Evaluating the impact of artificial intelligence integration on sustainable learning outcomes in Saudi Arabian higher education institutions

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Abstract

The study examines the role of incorporating Artificial Intelligence (AI) in advancing sustainable learning within institutions of higher education in Saudi Arabia as it relates to Sustainable Development Goal 4 (SDG 4) and Saudi Vision 2030. A survey cross-sectional design (quantitative) was employed using a sample of 400 participants at various universities. Data analyses were performed using SPSS to understand the relationship between AI adoption, the ICT infrastructure of the institution, and sustainable learning outcomes. The results revealed that the use of AI has significantly improved teaching efficiency, personalized learning, and student engagement. This relationship was moderated by institutional workforce ICT infrastructure, which enhances the effectiveness of AI-supported learning environments. Findings suggest AI policies, digital literacy, and faculty training must be improved to support the sustainable implementation process for all Saudi higher education institutions. The research paper provides empirical evidence, connects an integration of the AI toward sustainable education, and presents national educational change contextualized within Saudi Vision 2030.

Keywords: Artificial intelligence, Educational policy, Higher education, ICT infrastructure, Saudi vision 2030, SDG 4, Sustainable Learning outcomes.

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1. Introduction

1.1. Background

Education is a very important pillar of the Saudi Arabian Vision 2030, as it plans to modernize the higher education system in the country and promote a knowledge-based economy [1, 2]. The main aspect of this vision is the implementation of Artificial Intelligence (AI) technologies within universities to improve the quality of education, foster innovation, and train students with the digital skills necessary in the modern workplace [3, 4]. AI systems (adaptive learning systems, intelligent tutoring platforms, learning analytics systems) provide individual student-oriented learning experiences that maximize instructional effectiveness and provide ongoing feedback [5, 6].

Internationally, AI has demonstrated significant potential to enhance students' learning, engagement, performance, and motivation. Adaptive platforms also adapt content as learners perform better, and learning analytics provide educators with effective feedback to track progress and personalize teaching [5, 7]. Besides, AI is inclusive, as it offers a variety of learning formats and supports learners with diverse abilities and learning preferences. For example, AI can turn text into audio, provide real-time translation, or suggest customized learning courses, thereby encouraging fair access to learning opportunities [6, 8].

The concept of sustainable learning outcomes, which the United Nations focuses on in Sustainable Development Goal 4 (SDG 4), includes fair access to quality education, the acquisition of relevant skills, and the possibility of lifelong learning [8, 9]. The application of AI in the Saudi context of higher education can be discussed in connection with the said objectives because it can support the learner-focused approach, competency-oriented education, and effective retention of knowledge [1, 10]. Moreover, the adoption of AI makes Saudi universities part of the digital trend of education across the world, making them competitive in the ever-increasing technology-oriented environment [11].

Nevertheless, there are difficulties in applying AI in universities in Saudi Arabia [8]. The faculty's digital literacy, institutional readiness, and variations in ICT infrastructure may impede the effective implementation of AI solutions [10]. These institutional and contextual factors are key to empirical research aimed at understanding the effects of AI adoption on sustainable learning outcomes. To ensure that the benefits of AI are optimized and to eliminate potential differences across universities, it is critical to address these gaps [12, 13].

1.2. Problem Statement

Although the role of AI in higher education is increasing within Saudi Arabia, there is very little empirical evidence that shows the conditions for AI use, as well as its outcome-related effects on learning, align with each other [10]. Most studies have focused on telling stories about AI technology, faculty attitudes, or policy discussions, rather than establishing a systematic analysis of AI and quantifiable effects on student performance, engagement, or satisfaction [14]. Additionally, the institutional characteristics of the country such as ICT infrastructure, type of university (public vs. private), and geographic region have been largely unexplored. This lack of knowledge hinders policymakers and leadership from implementing evidence-based AI practices that could lead to equitable and efficacious sustainable learning outcomes [12].

