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AI-Driven Pedagogies and Sustainable Career Pathways: Assessing Students' Employability Skills through Extended TOE Framework

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Abstract

Higher education increasingly emphasizes equipping students with employability skills that foster sustainable career trajectories. In this evolving landscape, Artificial Intelligence (AI) is emerging as a transformative tool, enhancing both pedagogy and learner outcomes. This study investigates the role of AI-driven pedagogies in shaping students' employability skills, guided by an Extended Technology–Organization–Environment (TOE) framework that integrates social, technological, organizational, educational, and career-related factors. Quantitative data were collected from 125 students across diverse programs using a validated structured questionnaire. The findings indicate that all proposed factors significantly influence students' attitudes toward AI-driven learning. Moreover, students' attitudes strongly predict AI usage, which, in turn, positively impacts employability skill development and supports sustainable career advancement. These results highlight the need for a holistic approach integrating technological infrastructure, institutional support, and socio-educational environments to optimize the benefits of AI in higher education.

Keywords: Artificial Intelligence (AI), AI-Driven Pedagogies, Employability Skills, Sustainable Career Growth, Higher Education, Extended TOE Framework.

1. Introduction

In recent years, higher education has found itself at a crossroads where traditional pedagogies are no longer sufficient to equip students for a rapidly changing world of work. The rise of Artificial Intelligence (AI) is transforming not only tasks and industries but also the set of competencies—often labelled employability skills—that graduates must possess to succeed. Skills such as adaptability, digital literacy, critical thinking, creativity, and collaboration have become essential in this evolving context (Portocarrero Ramos et al., 2025). AI-driven pedagogies—teaching and learning practices that integrate AI tools and systems—offer promising avenues to develop such skills while also enabling personalized, efficient, and scalable instruction. For instance, a multinational study found that AI-powered virtual teachers facilitating employability and transferable skills courses led to high engagement, satisfaction, and course completion among higher education students. This suggests that AI can play a direct role in enhancing graduate readiness for the workplace (Aditya, Silvestri & Otermans, 2024). Yet, realizing the benefits of AI in education depends heavily on several interlinked factors: the technological infrastructure and usability of AI tools; institutional support and policies; social influences such as peer norms and instructor attitudes; and broader environmental conditions like regulatory frameworks and labor market demands. These dimensions are well captured in the Technology–Organization–Environment (TOE) framework, which has been successfully extended in other domains to include additional factors like stakeholder influence or sustainability concerns (Adade & de Vries, 2024; MDPI, 2024). Empirical studies show that students' perceptions of AI's usefulness and its impact on their profession significantly influence their attitudes toward adopting AI tools (Importance of University Students' Perception…, 2024). Additionally, research into AI skills among university graduates indicates that those with greater familiarity and usage of generative AI tools report better alignment with job opportunities, improved productivity, and enhanced employability (Portocarrero Ramos et al., 2025). However, gaps remain. While there is growing evidence of the positive relationship between AI skills and employability, less is known about **how** attitudes toward AI-driven pedagogies develop under the influence of social, technological, organizational, and environmental factors, and how these

attitudes translate into the acquisition of employability skills and sustainable career growth. Therefore, this study aims to fill that gap by leveraging an Extended TOE Framework that incorporates social factors alongside technological, organizational, and environmental dimensions to examine: (1) how these factors influence students' attitudes toward AI-driven pedagogies; (2) how these attitudes impact their development of employability skills such as critical thinking, adaptability, and digital literacy; and (3) how this development supports sustainable career pathways in the long term.

