The impact of artificial intelligence applications on E-governance in higher education institutions: opportunities and challenges

أثر تطبيقات الذكاء الاصطناعي على الحوكمة الإلكترونية في مؤسسات التعليم العالي: الفرص والتحديات

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Abstract:

This study investigates the impact of artificial intelligence (AI) application on e-governance within higher education institutions, focusing on both opportunities and challenges. A quantitative research design was adopted, utilizing a structured questionnaire distributed to a random sample of 38٥ participants affiliated with various higher education institutions. Following a comprehensive data cleaning and validation process, 91% of the responses were retained for analysis, while 9% were excluded due to incompleteness. The questionnaire items were categorized into structured variable groups: Q1–Q3 represented demographic variables, Q4 was designated as the independent variable encompassing multiple AI application dimensions, Q5 and Q6 constituted the mediating variables capturing organizational opportunities and challenges, and Q7 represented the dependent

variable reflecting e-governance outcomes and effectiveness. Data analysis was conducted using Python libraries including Pandas, Seaborn, and Matplotlib to generate correlation heatmaps and explore inter-variable relationships. To validate the proposed theoretical model, Structural Equation Modeling (SEM) was employed, enabling the examination of both direct and indirect effects among constructs. The findings revealed strong positive correlations between AI application development and e-governance effectiveness, with the mediating variables playing a significant role in shaping this relationship. The SEM results further confirmed the model's explanatory power, highlighting that institutional capabilities and readiness significantly influence the success of AI integration. These results underscore the importance of strategic investment in AI infrastructure and organizational preparedness to address implementation challenges and enhance governance outcomes such as transparency, efficiency, and service quality.

Keywords: artificial intelligence, electronic governance, Higher Education, Challenges, Opportunities. Python, SEM.

الملخص

تهدف هذه الدراسة إلى استقصاء أثر تطبيقات الذكاء الاصطناعي على الحوكمة الإلكترونية في مؤسسات التعليم العالي، مع التركيز على كل من الفرص التي تتيحها هذه التطبيقات والتحديات التي قد تعيق تنفيذها. وقد تم اعتماد منهج بحث كمي، من خلال تصميم استبيان منظم وُزّع على عينة عشوائية مكوّنة من (٣٨٥) مشاركًا من

المنتسبين إلى عدد من مؤسسات التعليم العالي. وبعد تنفيذ إجراءات دقيقة لتنقية البيانات والتحقق من صحتها، تم الاحتفاظ بنسبة ٩١% من الاستجابات، في حين تم استبعاد 9% منها لعدم اكتمالها.تضمنت أداة الدراسة مجموعة من المتغيرات المصنفة على النحو الآتي: مثّلت الأسئلة من Q1 إلى Q3 المتغيرات الديموغرافية، بينما خُصص السؤال Q4 لقياس المتغير المستقل المتعلق بأبعاد تطبيقات الذكاء الاصطناعي. واعتُبر السؤالان Q5 و Q6بمثابة المتغيرات الوسيطة التي تعكس الفرص التنظيمية والتحديات المؤسسية، في حين تمثّل السؤال Q7 في المتغير التابع الذي يقيس مخرجات الحوكمة الإلكترونية ودرجة فعاليتها.تم تحليل البيانات باستخدام عدد من مكتبات لغة البرمجة بايثون(Python) ، من بينها Pandas :و Seaborn وMatplotlib، وذلك لتوليد خرائط الارتباط الحراري وتحليل العلاقات المتبادلة بين المتغيرات. وللتحقق من مدى صحة النموذج النظري المقترح، تم توظيف نمذجة المعادلات الهيكلية (SEM) والتي مكّنت من تحليل كل من التأثيرات المباشرة وغير المباشرة بين المتغيرات.وقد كشفت النتائج عن وجود علاقات ارتباط إيجابية قوية بين تطوير تطبيقات الذكاء الاصطناعي وفعالية الحوكمة الإلكترونية، حيث تبين أن المتغيرات الوسيطة (الفرص والتحديات) تلعب دورًا جوهريًا في تشكيل هذه العلاقة. كما أكدت نتائج نمذجة المعادلات الهيكلية على قوة النموذج التفسيرية، موضحةً أن الجاهزية المؤسسية والقدرات التنظيمية تعد من العوامل الحاسمة لنجاح إدماج تقنيات الذكاء الاصطناعي.وتخلص الدراسة إلى أهمية الاستثمار الاستراتيجي في البنية التحتية للذكاء الاصطناعي، وتعزيز الاستعداد المؤسسي، بما يُسهم في تجاوز تحديات التنفيذ وتحقيق نتائج إيجابية على مستوى الحوكمة، لا سيما في مجالات الشفافية، والكفاءة، وجودة الخدمات.

الكلمات المفتاحية :الذكاء الاصطناعي، الحوكمة الإلكترونية، التعليم العالي، التحديات، الفرص، بايثون، نمذجة المعادلات الهيكلية.(SEM)

Introduction:

The rapid advancement of artificial intelligence (AI) technology is profoundly transforming various sectors, and higher education is no exception. As institutions of higher learning seek to improve operational efficiency, elevate student experiences, and remain competitive in an increasingly globalized landscape, the integration of AI into e-governance systems presents a strategic opportunity—along with a complex set of challenges. E-governance in higher education refers to the use of information and communication technologies (ICTs) to streamline administrative processes, enhance institutional transparency, and facilitate informed decision-making. The shift from traditional governance to digital and intelligent systems marks a fundamental transformation in how universities and colleges operate. The incorporation of AI technologies—including chatbots for student support, machine learning algorithms for resource optimization, and predictive analytics for institutional planning has enabled more responsive, data-driven, and personalized governance models. As (Kim, JS, Seo,.D 2023) highlights, AI enables a redefinition of governance through smarter decision-making and increased automation of administrative tasks. Furthermore, (Verma, M, 2012) emphasize that such transformation demands not only technological upgrades but also deep organizational and cultural shifts to ensure alignment between institutional goals and technological

capacity. his research explores the multifaceted impact of AI application development on e-governance within higher education institutions. It investigates how AI-driven solutions can address long-standing challenges in administration, such as enrollment management, institutional research, resource allocation, and personalized student services. Moreover, the study considers the transformative potential of AI in promoting inclusivity and accessibility in education, thereby potentially reducing structural barriers to higher education access. However, integrating AI into governance systems is not without complexities. The study also examines the ethical, infrastructural, and socio-organizational challenges associated with AI adoption. These include concerns around data privacy, algorithmic bias, the automation of administrative roles, and the need for ongoing investment in digital infrastructure and workforce training. It further addresses the risk that AI adoption may deepen inequalities between well-resourced institutions and those lacking the capacity to implement such technologies effectively.
Therefore, the purpose of this study is to assess the opportunities and challenges associated with the development and implementation of AI applications in higher education e-governance. Through this investigation, the research aims to provide a balanced and empirically grounded understanding of how AI can support effective, transparent, and inclusive governance، while also identifying the limitations and ethical

considerations that must be addressed to ensure its responsible and equitable deployment.