1.3. Research Objectives

The objectives of this study are to:

1. To assess the impact of Artificial Intelligence (AI) integration on sustainable learning outcomes in Saudi higher education institutions.
2. To evaluate the moderating effects of institutional characteristics, including ICT infrastructure, university type (public vs. private), and regional location, on the relationship between AI adoption and learning outcomes.
3. To provide evidence-based policy recommendations for the effective and sustainable implementation of AI-based learning strategies.

1.4. Research Questions

This study seeks to answer the following research questions:

- **RQ1:** What is the effect of AI integration on sustainable learning outcomes in Saudi universities?
- **RQ2:** How do institutional characteristics (ICT infrastructure, university type, and region) moderate the relationship between AI adoption and learning outcomes?

1.5. Significance of the Study

The research is enhancing the current literature as it indirectly proves the impact of AI in the sustainable learning output, in the context of Saudi Arabia's higher education [1]. The results were indicative of success rates of AI-based teaching interventions as well as the role of the institution in providing equal and effective implementations through policy. The research indicates that AI and SDG 4 goals will have a future positive correlation. The study also provides practical implications of the teachers and administrators' roles, stating that AI should be adopted to improve the quality of education and not to remove the existing online institutions' disparities [13]. More so, the results can be of assistance to other Middle Eastern nations that wish to incorporate AI in higher education, thereby contributing to the discussion on the digital education processes that are sustainable globally.

2. Literature Review

2.1. AI in Higher Education

The use of Artificial Intelligence (AI) in higher education is growing across the world due to the demand for developing personalized learning experiences and increased educational achievement [1, 11]. The most striking part of this shift involves AI technologies (adaptive learning platforms, AI-supported analytics, and intelligent tutoring systems) [3]. Adaptive learning systems leverage algorithms to offer a personalized educational experience while assisting teachers in modifying educational content to each individual learner [14]. The analytics provided by AI can help a teacher track the progress of the students and provide a timely intervention and help [11]. Immediate feedback and advice are offered by smart tutoring systems, which mimic the one-on-one tutoring that enhances efficiency and accessibility to learning [5].

2.2. Regional Adoption: Saudi Arabia and MENA Countries

Saudi Arabia has become a pioneer in the use of AI in higher education in the MENA region of the Middle East and North Africa [5]. The Saudi Ministry of Education has also opened several programmes to incorporate AI into university programs, and it can be seen as part of Vision 2030's strategic goals of having a knowledge-based economy [12, 15]. Intelligent learning platforms and analytics systems, among other AI technologies, have been invested in by both the public and private universities, though the degree of adoption may differ depending on the institutional resources and willingness [3, 13]. Special attention has been paid to the use of AI tools in teaching and learning by private universities; in this regard, in particular, they have been more proactive [14].

2.3. Sustainable Learning Outcomes

The sustainable learning outcomes focus on quality education based on inclusive, equitable, and lifelong learning [9]. The implications of AI integration on these outcomes include the delivery of individual learning experiences and live support, which may enhance inclusivity and cater to a wide variety of learning requirements [11]. Learning analytics that are facilitated by AI can be used to recognize gaps in learning and provide specific interventions to address these gaps and increase the efficiency of learning [14]. Such abilities should be aligned with Sustainable Development Goal 4 (SDG 4), which emphasizes the need to provide equitable access to quality education and lifelong learning to everyone [8, 9].

The use of AI in institutions of higher learning facilitates a number of SDG 4 indicators, such as quality education, equal access, and lifelong learning [11]. The AI technologies support individual studies that address various learning styles and speeds of students, which improves the quality of education [5]. Besides, AI systems may make learning resources of high quality available to students in underserved areas, minimizing regional differences and contributing to the effectiveness of education [12].

2.4. Institutional Characteristics

Institutional factors, including the ICT facilities, accessibility of funds, the type of university (public or private), and the location area (region), determine the level of AI implementation and its success in higher education [1, 3]. The use of AI tools implies a strong ICT infrastructure needed to support all the hardware and software needs [14]. The budgets define whether or not the institution will be able to acquire AI technologies and train its faculty and students [11, 13]. The public university could be in a more difficult financial situation than the private institution and this might limit the use of AI [5]. Another factor is the region where the university is located, with urban-based institutions being more likely to have AI resources than those in the country [12].