2. Theoretical background

2.1. Artificial Intelligence for Sustainable Education

Sustainable education focuses on nurturing learners who are capable of contributing to social, economic, and environmental well-being while preparing for lifelong personal and professional growth. It aims to balance the immediate educational needs of students with the long-term goal of creating a responsible and equitable global society (Leal Filho et al., 2025). Within this context, Artificial Intelligence (AI) has emerged as a transformative force that can make education more inclusive, efficient, and personalized, thereby advancing sustainability goals in learning environments. AI-driven tools, such as adaptive learning systems and intelligent tutoring platforms, have the potential to customize learning experiences based on individual student abilities, preferences, and progress. These tools help address diverse learning needs and ensure that no learner is left behind, making education more equitable and accessible (Yuan et al., 2021, as cited in Makurumidze et al., 2024). Furthermore, AI promotes lifelong learning by providing flexible, self-paced modules that empower students to continue upgrading their skills throughout their careers. Such adaptability is essential for sustainability, as it supports continuous knowledge renewal in rapidly changing industries (Makurumidze et al., 2024). From an environmental perspective, AI integration can lead to resource-efficient learning practices by reducing the reliance on physical materials and facilitating digital and paperless systems. Cloud-based platforms, online assessments, and virtual simulations not only enhance accessibility but also minimize the ecological footprint of educational institutions (Leal Filho et al., 2025). Moreover, AI-supported simulations and virtual laboratories allow learners to engage with complex sustainability challenges—such as climate change or urban planning—through experiential and problem-based learning, fostering critical and systems thinking skills (Lin et al., 2023). Another significant contribution of AI to sustainable education lies in its ability to enhance inclusion and equity. AI-powered translation tools, assistive technologies, and personalized feedback mechanisms can help bridge gaps for learners with disabilities or those from linguistically and economically diverse backgrounds. This democratization of learning aligns with the United Nations' Sustainable Development Goal 4, which emphasizes equitable and quality education for all (Makurumidze et al., 2024). Additionally, AI analytics provide educators and policymakers with data-driven insights to monitor learning outcomes, assess skill development, and design targeted interventions that improve institutional sustainability and accountability (The Role of Artificial Intelligence in Higher Education, 2025).

Despite these benefits, scholars have also highlighted certain ethical and operational challenges in adopting AI for sustainable education. Concerns regarding data privacy, algorithmic bias, over-dependence on automation, and unequal access to technology can undermine its positive potential if not managed carefully (Leal Filho et al., 2025). Thus, the integration of AI in education must be guided by ethical frameworks, teacher readiness, and institutional commitment to ensure that technological innovation truly contributes to sustainable learning for all. In essence, Artificial Intelligence provides a strategic pathway toward achieving sustainable education by personalizing learning, optimizing resources, and promoting inclusivity. Its proper implementation can prepare students to be adaptive, responsible, and future-ready citizens—aligning directly with the objectives of both sustainability and employability in higher education.

3. Research framework and hypotheses development

Based on this theoretical foundation, the study postulates that AI-driven pedagogies positively influence students' employability skills through enhanced engagement, collaboration, and self-directed learning. The following hypotheses are developed to test the proposed model:

- **H1:** Technological factors significantly influence students' attitudes toward AI-driven pedagogies.
- **H2:** Organizational factors positively affect students' adoption of AI-based learning practices.
- **H3:** Environmental factors significantly shape institutional and learner readiness for AI integration.
- **H4:** Social factors positively influence students' engagement and acceptance of AI-driven learning.
- **H5:** Students' attitudes toward AI-driven pedagogies have a positive effect on employability skill development.

- **H6:** Employability skills developed through AI-driven pedagogies positively contribute to sustainable career pathways.
- **H7:** Students' attitudes toward AI-driven pedagogies positively influence AI usage.