The problem of research

Main Research Question:

To what extent does the development of artificial intelligence applications impact the effectiveness of e-governance in higher education institutions, and what are the key opportunities and challenges associated with their integration?

Sub-Research Questions:

1. How do AI applications influence administrative efficiency and decision-making processes in higher education governance?
2. To what extent do AI-driven systems contribute to transparency, accountability, and responsiveness in university governance models?
3. How do public and private higher education institutions differ in terms of their adoption, implementation, and outcomes of AI-driven e-governance systems?
4. What challenges do institutions face when integrating AI into their governance systems, including ethical, legal, and technical concerns?
5. How does the implementation of AI in e-governance affect equity and access in higher education environments?

Research Gap

Despite the growing interest in artificial intelligence (AI) and its transformative potential across various sectors, the integration of AI technologies into e-governance systems in higher education remains an underexplored area of research. While numerous studies have examined digital transformation and governance in educational contexts, few have specifically addressed the intersection between AI application and the effectiveness of e-governance in universities and colleges. Moreover, existing literature often emphasizes either the technological or organizational aspects of digital governance, with limited attention to how AI innovations reshape administrative processes, stakeholder engagement, and decision-making in academic institutions. Empirical studies that adopt a comprehensive analytical approach examining both opportunities and challenges are particularly scarce, especially in the context of developing countries. In addition, there is a lack of comparative analysis regarding how institutional type (e.g., public vs. private) influences the adoption and impact of AI-powered governance systems. This gap limits our understanding of the contextual factors that mediate the success of AI implementation in different educational environments. Therefore, this study seeks to fill this gap by providing an integrated empirical investigation into the impact of AI application development on e-governance effectiveness in higher education institutions. It explores both the

enabling and constraining factors, while accounting for organizational readiness, institutional diversity, and the socio-technical complexities involved in AI adoption.

Research Objectives

This study aims to bridge these gaps by:

1. Investigating the impact of artificial intelligence application development on the effectiveness of e-governance in higher education institutions.
2. Identifying the key opportunities that AI technologies offer for enhancing administrative efficiency, decision-making, and stakeholder engagement in academic governance systems.
3. Examining the main challenges and barriers associated with the integration of AI into e-governance frameworks, including technical, ethical, and organizational dimensions.
4. Analyzing the mediating role of organizational readiness and implementation factors in the relationship between AI application development and e-governance effectiveness.
5. Comparing public and private higher education institutions to assess how institutional type moderates the adoption, implementation, and outcomes of AI-driven e-governance systems.

Literature review

Abu Asr, R. M. (2023) conducted a study titled "Applications of Artificial Intelligence Models (ChatGPT) in Curricula and

Teaching Methods: Opportunities and Potential Threats," in which he examined the educational implications of emerging generative AI tools, with a particular focus on ChatGPT. The study highlights the transformative potential of advanced language models in enhancing teaching and learning processes. It identifies several opportunities offered by ChatGPT, such as the facilitation of personalized learning, improved access to information, interactive dialogue capabilities, lesson planning support, innovative assessment methods, and new approaches to explaining complex concepts. At the same time, the research critically addresses several potential risks associated with the widespread adoption of such technologies in educational settings. These include the risk of academic dishonesty in online assessments, the generation of highly polished content that may undermine students' intellectual effort, a potential decline in learners' critical thinking skills, and challenges in verifying the credibility and accuracy of AI-generated information. Drawing on the perspectives of both students and educators, the study provides a nuanced understanding of how AI tools like ChatGPT can both enrich and disrupt traditional educational practices. It calls for careful integration strategies that maximize the pedagogical benefits of AI while mitigating its unintended consequences.(Alqahtani, T, et al. 2023) present a comprehensive study titled "The Emerging Role of Artificial Intelligence, Natural Language Processing, and Large Language

Models in Higher Education and Scientific Research." The study aims to contribute to the ongoing scholarly discourse on the integration of artificial intelligence (AI) in educational and research contexts by highlighting its transformative potential to improve outcomes for students, educators, and researchers alike. This work offers an in-depth examination of AI technologies—particularly Natural Language Processing (NLP) and Large Language Models (LLMs), such as GPT-4 and Google's BARD—and their projected influence on academic practice. Through the exploration of key benefits, challenges, and real-world applications, the authors underscore how these innovations are reshaping pedagogical methods and research workflows. The study outlines a range of practical applications of AI in academic research, including text generation, data analysis and interpretation, literature review assistance, formatting and editing support, and peer-review facilitation. In educational settings, AI is shown to enhance instructional practices through personalized learning support, constructive feedback, automated assessment and grading, curriculum customization, career guidance, and even mental health assistance. Importantly, the study emphasizes that realizing the full potential of AI technologies in education and research requires addressing critical concerns, such as ethical implications and algorithmic bias. The authors argue that tackling these challenges is essential for fostering equitable, responsible, and effective AI integration that ultimately enhances learning and

scientific advancement. (Bahrini, A, et al. 2023) conducted a comprehensive study titled "ChatGPT: Applications, Opportunities, and Threats," aiming to explore the practical implications of ChatGPT across ten key domains. Building on a review of the existing literature, the study examined both the potential benefits and associated risks of ChatGPT, with a particular focus on its applications in education, industry, and business contexts. An experimental component of the research involved a comparative evaluation of GPT-3.5 and GPT-4, assessing their performance and effectiveness in generating human-like text. ChatGPT, developed by OpenAI, is a Conditional Generative Pre-Trained Transformer (GPT), fine-tuned through supervised learning and reinforcement learning techniques. It combines the power of large-scale deep learning models with programmable interfaces, enabling it to autonomously produce fluent and coherent natural language responses. The findings indicate that GPT-4 significantly outperforms its predecessor in terms of generating more accurate and contextually relevant outputs. Nevertheless, the authors emphasize that, despite its impressive capabilities, ChatGPT lacks essential human qualities such as emotional understanding, genuine empathy, and creative reasoning. Consequently, the study asserts that while ChatGPT offers substantial support for various tasks, it cannot fully substitute human involvement, particularly in nuanced or complex scenarios. As artificial

intelligence (AI) technologies continue to evolve and gain widespread adoption across sectors, the governance of their development and implementation has emerged as a critical area of concern and debate among policymakers, scholars, and industry leaders (Erdelyi & Goldsmith, 2018; Thiebes, Lins, & Sunyaev, 2021; Bucknall & Dori-Hacohen, 2022). AI governance refers to the set of frameworks, policies, and institutional practices designed to ensure that AI systems are developed and deployed in accordance with ethical standards, legal regulations, and societal norms. It encompasses the formulation of responsible use guidelines, the establishment of accountability mechanisms, and the implementation of procedures to mitigate risks associated with AI technologies (Felzmann, et al., 2020; Balasubramaniam et al., 2023; Rismani & Moon, 2023; Henriksen, Enni, & Bechmann, 2021).Institutions and organizations typically engage in a comprehensive governance process that involves identifying foundational ethical principles, designing operational frameworks, and instituting oversight models to ensure compliance throughout the AI lifecycle (Janssen et al., 2020; Georgieva et al., 2022; Bessen, Impink, & Seamans, 2022). This process often begins with a recognition of the need to uphold human rights and values in AI deployment, particularly given the complexity and opacity of AI systems and their potential to compromise fairness, accountability, and transparency (Díaz-Rodríguez et al., 2023; Akinrinola et al.,