2.5. Theoretical Framework

The Technology Acceptance Model (TAM) has been a very good framework for understanding technology adoption in the classroom [11]. With the adoption of AI, this model can be further applied to find out the influence of the perceived ease of use and perceived usefulness on both educator and student acceptance of the AI tools [3]. The institutional characteristics that bring about the moderating effect of these traits in the context of AI can also explain the different rates of AI adoption and the associated implications for sustainable learning outcomes. The conceptual framework depicts the independent variable as AI adoption and the dependent variable as sustainable learning outcomes along with the moderators of institutional traits (like ICT infrastructure, university type, and region) [13, 14].
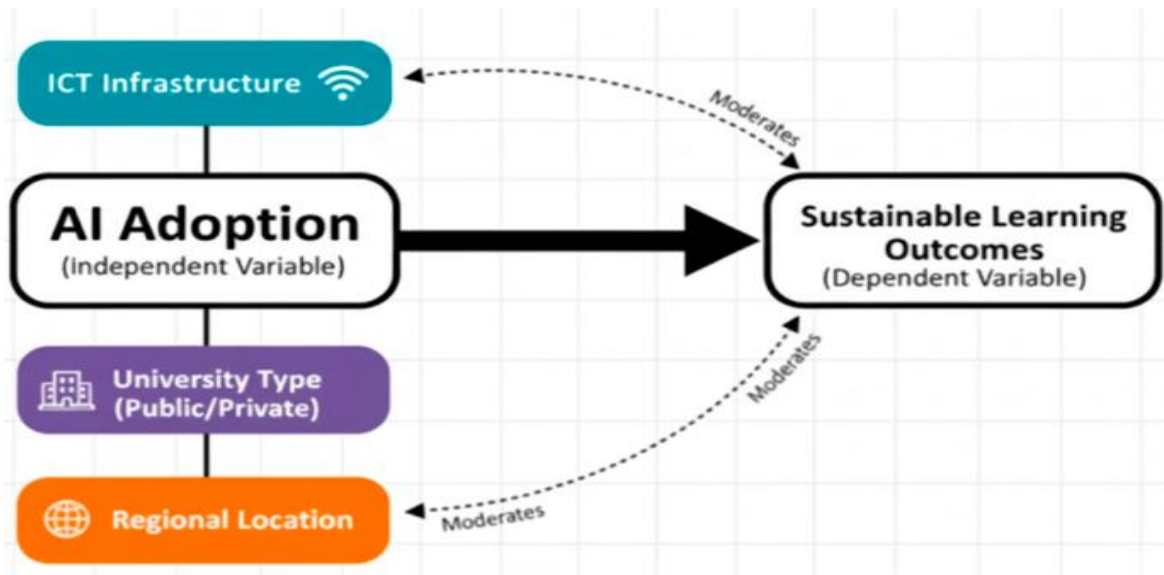
Figure 1.
Conceptual Framework of the Study.

2.6. Research Gaps

While the implementation of artificial intelligence in higher education in Saudi Arabia has emerged as a principal topic of interest, little quantitative research has been conducted to evaluate the impact of AI on sustainable learning outcomes in that context [1, 11]. The major portion of the literature is either qualitative or conceptual, or in international settings, which restricts the generalizability of the results to Saudi universities [5].

Although the topic of AI technologies and sustainable learning has been studied individually, the empirical evidence concerning the direct relationship between AI adoption and sustainable learning outcomes has not been extensively studied [14]. This knowledge vacuum prevents the informed policy formulation of AI integration and justifies the addition of context-specific studies to Saudi higher education.