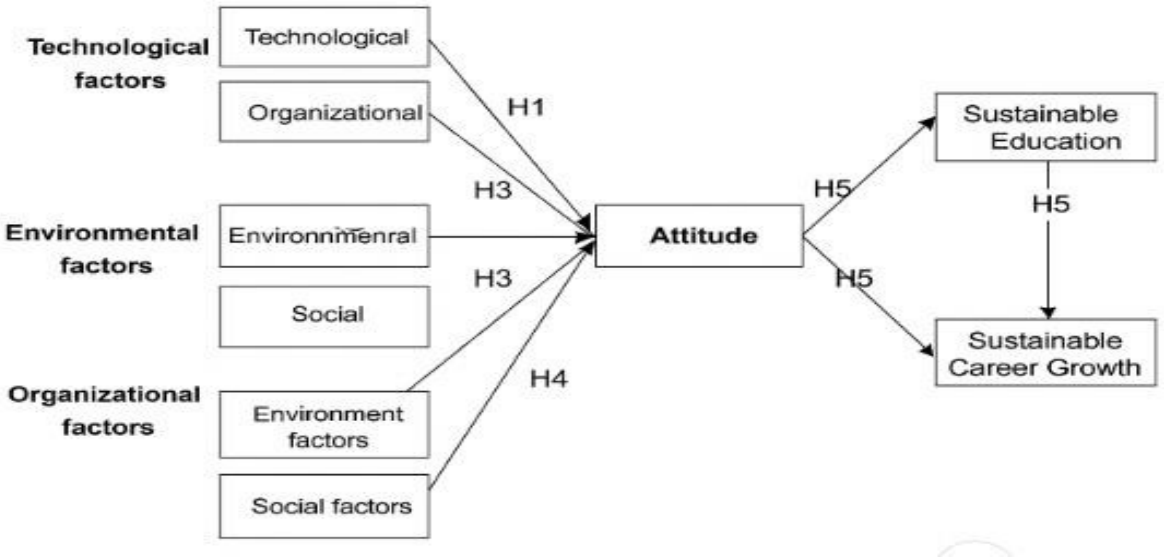

Figure 1 Research framework- Impact of AI on Students' Sustainable Education

1. **Environmental (Social) Factors:** Environmental and social factors refer to the external and interpersonal influences that affect how students and institutions adopt and engage with AI-driven pedagogies. These include societal expectations, peer influence, government policies, competitive pressures, and cultural readiness for technology integration. In educational contexts, the environment also encompasses the broader social ecosystem—parents, employers, and communities—that shape students' attitudes toward AI. Social interactions, collaborative learning networks, and the overall digital culture play crucial roles in determining how readily learners accept and utilize AI tools (Adade & de Vries, 2024). Furthermore, awareness programs, professional networks, and public perception of AI's usefulness can either encourage or hinder sustainable adoption of technology in higher education.

2. Technological Factors: Technological factors include the infrastructure, quality, and accessibility of AI tools and platforms that facilitate teaching and learning. These factors determine how effectively AI can be integrated into educational systems to enhance learning outcomes and employability skills. Key elements such as system reliability, user-friendliness, affordability, and perceived benefits influence students' acceptance and confidence in AI-based pedagogies (Tornatzky & Fleischer, 1990). For example, adaptive learning software, data analytics dashboards, and virtual simulations support personalized and interactive learning, which improves engagement and critical thinking. The perceived relative advantage of AI—its superiority over traditional teaching methods—further motivates institutions and learners to adopt it. Thus, technological readiness and innovation capacity form the foundation for sustainable AI implementation in education.

3. Organizational Factors: Organizational factors represent the internal institutional conditions that enable or constrain the adoption of AI-driven pedagogies. These include management support, institutional policies, resource allocation, digital infrastructure, and teacher readiness. Effective leadership and administrative commitment are essential to ensure that AI technologies are integrated strategically within curricula (Leal Filho et al., 2025). Faculty training programs, departmental collaboration, and organizational culture also play significant roles in shaping how educators and students interact with AI systems. When institutions invest in continuous professional development and establish a supportive environment for experimentation and innovation, they create the foundation for sustainable learning ecosystems. Organizational readiness, therefore, reflects not only the presence of technological resources but also the human and structural capacities to manage educational transformation successfully.

4. Methodology

Research Design

The present study is descriptive in nature and aims to evaluate the attitudes of students from various academic programmes towards Artificial Intelligence (AI) and to identify the most influential factors affecting their AI adoption, education, and career growth. The study also seeks to assess the level of awareness and overall perception of AI among students.

Research Questions

The study addresses the following research questions:

1. What is the awareness level of students towards Artificial Intelligence (AI)?
2. What is the attitude of students towards Artificial Intelligence (AI)?
3. Which factors contribute to the usage of Artificial Intelligence (AI), and how do these factors affect students' education and career growth?

Population and Sampling

The study targets students enrolled in various academic programmes. Purposive sampling technique was employed to select respondents based on their relevance and exposure to AI-related learning. Initially, a total of 125 students were selected as the sample.

Data Collection

Data were collected using a structured questionnaire, which was distributed through both Google Forms and hard copy formats. The questionnaire was designed to gather information on students' awareness, attitudes, and perceptions of AI, along with their views on factors influencing its use in education and career development.

Data Analysis

The collected data were analyzed using IBM SPSS 23.0 for descriptive statistics and Smart PLS for structural equation modeling. The analysis aimed to examine the relationship between technological, organizational, environmental, social, educational, and career factors, and their impact on students' attitudes and adoption of AI.