2024; Diakopoulos, 2020).In response, international organizations and institutional bodies have issued ethical AI principles intended to articulate core values and high-level requirements for responsible AI development and use (Rees, c, & Muller, B, 2023). However, the true efficacy of these principles depends on their operationalization—specifically, their translation into measurable, actionable policies and practices that can be applied in real-world settings (Felländer, A et al., 2022). To bridge the persistent gap between abstract ethical principles and their practical implementation, organizations are increasingly adopting structured governance models—such as the hourglass model of organizational AI governance. This model advocates for a multi-level governance framework encompassing the environmental, organizational, and AI system dimensions, thereby aligning ethical imperatives with the full lifecycle of AI technologies (Huriye,A,.Z,. 2023). These integrated efforts underscore the necessity of a comprehensive and systematic approach to AI governance, ensuring that AI innovations are designed and deployed in ways that are ethically sound and socially beneficial (Smuha, N.A 2019). Higher education institutions (HEIs) play a pivotal role in this process. Through academic research and institutional practice, HEIs contribute significantly to evaluating the societal impacts of intelligent technologies, mitigating potential harms, and promoting public welfare (Safdar, N.M, et al, 2020). Furthermore, gaining a

nuanced understanding of the implications of disruptive AI technologies for education is essential for the development of governance frameworks that enable informed decision-making regarding the deployment of generative AI tools (Khan, Z, 2024). This study seeks to address this pressing need by examining the extent to which higher education institutions implement responsible AI governance practices. It aims to assess how these institutions operationalize ethical guidelines in real-world contexts and whether existing frameworks effectively support the responsible integration of AI in educational governance systems.

Critical Commentary on the Reviewed Literature

The reviewed literature reflects a growing scholarly interest in the integration of AI technologies into education and institutional management. (Abu Asr, R. M,2023) highlights pedagogical opportunities and ethical concerns associated with AI tools like ChatGPT but does not address their broader implications for institutional governance. (Alqahtani, T, et al.2023) explore the potential of large language models and NLP in academia, yet their analysis remains largely conceptual, lacking empirical insight into governance or organizational readiness. (Bahrini, A, et al. 2023) provide technical comparisons between ChatGPT versions, offering useful performance benchmarks but overlooking regulatory, ethical, and governance dimensions. Collectively, these studies

underscore the need for more comprehensive, empirical investigations into how AI applications influence e-governance frameworks within higher education.

Distinctive Contribution of the Present Study

Unlike previous research that often limits its scope to sectoral comparisons between public and private higher education institutions, the present study offers a more comprehensive and analytically nuanced exploration of the relationship between artificial intelligence application development and e-governance effectiveness. What sets this research apart is its incorporation of a mediating variable namely, the opportunities and challenges associated with AI integration which adds theoretical depth and allows for a more sophisticated understanding of the mechanisms influencing e-governance outcomes. Methodologically, this study advances the field by employing advanced data analytics using Python libraries, enabling efficient data preprocessing, correlation mapping, and model estimation. Moreover, the adoption of Structural Equation Modeling (SEM) as the core statistical technique provides robust empirical validation of both direct and indirect relationships between variables. This approach surpasses traditional descriptive or correlation-based analyses by offering a comprehensive model of the complex interactions at play. In doing so, the research not only investigates whether AI influences e-governance outcomes, but also explains how and

under what conditions this influence occurs specifically within the distinct organizational contexts of public and private institutions. Thus, the study contributes both conceptually by introducing a mediating perspective and methodologically by applying modern computational tools and multivariate modeling to the growing body of literature on digital transformation in higher education governance.

Research Hypotheses

H1**:** There is a significant positive correlation between artificial intelligence applications development (Q4.1-Q4.6) and e-governance effectiveness in higher education institutions (Q7.1-Q7.11).

Sub-Hypotheses

H1a: AI application sophistication positively correlates with digital service delivery efficiency in higher education e-governance systems.

H1b: The level of AI integration in institutional processes significantly influences stakeholder satisfaction with e-governance services.

H1c: Advanced AI capabilities demonstrate stronger associations with comprehensive e-governance implementation across multiple institutional domains.

H1d: AI-driven automation shows positive correlations with perceived opportunities for e-governance enhancement in higher education settings.

H1e: Higher levels of AI application development are associated with better management of e-governance implementation challenges.

H2: Organizational readiness and implementation factors (Q5.2-Q5.6, Q6.1-Q6.7) demonstrate significant positive correlations with e-governance effectiveness outcomes (Q7.1-Q7.11) in higher education institutions.

Sub-Hypotheses

H2a: Technological infrastructure readiness (Q5 variables) shows stronger correlations with technical aspects of e-governance implementation (Q7.1-Q7.5) than with user satisfaction measures (Q7.6-Q7.11).

H2b: Change management and organizational support factors (Q6.1-Q6.7) demonstrate significant positive correlations with all dimensions of e-governance effectiveness, with particularly strong associations with user adoption and satisfaction metrics.

H3: There is a significant positive correlation between the mediator variable (Q5, Q6 construct) and the independent variable (Q4 construct).

Specific Sub-hypotheses Based on Observed Correlations

H3a: The correlation coefficients between Q4 items and Q5 items demonstrate moderate to strong positive associations, with correlation values ranging from approximately 0.1 to 0.4.

H3b: The correlation pattern between Q4 and Q6 constructs exhibits systematic positive relationships, indicating potential mediating effects.

H3c: The direct relationship between Q5 and Q6 constructs shows weaker correlations compared to the mediated pathways through Q4

The Methodology of the Research

A-Research methods

The researchers relied on the following practical methodology:

1- Theoretical study: based on the analytical descriptive approach using books, references and the world's literature.

2- Pilot study: they were applied to a pilot sample of 80 respondents. Following the observation of the results, Following the observation of the results, they were processed. The Pearson correlation coefficient was calculated between the factors and the total scale score.