3. Methodology

3.1. Research Design

This study employed a quantitative, cross-sectional survey design to examine how connecting Artificial Intelligence (AI) to learning can produce sustainable learning outcomes for Saudi Arabia higher learning institutions. In the case of quantitative research, it is considered to be the most appropriate research methodology in the field of education, particularly when the researcher is looking into the relationships between two or more variables and/or testing the hypotheses [16]. The cross-sectional design was employed as it provided a snapshot view of AI adoption along with its perceived effects at the same time allowing a comparison of different institutions [17]. This facilitated the researcher in collecting empirical evidence on varying types of faculty and students who were fond of AI learning tools.

3.2. Population and Sample

The research sample was made up of faculty members and students of 68 higher education institutions in Saudi Arabia, which consisted of 43 public and 25 private universities [18]. To guarantee that the representation was accurate, a stratified random sampling method was adopted, in which the participants were divided according to the type of university and different geographical areas. The research population consisted of 400 respondents who were selected according to the distribution of individuals in public and private institutions as well as rural and urban areas. The sample is considered sufficient to provide the necessary statistical power for hypothesizing and inferring through educational survey research [19].

3.3. Data Collection Instrument

The data collection tool that was designed to collect the data was aimed at understanding three things: AI adoption, sustainability in learning outcomes, and the institution's characteristics. There were four parts to the instrument. To start with, the questionnaire for AI adoption assessed its type, regularity, and users' contentment with the usage. The second section dealt with the sustainable learning outcomes, where lifelong learning, equitable access, and learning efficiency were among the indicators used. The third part assessed institutional factors like ICT infrastructure, funding, university type, and location. The last section dealt with demographic characteristics - age, gender, academic position (faculty/student), and years of experience. The scale used was a five-point Likert Scale (1 = Strongly Disagree to 5 = Strongly Agree), which was applied to measure perceptions and experiences. Some example statements are: AI tools enable me to learn faster, AI implementation bares no discrimination to access to learning resources, and my university has well enough ICT infrastructures to apply AI in teaching and learning [20]. The systematic approach made the responses clear, comparable and reliable among the respondent groups.

3.4. Data Analysis

The data analysis procedure employed both descriptive and inferential statistics. The primary descriptive statistics for AI adoption practices and the respondents' attitudes towards sustainable learning outcomes were mean, standard deviation, frequency, etc. More so, the identical inferential statistics which were used for the correlational analysis, that is, Pearson correlation and multiple regressions were also employed for the relationships that were determined among AI adoption, institutional characteristics and sustainable learning outcomes [21]. The reliability of the questionnaire was computed using Cronbach's alpha, and confirmatory factor analysis was carried out to establish the construct validity [22].

3.5. Ethical Considerations

In conducting the research, the participants were interviewed, and ethical approval was sought from the Institutional Review Board (IRB) of the main institution, and informed consent was obtained. The subjects were assured that their participation would be anonymous and confidential. Participation was by choice, and at any time the participants could withdraw. These actions were taken in line with and respecting the ethical guidelines for educational research, and they had a dual purpose of protecting the attendees' rights and also preserving the credibility of the entire research process [23].

4. Results

This research contains the statistical findings of reliability analysis, descriptive statistics, correlation analysis, hierarchical regression, and the frequency of AI tool usage. All analyses were performed using SPSS version 26.

4.1. Reliability Analysis

Table 1.
Reliability analysis of measurement scales.

Scale	N of Items	Cronbach's Alpha (α)
AI Adoption Scale	8	0.891
Sustainable Learning Outcomes Scale	12	0.923
ICT Infrastructure Scale	6	0.902

The reliability analysis was conducted to assess the internal consistency of the measurement scales used in this study. As presented in Table 1, all constructs demonstrated high reliability, with Cronbach's alpha values exceeding the acceptable threshold of 0.70. The AI Adoption Scale (α = .891), Sustainable Learning Outcomes Scale (α = .923), and ICT Infrastructure Scale (α = .902) indicated excellent internal consistency. These results confirm that the items within each construct measured the same underlying dimension, ensuring the reliability of the scales for subsequent statistical analyses.