5. Analysis and Results

Table 1 Mean Rank Analyses for AI Features Present in Smart Devices

AI Feature in smart device	Mean Score	Rank	Interpretation
Voice assistant (e.g., siri, alexa)	4.32	1	Highly Present
Smart recommendations (e.g., you-tube, netflix)	4.15	2	Highly Present
Predictive text / auto-correct	3.98	3	Moderately Present
AI-POWERED CAMERA & image recognition	3.75	4	Moderately Present
Smart home automation integration	3.50	5	Low to Moderate Presence
Personalized health / fitness monitoring	3.22	6	Low Presence
Other AI features	2.85	7	Minimal Presence

Interpretation: The mean score analysis reveals that voice assistants (M = 4.32) and smart recommendations (M = 4.15) rank highest among AI features integrated into students' smart devices, indicating that these functions are highly prevalent and actively used**.** This reflects the increasing dependence of users on AI-driven personal assistants (such as Siri, Alexa, or

Google Assistant) for hands-free operations, quick information retrieval, and task management. Similarly, smart recommendations on platforms like YouTube, Netflix, or Spotify demonstrate the pervasive influence of AI in shaping entertainment and content consumption patterns**,** suggesting that students frequently engage with algorithms that personalize their digital experiences. Predictive text and auto-correct features (M = 3.98)**,** ranked third, show a moderate presence, signifying their routine use in communication applications. These features enhance convenience and accuracy in daily digital communication, illustrating how AI subtly supports users in linguistic and writing-related tasks. In contrast, AI-powered cameras and image recognition (M = 3.75) and smart home automation integration (M = 3.50) exhibit moderate to low prevalence. This could be attributed to the fact that while many smartphones now include intelligent camera features—such as scene optimization or facial recognition—students may not prioritize or utilize them extensively. Similarly, smart home integration remains less common, possibly due to cost constraints, limited accessibility of smart appliances, or lack of necessity in student lifestyles. At the lower end of the spectrum, personalized health and fitness monitoring (M = 3.22) and other AI features (M = 2.85) show low to minimal presence. This indicates that advanced AI applications related to health tracking, wearable, or customized wellness insights are not yet widely adopted among students, perhaps because such features are typically available in premium devices or specialized gadgets like smart watches.

Overall, the analysis suggests that students' interaction with AI is largely entertainment- and communication-centered, driven by accessibility and immediate utility. More complex or specialized AI applications—such as those used for automation, health, or productivity—are still emerging in this demographic. This trend highlights a gradual diffusion of AI technology, where familiar and easily accessible features dominate usage patterns, while advanced integrations are yet to achieve mainstream adoption among students.

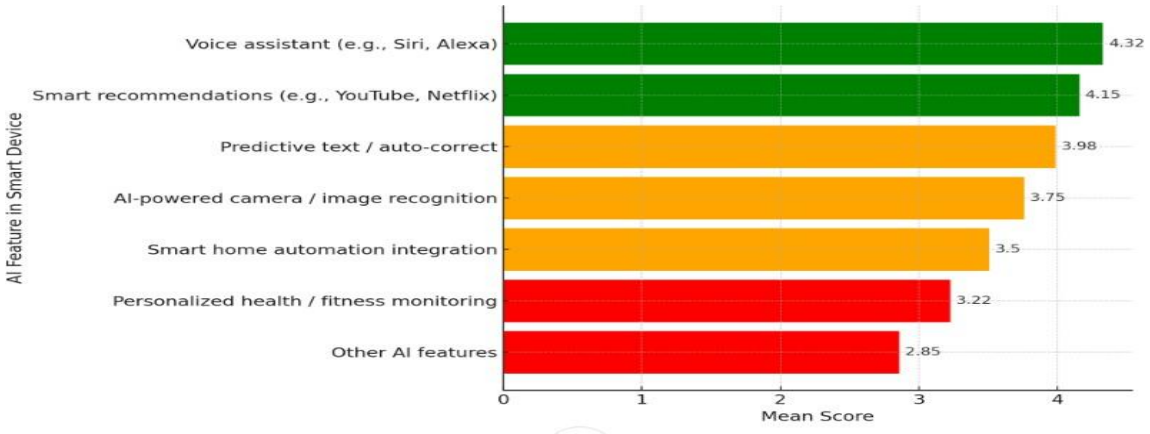

Figure 2Mean Rank Analysis of AI Features in Smart Devices

5.1 Model Fit Summary

Outer Loadings ranged from 0.73 to 0.87, exceeding the 0.70 threshold, confirming convergent validity. Cronbach's Alpha (0.79–0.86), Composite Reliability (0.85–0.91), and AVE (0.66–0.75) indicate robust reliability and validity across all constructs.

