education have launched targeted training workshops to equip administrative officials with the skills needed to apply AI in educational planning and establish national foresight units [42]. For individual HISTS, institutionalizing these professional development programs is a vital CSF to ensure that faculty members can confidently guide and assess hybrid learning [27].

Environmental Context: Market Integration and the Regulatory Vacuum

The environmental context of AI adoption in Libyan technical institutes is shaped by the urgent need to align graduate skills with industry demands and the absence of national governance [20]. The primary socioeconomic mandate of HISTS is to graduate technically proficient personnel who can drive local economic development [8]. However, given the historical mismatch between academic curricula and market requirements, integrating AI into applied engineering, electrical networks, and medical laboratory programs offers a powerful mechanism to revitalize the TVET sector and prepare graduates for the contemporary workforce [4]. Building robust, collaborative partnerships with domestic industries to co-design AI-driven curricula and facilitate hands-on student internships is therefore a vital CSF for technical institutes [24]. Simultaneously, HISTS must navigate a complete national regulatory vacuum [20]. The state currently lacks unified laws,

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ethical codes, or standardized quality controls for AI deployment in higher education, leaving individual deans and academic boards to manage complex issues of data privacy, intellectual property, and academic fraud in isolation [20].In response to this administrative void, proactive technical institutes are establishing localized governance frameworks [44]. For example, the Taj Al-Ma'rifa Journal, published by the Tajoura Higher Institute of Science and Technology, implemented a comprehensive, formal AI usage policy [19]. This policy explicitly establishes clear boundaries for the use of artificial intelligence in scientific publishing. First, AI tools cannot be listed as authors or co-authors on any submissions, since authorship requires legal accountability and copyright ownership, responsibilities that AI systems cannot assume [19]. Second, while the use of AI for language editing and basic proofreading is permitted, the generation of entire research sections through AI assistance is strictly prohibited [19]. Third, authors are required to submit a formal disclosure statement specifying the exact software tool, its version, and the section of the manuscript where AI was applied [19]. Finally, peer reviewers are prohibited from uploading manuscripts to public AI tools in order to safeguard the confidentiality and intellectual property of the authors [19]. By codifying these principles, the policy ensures both the integrity of scholarly authorship and the responsible integration of AI into the research and review process. By establishing these clear, transparent guidelines, Tajoura HISTS protects academic integrity while permitting responsible technology use, providing a highly scalable governance model for other technical institutes [19].

Macro-Level Cascading Effects and Systemic Barriers

A deeper, second-order analysis of the empirical findings exposes several critical, systemic risks that could undermine the sustainability of AI integration if not addressed by national policy-makers. First, there is a severe risk that the uncoordinated adoption of AI will widen the existing domestic inequality gap [21]. The quantitative data from Misurata indicates that students view the potential widening of the educational gap as their most pressing social concern ($M = 4.11$, $SD = 1.04$) [21]. In Libya's post-conflict economy, well-funded urban institutes (such as those in Sirte, Tajoura, or Tripoli) can secure international development funding, stable electrical microgrids, and dedicated AI laboratories [5]. Conversely, remote oasis institutes (such as the Higher Institute of Medical Sciences and Technology in Jalu, or the HISTS in Ghadames) suffer from chronic underfunding, geographic isolation, and unstable telecommunications [9]. If national strategies do not actively prioritize resource equity and subsidize digital infrastructure for peripheral institutes, the transition to advanced, AI-driven learning will disproportionately benefit urban students, further marginalizing remote and underserved communities [9]. Second, a dangerous causal loop exists between faculty training deficits and student behavior [22]. When eighty-eight percent of students frequently use generative AI tools to complete coursework [32], but sixty percent of instructors lack the training to detect or guide this use [22], conventional assessment methods break down. Instructors who cannot distinguish between original student work and AI-generated text are highly likely to assign grades that do not accurately reflect student competencies [32]. Over time, this dynamic can lead to a decline in students' independent problem-solving and critical thinking skills a significant concern identified by the Misurata cohort ($M = 2.99$, $SD = 1.43$) [21]. This shift risks devaluing the High Diploma qualification itself, as employers may lose confidence in the actual practical skills of technical graduates, ultimately undermining the economic credibility of the entire HISTS sector [2]. Third, there is an epistemic concern regarding the uncritical adoption of Western-built AI technologies in Libyan classrooms [2]. Because Libyan HISTS lack localized data infrastructures and dedicated research funding [20], they must rely on external, cloud-based software developed in Western or East Asian contexts [2]. These systems carry specific embedded cultural norms, epistemic assumptions, and algorithmic biases that may not align with local values, religious traditions, or indigenous knowledge systems [2]. Adopting these tools without localization or critical pedagogical reflection can lead to a form of digital neo-colonialism, where local technical practices and cultural sensitivities are systematically marginalized by global algorithmic standards [2].

Strategic Roadmap for AI implementation in Libya

To guide administrative leaders and policymakers, this study proposes a phased, evidence-based strategic roadmap tailored to the resource-constrained realities of the Libyan technical education sector. The implementation phases, strategic timeline, measures and activities, target TOE, and key deliverables and expected outcomes are given in (Table 3).

Table 3. Recommended Roadmap Towards Successful AI Implementation

Implementation Phase	**Strategic Timeline**	**Actionable Measures and Core Activities**	**Target TOE Dimensions**	**Key Deliverables and Expected Outcomes**
Phase 1: Governance and Ethical Foundations	Months 1-3	Draft and implement institutional AI usage policies modelled on Taj Al-Ma'rifa standards; establish academic integrity guidelines; and form ethics review committees to monitor data use.	Environmental, Organizational	Formal AI codes of conduct; transparent guidelines for students and faculty; and established ethical oversight.
Phase 2: Infrastructure and Local Adaptation	Months 4-9	Upgrade campus computer labs; deploy offline-compatible or low-bandwidth AI applications to bypass connectivity barriers; and	Technological	Reliable local access points; reduced dependence on high-bandwidth cloud

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		select bilingual (Arabic-English) localized tools.		systems; and improved access for non-English speakers.
Phase 3: Capacity Building and Faculty Empowerment	Months 10-15	Execute mandatory professional development workshops to address the sixty percent training gap; train faculty in prompt engineering and AI-resilient assessments; and reduce technical friction.	Organizational	Certified, AI-literate faculty capable of redesigning curricula and confidently grading hybrid work.
Phase 4: Curricular Alignment and Industry Integration	Months 16-24	Partner with local industrial, medical, and energy companies to co-develop AI-driven simulators and graduation projects, aligning student skills with 4IR demands.	Environmental, Technological	Applied curriculum aligned with market needs, leading to improved graduate employability and technical innovation.

Conclusion

This systematic review demonstrates that the integration of Artificial Intelligence within Libyan Higher Institutes of Science and Technology is a complex, double-edged process. While AI offers clear academic benefits—as evidenced by fifteen percent grade improvements in technology-supported learning successful adoption depends on aligning technical infrastructure, organizational capacity, and environmental regulations. HISTS cannot achieve sustainable digital transformation through isolated software pilots; instead, they require a coordinated strategy that addresses persistent infrastructural deficits, faculty training gaps, and ethical vulnerabilities. By systematically executing this phased roadmap, Libyan Higher Institutes of Science and Technology can move beyond fragmented, unstable technology use. Aligning infrastructure investments with structured professional development and robust ethical guidelines will allow HISTS to harness the transformative potential of AI. This approach will enable them to modernize technical education, improve academic performance, and supply the Libyan labor market with highly skilled, future-ready technical professionals.

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Conflicts of Interest

The authors declare no conflicts of interest.

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