4.2. Descriptive Statistics

Table 2.
Descriptive Statistics of Main Study Variables.

Variable	N	Mean	Standard Deviation
AI Adoption Composite Score	400	3.25	0.94
Sustainable Learning Outcomes	400	3.68	0.83
ICT Infrastructure	400	3.52	0.89

Note: Valid N (list-wise): 400

Table 2 presents the descriptive statistics for the main study variables. The mean scores for AI Adoption (M = 3.25, SD = 0.94), Sustainable Learning Outcomes (M = 3.68, SD = 0.83), and ICT Infrastructure (M = 3.52, SD = 0.89) indicate that participants expressed generally positive perceptions regarding AI integration and institutional technological capacity. These results suggest that Saudi universities demonstrate moderate to high levels of AI adoption and digital preparedness in their learning environments.

4.3. Correlation Analysis

Table 3.
Correlation Analysis Between Key Variables.

Variables	AI Adoption	Learning Outcomes	ICT Infrastructure
AI Adoption	1	—	—
Learning Outcomes	0.621**	1	—
ICT Infrastructure	0.451**	0.503**	1

Note: $p < .001$ (2-tailed)

As shown in Table 3, all key variables were significantly and positively correlated. A strong positive correlation was observed between AI Adoption and Sustainable Learning Outcomes (r = .621, p < .001), indicating that higher levels of AI use were associated with better learning outcomes. Moreover, AI Adoption exhibited a moderate positive correlation with ICT Infrastructure (r = .451, p < .001), while ICT Infrastructure also showed a significant positive correlation with

Sustainable Learning Outcomes (r = .503, p < .001). These findings suggest that improvements in AI adoption and technological infrastructure jointly enhance the quality and sustainability of learning outcomes.

4.4. Hierarchical Regression Analysis

Table 4.
Hierarchical Regression Analysis Summary.

Model	R	R Square	Adjusted R Square	Std. Error of Estimate	R Square Change
1	0.652	0.425	0.420	0.632	0.425
2	0.715	0.511	0.503	0.589	0.086

The hierarchical regression analysis was conducted to examine the effect of AI adoption on sustainable learning outcomes and to determine the moderating influence of institutional characteristics, including ICT infrastructure, university type, and regional location. As displayed in Table 4, Model 1 explained 42.5% of the variance in learning outcomes (R^2 = .425), whereas Model 2, which included moderator variables, explained 51.1% of the variance (R^2 = .511). The R^2 change of .086 indicates that the inclusion of institutional characteristics significantly improved the model's explanatory power. These results suggest that institutional context plays a crucial role in enhancing the relationship between AI adoption and sustainable learning outcomes.

4.5. Regression Coefficients (Model 2)

Table 5.
Regression Coefficients for Model 2.

Variable	Unstandardized B	Std. Error	Standardized Beta	t	Sig.
(Constant)	0.802	0.172	—	4.663	0.000
AI Adoption	0.423	0.040	0.489	10.575	0.000
ICT Infrastructure	0.184	0.051	0.197	3.608	0.000
University Type	0.135	0.068	0.088	1.985	0.048
Region	-0.098	0.078	-0.059	-1.256	0.210
AI_Adop × ICT	0.088	0.029	0.147	3.034	0.003
AI_Adop × Type	0.055	0.037	0.075	1.486	0.138
AI_Adop × Region	-0.048	0.039	-0.061	-1.231	0.219

The regression coefficients in Table 5 reveal that AI Adoption was the strongest predictor of Sustainable Learning Outcomes (β = .489, p < .001), followed by ICT Infrastructure (β = .197, p < .001). University type showed a smaller yet statistically significant effect (β = .088, p = .048). In contrast, region did not have a significant influence (p > .05). Among the interaction terms, only AI Adoption × ICT Infrastructure was significant (β = .147, p = .003), demonstrating that the relationship between AI adoption and learning outcomes strengthens when institutions have robust ICT systems.