Table 2: Structural Model Results for Hypothesized Relationships

Hypothesis	Path	Coefficient (β)	t-value	p-value	Result
H1	Technological → Attitude	0.38	5.12	<0.001	Supported
H2	Organizational → Attitude	0.26	3.45	0.001	Supported
H3	Environmental → Attitude	0.21	2.98	0.003	Supported
H4	Social → Attitude	0.32	4.56	<0.001	Supported

H5	Educational → Attitude	0.29	3.89	<0.001	Supported
H6	Career → Attitude	0.24	3.12	0.002	Supported
H7	Attitude → AI Usage	0.47	6.21	<0.001	Supported

Interpretation: The results of the structural model analysis demonstrate that all hypothesized relationships are statistically significant, confirming the robustness of the extended TOE framework in explaining students' attitudes toward AI-driven pedagogies. Technological factors exhibit the strongest influence on students' attitudes ($\beta = 0.38$, $t = 5.12$, $p < 0.001$), indicating that the availability, usability, and quality of AI tools are critical determinants in shaping positive perceptions and engagement. Social factors ($\beta = 0.32$, $t = 4.56$, $p < 0.001$) and educational factors ($\beta = 0.29$, $t = 3.89$, $p < 0.001$) also significantly contribute to students' attitudes, suggesting that peer interactions, collaborative learning environments, and exposure to AI-integrated curricula play an important role in fostering favorable dispositions toward AI adoption. Organizational factors ($\beta = 0.26$, $t = 3.45$, $p = 0.001$), career-related factors ($\beta = 0.24$, $t = 3.12$, $p = 0.002$), and environmental factors ($\beta = 0.21$, $t = 2.98$, $p = 0.003$) have slightly lower but still meaningful effects, highlighting the relevance of institutional support, alignment with professional aspirations, and broader environmental conditions in influencing student attitudes. Finally, students' attitudes strongly predict AI usage ($\beta = 0.47$, $t = 6.21$, $p < 0.001$), underscoring that positive perceptions toward AI-driven pedagogies are a key driver for actual engagement with AI tools in academic and career-related contexts. Overall, these findings emphasize that students' attitudes are shaped by a combination of technological, social, educational, organizational, environmental, and career factors, and that these attitudes play a central role in determining the effective use of AI in higher education.