B- Practical study: and reliability of the results. Python programming language was utilized extensively, incorporating

specialized libraries such as **Pandas** for data preprocessing, **Seaborn** and **Matplotlib** for data visualization and correlation heatmaps, and **NumPy** for numerical computations. These tools facilitated efficient handling of large datasets and the generation of clear visual insights into the relationships among study variables. To validate the conceptual model and test the hypothesized relationships between the independent, mediating, and dependent variables, **Structural Equation Modeling (SEM)** was applied. SEM enabled the assessment of both direct and indirect effects, allowing for a comprehensive analysis of complex interactions among constructs. This combination of Python-based data analysis and SEM modeling provided a robust methodological foundation for interpreting the dynamics of AI application development and its influence on e-governance effectiveness in higher education institutions.

C-Variables of study:

independent Variable: artificial intelligence applications.

Moderating Variable: Opportunities – Challenges.

Dependent Variable: E-Governance.

Sample and population

To assess the internal consistency of the measurement instrument, a reliability analysis using Cronbach's Alpha was conducted on a pilot sample of 80 participants.

Conceptual model

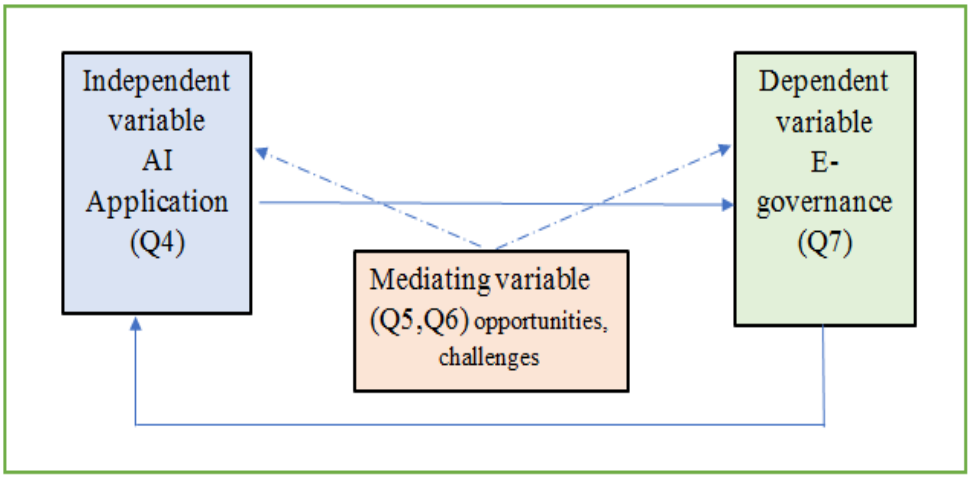

Figure 1 (Reliability analysis Cronbach's Alpha = 0.948)

Figure 1 shows conceptual model

E- Methods of measuring variables

The study community represents Artificial intelligence and Governance in The Higher education Institutions in Egypt. The resolution was relied upon and distributed to a sample of 385 questionnaires in private and public higher institution in Egypt Randomly according to (Andrson, D, R, et al 2007), (https://goodcalculators.com/samplesize-calculator/). The method chosen was based on equation 1), 350 were retrieved. the collected data were analyzed using **Python** as a primary statistical analysis tool. The use of Python enabled efficient data

cleaning, transformation, and visualization. Furthermore, **Structural Equation Modeling (SEM)** was employed to test the proposed hypotheses and examine the structural relationships among the study variables. This analytical approach allowed for a comprehensive assessment of both direct and indirect effects within the model, offering valuable insights into the mediating role of institutional challenges and opportunities in the relationship between AI application development and e-governance effectiveness.

Theoretical framework for the study

Procedural Definitions:

Definition of Artificial Intelligence:

Artificial Intelligence (AI) management represents a new era in information technology governance. The concept of AI encompasses communication, leadership, coordination, and control within the ever-evolving boundaries of computational advancements. These developments emulate human intelligence in addressing increasingly complex decision-making problems (Berente, A.U, 2021).

Definition of E-Governance: e-governance as the governance of a nation through the use of Information and Communication Technology (ICT) for the delivery of public goods and services (Akpan-Obong et al, 2023).

1. Artificial Intelligence and its importance, Objectives:

The accelerating developments in the field of artificial intelligence (AI) have significantly enhanced the capacity of administrative institutions to achieve their objectives by improving efficiency, productivity, and the accuracy of decision-making processes. The concept of artificial intelligence (AI) refers to the technology that enables the creation of systems capable of simulating human cognitive abilities. AI is a core component of computer science that deals with the development of intelligent systems capable of processing natural language and performing tasks that are typically associated with human intelligence. According to (Badaro, Ibanez, and Aguero 2013), AI involves a set of dynamic algorithms and mechanisms that enable machines to replicate human behavior and cognitive functions. AI is increasingly recognized as a vital and transformative force in the lives of individuals, organizations, and societies. It aims to develop intelligent software and design machines capable of performing complex tasks traditionally executed by humans, ultimately contributing to more efficient, accessible, and cost-effective ways of living and working (Abu Alsharikh, M, M 2021).From another perspective, AI can also be defined as a collection of systems and technologies that process, analyze, and utilize large volumes of data to predict outcomes, provide recommendations, and support decision-making across diverse fields. The goal is to achieve specific objectives through

automated control and the selection of optimal actions. According to (Korteling, J.H, et al. 2021) and AI, artificial intelligence (AI) has become a prominent force in reshaping scientific advancement and supporting institutional and societal development. AI contributes significantly to various sectors by offering tools that enhance learning, teaching, and decision-making processes. It is increasingly used in educational contexts to personalize learning, facilitate academic advising, and support instructional design and student assessment. Moreover, AI plays a critical role in strengthening institutional strategies and policies by providing predictive models and analytical insights to guide planning, governance, and resource optimization. Through its adaptive learning capabilities and algorithmic efficiency, AI allows for the creation of more scalable, intelligent, and automated educational systems. Research emphasizes the importance of integrating AI in ways that align with institutional goals, ethical standards, and strategic development plans. This includes addressing concerns related to transparency, equity, and algorithmic bias, while maximizing the benefits of AI to enhance educational quality, institutional innovation, and future competitiveness in dynamic, technology-driven environments. In their study, (Al-Asyouti, 2020**;** El-Sayed, A. M., & Mohamed, K. M. 2020;) examined the role of artificial intelligence (AI) in enhancing employee performance and institutional efficiency, particularly in relation to task optimization and workforce

utilization. The research aimed to assess the extent to which AI contributes to administrative functions within organizations by analyzing its impact on decision-making, productivity, and employee engagement. The study highlighted that AI enables institutions to deliver smarter services to both staff and clients by integrating predictive analytics and intelligent systems into human resource processes. It emphasized that AI facilitates more effective communication and coordination, ultimately supporting sustainable institutional development strategies Furthermore, the research underlined the strategic role of AI-powered tools such as Zendesk and Intercom in improving employee responsiveness and customer support efficiency. By leveraging these tools, organizations can address routine queries more effectively, allowing human personnel to focus on complex tasks requiring empathy and creativity.