4.6. Frequency of AI Tool Usage

Table 6.
Frequency of AI Tool Usage in Saudi Universities.

AI Tool	N	Minimum	Maximum	Mean	Std. Deviation
Adaptive Learning Platforms	400	1	5	3.75	1.21
Intelligent Tutoring Systems	400	1	5	3.15	1.32
AI-powered Analytics	400	1	5	2.90	1.45
Chatbots/Virtual Assistants	400	1	5	4.02	1.08

Table 6 presents the frequency of AI tool usage across participating universities. Chatbots or Virtual Assistants (M = 4.02) and Adaptive Learning Platforms (M = 3.75) were the most frequently utilized tools, while Intelligent Tutoring Systems (M = 3.15) and AI-powered Analytics (M = 2.90) were used less often. These findings indicate that Saudi higher education institutions primarily adopt interactive and adaptive AI tools that support personalized learning experiences, thereby promoting more student-centered and sustainable educational environments.

Finally, the research findings are supported by the empirical evidence that the application of AI has a positive effect on sustainability in learning in Saudi higher education institutions [1]. In addition to that, ICT infrastructure was mentioned as the greatest moderating variable that strengthened the statistically significant correlation. The fact that adaptive and interactive AI technologies such as chatbots and smart learning platforms have been embraced by people indicates that they have accepted their values of personalization, data-driven decision making, and environmentally-friendly teaching practices [13]. Moreover, the study has the value of guiding educational authorities and policymakers in the KSA who might think about the implementation of AI technologies concerning quality and sustainable development in the institutions of higher education.

5. Discussion

5.1. Interpretation of Findings in the Context of Saudi Vision 2030 and Global Literature

The outcomes of this exploration suggest that the implementation of Artificial Intelligence (AI) has a great and a positive impact on the learning process and the results that are sustainable in the higher education sector of Saudi Arabia [1]. Besides that, the use of AI in the educational sector of the Kingdom is, of course, the realization of one of the main strategies of Saudi Vision 2030 concerning educational reform, digital innovation, and the development of human capital for a knowledge-based economy [4, 12]. The findings also introduce AI into the discourse as one of the tools that can make learning more effective, inclusive, and accessible, hence, the three basic concepts linked with Sustainable Development Goal 4 (SDG 4) being, thereby, the role of the technology being presented as an enabler that can assist in achieving the educational aims, both locally and internationally.

The relationship between the adoption of AI and the learning outcomes sustainability is a positive one with a correlation coefficient of r = .621, p < .001. This shows that the AI tools' role in student engagement, performance, and skill development is substantial. These findings support previous global research, which has noted that AI usage leads to personalized educational experiences and improvements in academic performance outcomes [10]. The regression analysis found that AI use (β = .489, p < .001 was the strongest predictor of sustainable learning outcomes, which again supports the consensus that AI-supported teaching and learning support personalized, flexible, data-informed instruction that sustainably supports and builds learners' capacity for learning long-term [24].

Additionally, the moderating effect of ICT infrastructure highlights the role of digital readiness in achieving AI benefits [10]. Institutions that were well marketed with robust technology infrastructure experienced stronger relationships between AI adoption and learning outcomes (β = .147, p = .003). This finding supports previous evidence that infrastructural readiness is a condition for effective use of AI [25]. This issue is relevant in Saudi Arabia because the government is continuing its investment into the digital infrastructure as part of the National Transformation Program (NTP) and Vision 2030 [26, 27]. The different levels of ICT capacity between the public and private universities in this study indicate the disparities that were pointed out in national reports [5] thus making it clear that the equal distribution of technology investments is a must to avoid the fallacy of educational gaps widening. The absence of a regional effect (p > .05) indicated that the integration of AI in education has a stronger bond with institution readiness and government policy than geography [13]. This can be seen as a positive development as it means that with proper infrastructure, support, or funding AI education can be equally effective in all the areas of the Kingdom. The results of this study are congruent with worldwide studies that point out the fact that the access to digital means, not the location, is the main factor determining the success of technology-enhanced education [3, 11].