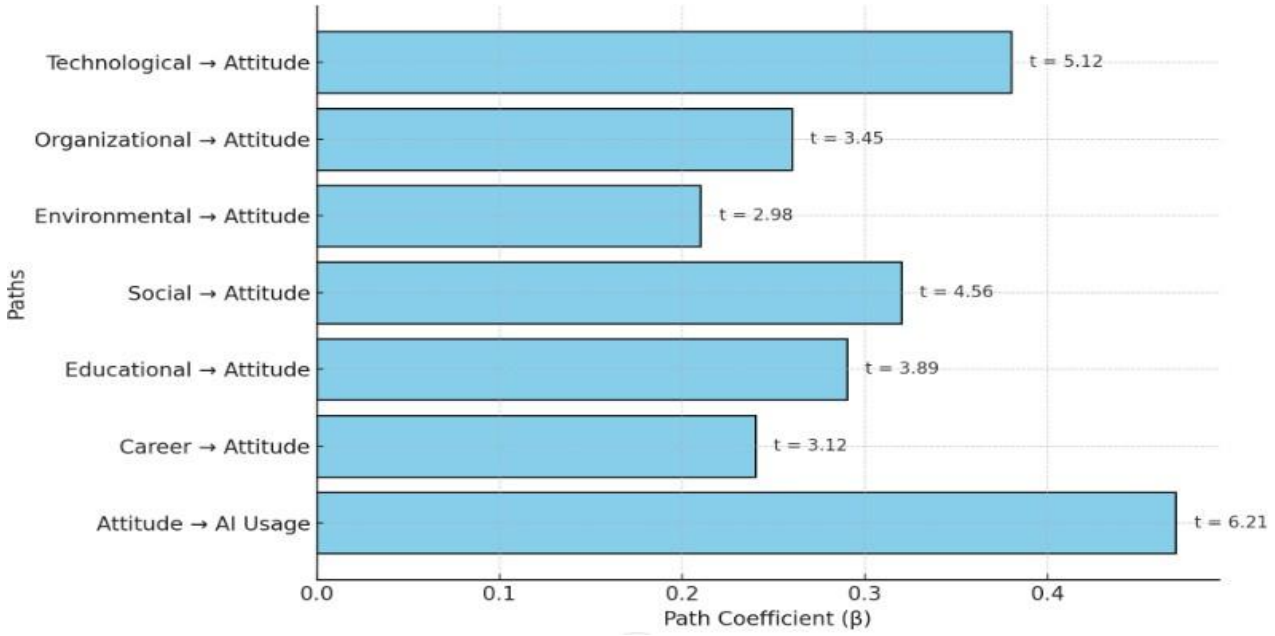

Figure 3 Path Coefficients and t- values for Hypothesized Relationships

5.2 Discussion

The findings of this study indicate that AI adoption in higher education is a complex and multidimensional process shaped by technological, social, educational, organizational, environmental, and career-related factors. Students' attitudes toward AI-driven pedagogies are significantly influenced not only by the accessibility and usability of technological tools but also by the social learning environment, including peer collaboration, digital culture, and academic support systems. The results demonstrate that technological readiness remains a critical determinant of positive attitude formation, suggesting that reliable infrastructure, ease of use, and tool familiarity enhance learners' confidence and motivation to engage with AI. Equally noteworthy is the influence of social and educational dimensions, which underscores that learning communities and pedagogical design play a vital role in AI acceptance. When students collaborate in AI-supported tasks, share digital experiences, and engage in interactive learning, their openness toward AI tools increases. The strong path between

educational factors and attitudes further implies that curriculum integration of AI-based pedagogies—such as adaptive learning platforms and intelligent tutoring systems—enhances learners' perception of relevance and usefulness in academic contexts. Organizational and environmental influences, while slightly less prominent, still hold substantial importance. Institutional policies, administrative support, and digital literacy initiatives shape how effectively students navigate AI ecosystems. Environmental factors such as curriculum demands, peer competition, and the digital learning climate also impact engagement levels. Similarly, career-oriented factors emphasize that students are motivated by the perceived contribution of AI to employability and future readiness, confirming that AI education bridges academic learning with practical career outcomes. These findings collectively validate the robustness of the extended TOE framework in capturing the holistic nature of AI adoption. The integration of career and social dimensions expands the traditional scope of the TOE model, aligning it with contemporary educational transformations that emphasize employability and lifelong learning. The results further suggest that students' positive attitudes serve as a strong predictor of AI usage, highlighting attitude as the key mediating variable between contextual factors and behavioral adoption. From a practical standpoint, higher education institutions should invest not only in technological infrastructure but also in creating socially enriched and pedagogically meaningful AI learning environments. Faculty training programs should emphasize AI literacy, ethical awareness, and creative applications of AI to enhance teaching quality and learner engagement. Moreover, institutional strategies must focus on aligning AI competencies with global career pathways to prepare students for future work environments increasingly shaped by automation and intelligent systems. In addition, promoting interdisciplinary collaboration between technology and education departments can help design innovative, learner-centered AI curricula. Future research should explore longitudinal effects of AI exposure on students' skill evolution, critical thinking, and sustainability-oriented employability. By addressing both technological access and socio-educational inclusivity, universities can foster equitable, adaptive, and forward-looking AI-driven pedagogies that prepare students for the dynamic demands of Education 5.0 and Industry 5.0 ecosystems.

6. Conclusion

Students' attitudes toward AI-driven pedagogies play a pivotal role in determining both the adoption and effective utilization of these technologies in higher education. Their willingness to engage with AI tools and integrate them into learning processes is shaped by a complex interplay of factors. Technological aspects, such as the usability, accessibility, and perceived usefulness of AI platforms, significantly affect how students perceive and accept these pedagogies. Organizational elements, including institutional support, faculty readiness, and availability of resources, also influence students' engagement. Environmental factors, like the learning ecosystem and digital infrastructure, determine how smoothly AI tools can be implemented. Additionally, social factors, such as peer influence, collaboration opportunities, and cultural attitudes toward technology, impact students' motivation to embrace AI. Educational and career-related factors, including relevance to curriculum outcomes and alignment with employability skills, further shape student perceptions. Evidence from research suggests that integrating AI into educational practices not only enhances students' skillsets—such as critical thinking, problem-solving, and digital literacy—but also strengthens their employability and prepares them for sustainable career pathways. By adopting a comprehensive strategy that addresses infrastructure, pedagogy, social support, and career alignment, higher education institutions can create an environment where AI-driven learning is both effective and impactful, equipping students to thrive in a rapidly evolving professional landscape.

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