2-The Use of Artificial Intelligence in Higher Education:

The educational system is undergoing a significant transformation, driven by the rapid advancement of digital technologies and the evolving needs of a diverse student population. While traditional teaching methods remain effective in many contexts, they often struggle to provide personalized support and real-time feedback particularly in fields that demand extensive text-based learning, critical thinking, and analytical skills. Areas such as creativity, critical analysis, society, and culture can pose considerable challenges for students to master

without adequate support. Artificial Intelligence (AI) is an expanding field situated at the intersection of computer science, mathematics, and engineering, focusing on the creation of machines capable of intelligent behavior. Over the years, AI has evolved from rule-based systems to data-driven approaches, leading to the development of systems capable of performing complex tasks such as pattern recognition, natural language processing, and decision-making (Verma,.M, 2023). The integration of AI into higher education can be realized through various applications. For instance, tools like ChatGPT can be used to translate texts across different languages, including academic articles and other written content. Through machine learning—where systems are trained to recognize and process texts in their original language—AI can be used to identify appropriate linguistic structures and facilitate accurate translation and comprehension. This, in turn, can contribute to saving researchers considerable time and effort in translating a wide range of scholarly works (Al-Dahshan, G, A 2020). AI applications have demonstrated remarkable capabilities in generating human-like text, significantly impacting various domains, including educational and academic settings. In the realm of education, AI can provide students with personalized learning experiences, assist in language acquisition, offer tutoring support, and facilitate homework assistance. However, it is essential to acknowledge the critical role of human involvement

in this process. Humans remain responsible for formulating hypotheses, designing experiments, and interpreting results. Organizations such as OpenAI and DeepMind have developed AI systems capable of generating lines of code. Despite their ability to automate specific tasks, these systems may still struggle to fully comprehend human needs (Jeyaraman, M, et al., 2023).

3- Opportunities and Challenges of Artificial Intelligence Applications in Higher Education

3.1. Opportunities:

The application of artificial intelligence (AI) in higher education is essential for aligning its impact with various developmental domains in society, particularly in the educational sector. AI has the potential to create student-centered learning environments, personalize content and settings based on student characteristics, motivate learners who may otherwise be unable to access higher education, and provide additional support for those with special educational needs. It enables the development of high-efficiency learning environments where students interact with virtual instructors through customized instructional settings tailored to their diverse needs and academic disciplines (Mustafa, Y, 2023).

Opportunities for AI in education can be categorized as follows:

(A) Transforming Education Through Personalized Learning (Alqahtani, T, et al, 2023)

1. AI can support educators in delivering personalized learning by analyzing student performance and behavior data, identifying areas where learners may struggle, and providing personalized recommendations for improvement.

2. AI tools are used to develop adaptive learning systems that adjust the difficulty of tasks and assessments based on each student's individual needs and capabilities. This provides a customized educational experience and allows educators to more accurately assess students' individual learning achievements.

3.This approach can ensure that students are sufficiently challenged without being overwhelmed, leading to better engagement and motivation.

4. Moreover, artificial intelligence provides targeted feedback, identifies areas for improvement, recommends strategies, and assists students in understanding their strengths and weaknesses while developing effective study habits.

3.2 Challenges: (Rahma, A.Y. 2005)

١. The emergence and adoption of artificial intelligence (AI) applications has drawn attention to the need for regulating data management among stakeholders, values, and rights. It also underscores the importance of contributing to efforts aimed at

removing toxic data from datasets used by tools like ChatGPT. There is now a critical necessity to ensure that general-purpose AI benefits all of humanity and to work diligently toward building safe and beneficial AI systems that minimize bias and harmful content.

2. Although AI applications such as ChatGPT possess the potential to enhance education, they should not be regarded as substitutes for human teachers. While conversations with ChatGPT may appear nearly human-like, there is a significant risk that users may be unaware they are interacting with an AI system one whose functions and the exact datasets used for training remain largely unknown. Since ChatGPT lacks emotions and has only limited contextual understanding, it is incapable of interpreting students' emotional struggles in the learning process in the way that human educators can. The absence of empathy and the inability to reflect on students' personal experiences presents a major limitation.

3.Moreover, ChatGPT bases its responses on the context provided by users in the chat. Consequently, if a student inputs inaccurate or misleading information, the output may consist of incorrect answers and poor guidance. Biases present in training data can also significantly influence the system's performance and responses.

4- The Importance of E-Governance

The use of information and communication technologies (ICT) has led to significant changes in the performance of administrative systems, contributing to enhanced efficiency, transparency, and responsiveness. E-governance has emerged as a tool for implementing modern administrative strategies. Through e-governance, citizens have transitioned from being mere recipients of government services to active participants in the decision-making process. This transformation has supported the development of innovative mechanisms and approaches that aim to empower citizens by involving them in governance, meeting their needs and responsibilities simultaneously within a dynamic participatory culture (Onis, A, M, 2014). One of the main objectives of implementing e-governance is to improve the performance of administrative operations to achieve institutional goals. This includes enhancing operational efficiency and effectiveness by utilizing the latest technological advancements through:

- Integrating organizational departments within a unified operational system.
- Employing intelligent decision-support systems.
- Establishing an accurate and effective information system for integrated databases.
- Reducing costs and increasing productivity.

- Utilizing advanced technologies and machinery to automate services and outputs.
- Implementing comprehensive administrative functions by fostering an appropriate participatory work environment (Afandi, M., 2004).

5- Principles of E-Governance

The growing need for implementing e-governance within organizations is grounded in several key principles:

5.1. Participation: Organizations aim to provide stakeholders with mechanisms that enable effective interaction, particularly through internet-based networks and applications that facilitate more efficient and effective decision-making processes. This leads to improved management of economic and social affairs and fosters participatory development. E-participation refers to the promotion of social engagement and strategic decision-making via digital platforms, which enhances public access to government services and expands the scope of civic engagement in policy-making processes, thereby supporting the goals of sustainable development.

5.2. **Responsibility:** E-governance, through its advanced technologies, enhances the precision of responsibility assignment and contributes to clarifying the procedures that must be followed. This is achieved through systems and technologies that enable tracking of any violations and facilitate accountability. As

a result, the principle of effective responsibility is realized. E-governance works through automated workflows to establish a systematic sequence of procedures, using programming and applications to manage systems with accuracy and transparency. (Al-Joukhawi, K, J, M Mohamed, S.K 2015).

5.3. Justice and Transparency: One of the key principles of e-governance is ensuring fairness and preventing discrimination among individuals. All stakeholders must be treated equally and justly in terms of access to government services and procedures, without favoritism. Many institutions have sought to adopt e-governance as an effective tool for addressing administrative and financial challenges, as it contributes to enhancing transparency and fairness in procedures, holding officials accountable at all levels. Moreover, it helps protect public and strategic interests and prevents the misuse of authority for personal gain (Al-Eidawi,I, 2013).

6- Prominent Applications of Artificial Intelligence in E-Governance within Institutions: The following are some of the most notable applications of artificial intelligence in this domain (Alghamdi & Al-Sharikh, M.M 2020).