5.2. Policy Implications

5.2.1. Guidelines for AI Implementation and ICT Infrastructure Planning

The findings point out that the adoption of national strategies for AI applications is a must for Saudi universities to use AI more or less in the same way. The new regulations should be prepared with proper consideration for the educational aims, ethics, and eco-friendliness in AI usage. The Ministry of Education in Saudi Arabia could draw a map that is common and indicates the standards, and the rules of engagement concerning the AI tools and solutions, data governance, and interoperability that all institutions must follow [15]. In addition to that, there should be a regular and strong investment in the ICT infrastructure fast and secure access for AI universities and high-speed data systems should be included so that the public and private universities will be able to use and access the technology quite evenly [28]. By doing so, the existing gap will be recognized and bridged, thus making the whole digital learning ecosystem more fair.

5.2.2. Teacher Training and Digital Literacy Programs

Faculty readiness was highlighted as a significant determinant for effective integration of an AI-based system. Consistent with studies globally, in order to implement an AI-based system successfully, educators must hold knowledge beyond technical competencies of its usage; they must also understand what it means to teach [28, 29]. Thus, teacher training and a digital literacy program should be organized as part of professional development, which emphasizes practical knowledge of the application of tools, the ethical implications for AI assessments, and how to analyze data to facilitate and integrate pedagogical knowledge into artificial intelligence tools [25]. Furthermore, considering examples from Saudi Arabia, the digital transformation and its eventual success in the education sector depend heavily on faculty development and the structures institutions have that support the development [15]. In addition, allowing faculty members to continue professional training for supported sustainable development can be facilitated by AI learning hubs that, again, follow the OECD [26] research recommendation for institutional evaluation, capacity building, and professional development.

5.2.3. Resource Allocation for Sustainable Learning Initiatives

The research demonstrates the degree of intersection between AI adoption and sustainability outcomes, while illustrating how the allocation of funds is central to this process [30]. Universities should allocate a budget for sustainable learning initiatives that utilize AI technologies such as adaptive learning, intelligent tutoring systems, and learning analytics [29]. Institutional policies should encourage collaboration with technology and research institutions to create AI applications that are relevant to the context [25, 28]. These collaborative initiatives will promote improvement and innovation while focusing on making technology fit with Saudi cultural and educational values [15]. Additionally, encouraging AI research and innovation in education through grant funds and competitive funding can help ensure that

practices stay sustainable and support ongoing educational improvement, in line with OCED [26] policy guidelines for sustainable education governance.

5.3. Contribution to the Literature

This study contributes to the rapidly expanding area of AI in education literature. First of all, the paper provides evidence from field on how AI integration has impact on sustainable learning and this is an area that there has not been so much written about [29]. Previous studies, up till now have focused on the use of AI by theoretical and descriptive perspectives [11, 14]. However, the current study demonstrates that learning sustainability is positively influenced by the increased efficacy, AI adoption and new attendance modalities.

Further, these studies contribute to the enhancement of the Technology Acceptance Model (TAM) through integration of institutional characteristics as moderator variables as well as provide deeper insights on AI implementation in higher education institutions [1]. The difference in ICT facilities, type of university and location results in a context-specific narrative on how the dominant contextual factors have an impact on the success of AI-based educational innovation [30]. This change is positive from the theoretical and practical point of view, since it says that AI implementation for higher education sustainability occurs thanks to technology but not via this alone but also the institutional capability and readiness [13].

In the end, the results contribute to the global discussion by providing evidence from Saudi Arabia. This data serves as a strong foundation for digital transformation projects, not just in Saudi Arabia but also across the Middle East and developing countries. Additionally, the idea that robust ICT infrastructures are necessary for AI to fully benefit education suggests that sustainable digital education results from both government initiatives and technology innovations [4, 10].