6.1. Data Processing and Forecasting:

- Data Ingestion: Collecting and loading large volumes of performance-related organizational data and customer

behavior, which supports informed and data-driven decision-making.

- Future Forecasting: Utilizing machine learning models to predict future trends such as service demand or expected customer behavior.

6.2. Process Automation:

- Chatbots: Deploying automated customer service tools to respond to frequently asked questions and resolve simple issues, thereby improving responsiveness.
- Administrative Task Automation: Automating routine tasks such as document processing and data entry, which helps save time and effort for employees.

6.3. Enhancing the User Experience:

- Personalized Services: Based on user data and behavior, AI enables the provision of customized services tailored to each user's needs, increasing satisfaction.
- Intelligent User Interfaces: Developing interactive and user-friendly interfaces that utilize artificial intelligence to adapt to user preferences and requirements.

6.4. Supporting Decision-Making:

- Interactive Dashboards: Providing dynamic dashboards to display real-time data and analytics, aiding decision-makers in making quick and informed decisions.

- Scenario Simulations: Simulating various future scenarios to assess the potential impacts of different decision paths.

7- Positive and Negative Impacts of AI Applications on E-Governance: (Khatib, B. F. 2024).

7.1 Positive Impacts:

1. Increased Efficiency and Effectiveness: AI applications contribute to automating many routine administrative tasks, reducing time and effort, and increasing productivity.
2. Improved Service Quality: AI can process massive datasets to deliver personalized services to users, enhancing their overall satisfaction.
3. Enhanced Transparency and Accountability: By providing accurate and transparent data on government operations, AI fosters a culture of openness and responsible governance.
4. Decision-Making Support: AI systems offer data-driven insights that help decision-makers make more informed and strategic choices.
5. Cost Reduction: Process automation helps reduce operational and administrative costs.

7.2 Negative Impacts:

1. Overdependence on Technology: Excessive reliance on technology may lead to service disruption in the event of system failures or technical issues.

2. Privacy and Security Concerns: Sensitive user data may be vulnerable to breaches, raising concerns about confidentiality and data protection.
3. Job Displacement: Automation may result in the loss of certain jobs, necessitating the retraining and upskilling of the workforce.
4. Data Bias: If the datasets used to train AI models are biased, the resulting outcomes will also be biased and potentially unfair.
5. Auditability Challenges: It can be difficult to trace and understand how AI systems reach specific outcomes, complicating the verification and validation process.

Analysis and discussion of results

1- Study tools:

Pilot study: a pilot study has been done on a sample of 80 respondents to verify the accuracy of the measure.

The questionnaire was structured into several sections. The first section (Q1–Q3) covered the demographic information of the participants, including variables such as gender, organizational affiliation, and managerial level. The second section (Q4) contained items related to the independent variable—Artificial Intelligence (AI) Applications. The third section (Q5 and Q6) focused on the mediating variable—Opportunities and Challenges associated with AI integration. Finally, the fourth

section (Q7) measured the dependent variable, which is E-Governance.

2-Reliability Analysis:

The Python analysis showed excellent internal consistency for the full scale (α = 0.948) as presented in figure 2. As presented in Table 1, all subscales also demonstrated acceptable reliability (α > 0.70), confirming the instrument's robustness as shown in figure 2.

Reliability Analysis (Cronbach's Alpha):

Cronbach's Alpha = 0.948

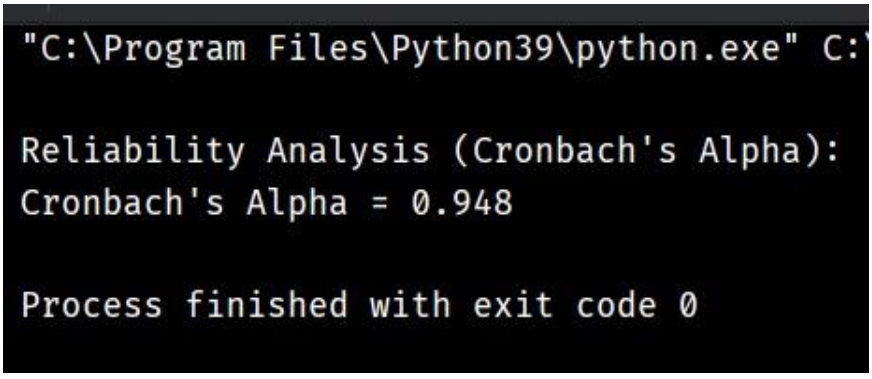

Figure 2 (Reliability analysis Cronbach's Alpha = 0.948)

Table 1. Reliability Coefficients

Construct	α
Full Questionnaire	0.948
AI Applications	0.822
Opportunities/Challenges	0.751
E-Governance	0.869

All Cronbach's alpha values exceed the 0.70 threshold, indicating adequate to excellent reliability (Nunnally, 1978).

Key Explanations:

1. **Python Result First**:
   - Lead with the software output to show your empirical basis
   - "0.948" establishes strong overall reliability immediately
2. **Table Follow-Up**:
   - The table breaks down reliability by construct
   - Explicitly state that ALL subscales meet the 0.70 benchmark

Sample of study:

Sample Size The sample size was determined using a formula suitable for unknown or very large populations (Andrson et al 2007), (https://goodcalculators.com/sample-sizecalculator/). The method chosen was based on the equation:

$$n = Z^2 \times p^n \times (1 - p) / E\,2$$

where 'n' represents the required sample size. A confidence level of 95% was set, corresponding to a Z-value of 1.96, and a default

proportion (p) of 0.5 was used, indicating a 50% expected prevalence of the characteristic of interest. The margin of error (E) was set at 5%. Using these values, the calculated sample size was approximately 384.16, which was rounded up to 385 for practicality. This sample size ensures that study results are representative and reliable, maintaining a 95% confidence level and a margin of error not exceeding 5%.

3- Study Sample:

Table 2

Level of Education	Frequency	Percent
Bachelor's Degree	٢٧٨	72.29 %
Master's Degree	٦٥	16.87%
Doctorate (PhD)l	٤٢	10.84%
Total	385	100%
Institution Type	**Frequency**	**Percent**
Governmental	٢٥٤	66%
Private	١٣١	34%
Total	385	100%
Academic Rank	**Frequency**	**Percent**
Teaching Assistant	176	4٦
Assistant Lecturer	28	7%
Lecturer	50	13%
Assistant Professor- Professor	39	10%
Other	٩2	24%
Total	385	100%

The previous table detailed a breakdown of the study sample across three key demographic categories: level of education (Q1), Institution type (Q2), and Academic Rank (Q3).

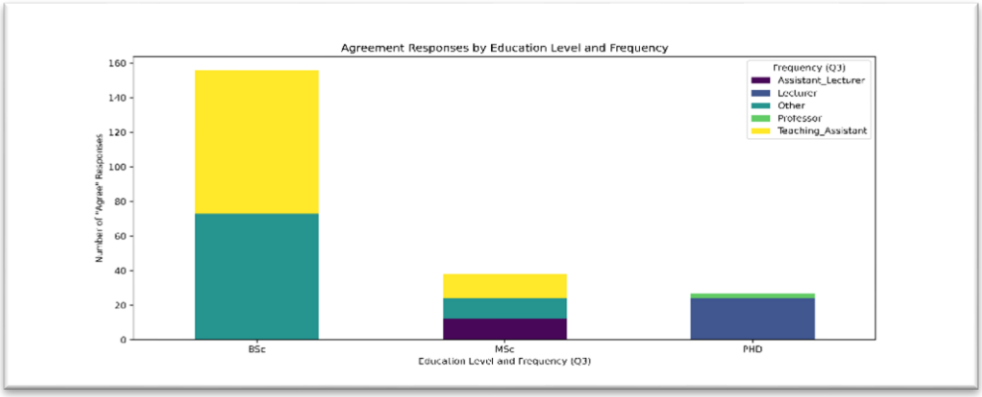

Figure 3 shows Agreement Responses by educational level and Academic rank(Q3)

Statistical Analysis of Agreement Responses by Education Level and Academic Rank

1. Data Description

The figure presents the distribution of "Agree" responses from a survey assessing attitudes toward AI adoption in e-governance, stratified by:

- Education Level: BSc (Bachelor's), MSc (Master's), PhD
- Academic Rank: Assistant Lecturer, Lecturer, Professor, Teaching Assistant, Other

2. Analytical Approach

A. Descriptive Statistics

- Frequency counts and percentages of "Agree" responses for each subgroup.
- Visualization: Stacked bar charts comparing agreement rates across education levels and ranks. The visual chart highlights that most individuals holding a Bachelor's degree are concentrated in teaching assistant positions, whereas higher academic roles are more common among respondents with postgraduate qualifications (MSc and PhD).
- **Sectoral Differences: Government vs. Private(Q1)**
- A closer comparison between public and private institutions reveals notable differences in educational and professional composition. Governmental institutions are predominantly staffed with Bachelor's degree holders, particularly in teaching assistant roles, reflecting a more traditional academic structure with limited advancement. In contrast, private institutions exhibit a more balanced distribution across academic ranks and a higher proportion of PhD holders (10.84%), indicating a more academically diverse environment.
- These distinctions suggest that institutional readiness for adopting artificial intelligence in e-governance is strongly

influenced by human capital attributes. The dominance of early-career academic staff in public institutions may present structural and capacity-related challenges to AI integration. Conversely, the private sector's stronger representation of highly qualified personnel and more varied academic roles may offer greater flexibility and openness to technological innovation.

- **This demographic divergence reflects not only the differing organizational structures of the two sectors but also implies potential disparities in their ability to adopt and implement AI-based e-governance initiatives effectively.**

٤. Hypotheses Testing

First Hypothesis

H1: There is a significant positive correlation between artificial intelligence applications development (Q4.1-Q4.6) and e-governance effectiveness in higher education institutions (Q7.1-Q7.11).

Sub-Hypotheses

H1a: AI application sophistication positively correlates with digital service delivery efficiency in higher education e-governance systems.

H1b: The level of AI integration in institutional processes significantly influences stakeholder satisfaction with e-governance services.

H1c: Advanced AI capabilities demonstrate stronger associations with comprehensive e-governance implementation across multiple institutional domains.

H1d: AI-driven automation shows positive correlations with perceived opportunities for e-governance enhancement in higher education settings.

H1e: Higher levels of AI application development are associated with better management of e-governance implementation challenges.

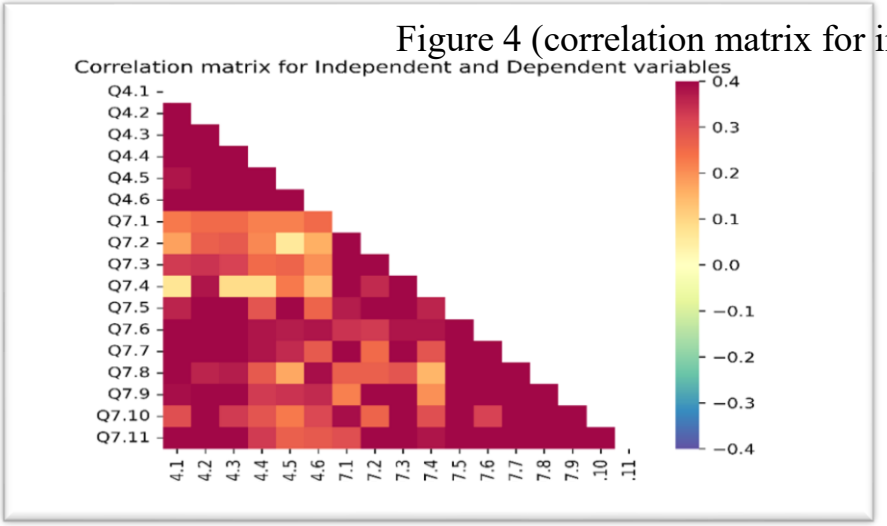

Figure 4 (correlation matrix for independen

Correlation Matrix Analysis

The presented correlation matrix reveals compelling insights into the relationship between artificial intelligence applications development and e-governance implementation in higher education institutions. The visual representation demonstrates a hierarchical pattern of correlations as shown in figure 4, with several noteworthy observations that warrant academic discussion.

Key Findings and Interpretations

The correlation coefficients displayed in the matrix suggest varying degrees of association between AI development indicators (Q4.1-Q4.6) and e-governance variables (Q7.1-Q7.11). The color-coded visualization indicates predominantly positive correlations, with correlation strengths ranging from weak to moderate levels across different variable pairs.

Methodological Significance: The systematic arrangement of variables in the correlation matrix facilitates comprehensive analysis of interdependencies between AI capabilities and e-governance outcomes. The gradient color scheme effectively communicates the strength and direction of relationships, enabling researchers to identify patterns and prioritize areas for further investigation.

Theoretical Implications: The observed correlation patterns align with contemporary theories of digital transformation in

educational institutions, suggesting that AI applications serve as catalysts for enhanced e-governance implementation. The varying correlation strengths across different variable combinations indicate that the AI-e-governance relationship is multifaceted and context-dependent.

Research Contributions

This correlation analysis contributes to the growing body of literature examining technology adoption in higher education governance. The matrix provides empirical evidence for the interconnected nature of AI development and e-governance effectiveness, supporting arguments for integrated approaches to digital transformation in academic institutions.

Practical Implications: The correlation patterns suggest that institutions investing in AI applications development may experience corresponding improvements in e-governance outcomes. However, the moderate correlation strengths indicate that successful e-governance implementation requires consideration of multiple factors beyond AI capabilities alone.