5.4. Limitations and Directions for Future Research

Although this study has important contributions, it is also limited in numerous ways. First, the cross-sectional design collects data at a single time point. As a result, while it is possible to state that there is evidence of an association between AI adoption and sustainable learning outcomes, the study design does not allow this to be assumed as a causal relationship. Future studies could explore longitudinal designs to assess change in learning outcomes over time as AI is implemented.

Second, as the study relies only on self-reported data, this could lead to response bias, as participant' perceptions of their actual usage patterns or learning performance may differ. In future research, combining survey data with more objective measures, such as academic performance measures or digital learning analytics, could improve the validity of results.

Third, while the sample of 400 respondents across 68 universities offered broad coverage, generalizability is limited to the higher education context in Saudi Arabia. Future research should include multisite studies and comparative studies in other countries to identify how culture, economy, and policy may impact AI adoption and sustainability outcomes.

Finally, qualitative or mixed-method studies could provide further insights into the faculty and student experience of AI use and explore various nuances that assist in understanding the quantitative trends seen here. Qualitative or mixed-method studies would elicit the human dimensions of using AI, the ethical dimensions of its use, and the pedagogical dimensions of its use, respectively, which the numerical data cannot fully capture.

Overall, this research provides empirical evidence that integrating AI enhances sustainable learning outcomes for students in higher education institutions in Saudi Arabia, particularly when a strong ICT infrastructure supports that integration. These findings address aspects of Saudi Vision 2030's strategy for educational reform while simultaneously supporting the global commitment to sustainable, equitable, and technology-enabled learning. By identifying approaches to infrastructure, training, and resourcing, it will be possible for policymakers to ensure that the use of AI modernizes education, while also developing and supporting learning for all students over the long term in a relevant, inclusive, and high-quality manner.

6. Conclusion

The present study examined how Artificial Intelligence (AI) can be used in the education sector of Saudi Arabia which is a higher education system and the resultant sustainability of the learning outcomes. The results showed that the acceptance of AI is a variable which influenced the teaching efficiency, personalized learning, and student engagement in an academic process positively. The participants considered these to be the sustainable learning outcomes. Moreover, it is important that the high level of institutional readiness, as well as the great quality of the ICT infrastructure, contributed to the introduction of AI into the learning process of the students, which, in its turn, resulted in the creation of sustainable outcomes. This indicates that the technology-aided learning might be embedded in the long-term methods of improvement of the educational standards and accessibility by the means of sustainability.

These findings correspond to Saudi Vision 2030 and Sustainable Development Goal 4 (SDG 4) that strive in various ways to completely change the educational system by ensuring that quality education is provided to everyone with no limit to the time and place. The educational sector in Saudi Arabia is one of the sectors that have numerous resources and capabilities in which AI can be applied. The AI can benefit the higher education system in a number of ways; furthermore, it was transforming the country into a creative, knowledge-based economy, which was make the entire learning process adaptive, inclusive, and sustainable. In addition to that, the learning outcomes also indicate that AI literacy and digital skills should be included in the higher education institutions curriculum, particularly among student teachers, to establish a sustainable learning environment.

The policy perspective of the analysis suggests that AI governance should be presented in the higher education domain on a universal basis. In addition, it ought to pay attention to the provision of ICT infrastructure, teacher support, and the process of supporting the continuous professional development. These factors are critical in ensuring that AI initiatives are executed properly. Furthermore, the cooperation of policymakers, institutional heads, and AI providers will be required to create an ethical and sustainable AI ecosystem that would be aligned with the educational goals of the nation.

The study proposes that the longitudinal studies might be the next avenue of research to determine the effects of AI on the learning outcomes of students in various subjects. In addition, the qualitative studies could be more revealing in this instance of sharing the experience of students and teachers. Such a study is replicable to other areas and locations that provide highly valuable information regarding the power of context in the adoption of AI and creation of sustainable learning practices. In conclusion, the implementation of AI in Saudi higher education is a major step towards building a sustainable, inclusive, and innovative learning experience, in line with the primary objectives of Vision 2030 and SDG 4.

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