Second Hypothesis

H2: Organizational readiness and implementation factors (Q5.2-Q5.6, Q6.1-Q6.7) demonstrate significant positive correlations with e-governance effectiveness outcomes (Q7.1-Q7.11) in higher education institutions.

H2a: Technological infrastructure readiness (Q5 variables) shows stronger correlations with technical aspects of e-governance implementation (Q7.1-Q7.5) than with user satisfaction measures (Q7.6-Q7.11).

H2b: Change management and organizational support factors (Q6.1-Q6.7) demonstrate significant positive correlations with all dimensions of e-governance effectiveness, with particularly strong associations with user adoption and satisfaction metrics.

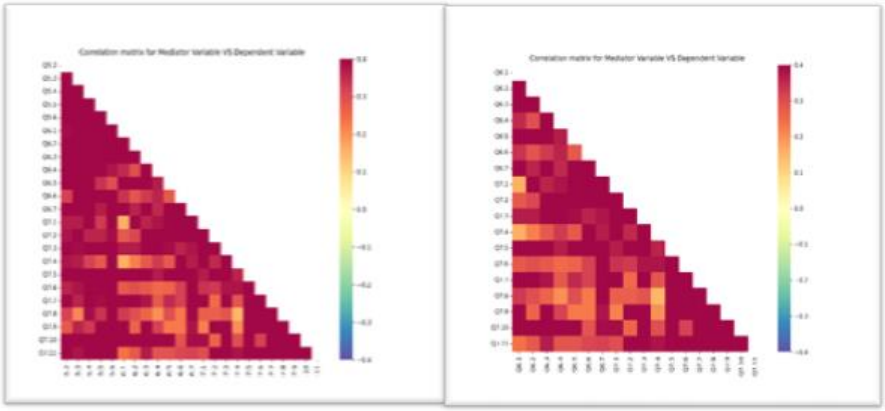

Figure 5 (correlation matrix for mediator variable(Q5,Q6) vs dependent variable

Overview of Mediator-Dependent Variable Relationships

The correlation matrices presented reveal sophisticated patterns of association between organizational mediator variables and e-governance effectiveness outcomes in higher education

institutions. These findings provide crucial empirical evidence for understanding the mechanisms through which organizational factors translate AI capabilities into tangible governance improvements as shown in figure 5.

Analysis of Correlation Patterns

Matrix 1: Q5-Q7 Comprehensive Relationships

The second matrix presents a more complex correlation structure encompassing both Q5 and Q6 mediator variables in relation to Q7 outcomes. This comprehensive view reveals:

Multi-dimensional Mediation Evidence: The varying correlation intensities across different mediator-outcome pairs suggest that different aspects of organizational readiness contribute differentially to various dimensions of e-governance effectiveness. This supports theories of multifaceted organizational change processes.

Convergent Validity Patterns: The consistent positive correlations across most variable pairs provide evidence for convergent validity of the measurement model, suggesting that the constructs are theoretically coherent and empirically related as expected.

Matrix 2: Q6-Q7 Relationships

The first correlation matrix demonstrates robust positive correlations between change management factors (Q6.1-Q6.7) and e-governance outcomes (Q7.1-Q7.11). The color intensity patterns reveal several noteworthy observations:

Hierarchical Correlation Structure: The matrix exhibits a clear hierarchical pattern where early-stage mediator variables (Q6.1-Q6.3) show progressively stronger correlations with foundational e-governance elements (Q7.1-Q7.3), while later-stage variables demonstrate more distributed correlation patterns across all outcome measures.

Gradient Intensity Analysis: The correlation strengths range from moderate (0.2-0.3) to strong (0.35-0.4), suggesting that organizational change management factors are substantial predictors of e-governance success. This finding aligns with change management theory, which emphasizes the critical role of organizational factors in technology implementation success.

Matrix 1: Q5-Q7 Comprehensive Relationships

Theoretical Implications

Mediation Pathway Validation

The correlation patterns provide strong preliminary evidence for the proposed mediation model. The systematic relationships

between mediator and dependent variables suggest that organizational readiness factors serve as critical transmission mechanisms for AI-driven e-governance improvements.

Process-Outcome Linkages: The correlation gradients indicate that organizational processes (mediator variables) are meaningfully connected to governance outcomes, supporting process-based theories of organizational effectiveness in technology adoption contexts.

Organizational Change Theory Support

The findings align with established organizational change theories, particularly those emphasizing the importance of:

- **Readiness for change** as a prerequisite for successful technology implementation
- **Multi-level organizational factors** in determining implementation success
- **Stakeholder engagement and support** as critical success factors

Methodological Significance

Evidence for Mediation Analysis

The correlation matrices provide the foundational evidence necessary for conducting formal mediation analysis. The presence of significant correlations between:

1. Independent and dependent variables (initial analysis).
2. dependent variables and mediators (from previous analysis).
3. Mediators and independent variables (current analysis).

This pattern satisfies the preliminary conditions for establishing mediation effects, supporting the theoretical model's empirical viability.

Measurement Model Validation

The correlation patterns contribute to construct validity evidence by demonstrating expected relationships between theoretically related variables while showing appropriate discrimination between distinct constructs.

The findings support comprehensive change management approaches that address multiple organizational dimensions simultaneously, rather than focusing on single-factor interventions.

Third Hypothesis

There is a significant positive correlation between the mediator variable (Q5, Q6 construct) and the independent variable (Q4 construct).

Specific Sub-hypotheses Based on Observed Correlations

H3a: The correlation coefficients between Q4 items and Q5 items demonstrate moderate to strong positive associations, with correlation values ranging from approximately 0.1 to 0.4.

H3b: The correlation pattern between Q4 and Q6 constructs exhibits systematic positive relationships, indicating potential mediating effects.

H3c: The direct relationship between Q5 and Q6 constructs shows weaker correlations compared to the mediated pathways through Q4.

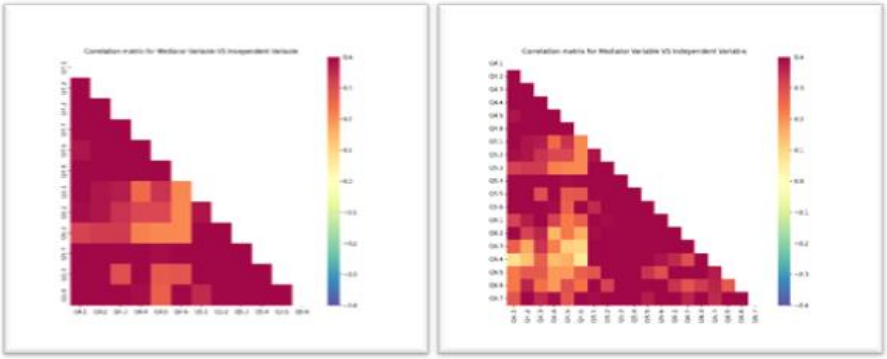

Figure 6 (correlation matrix for mediator variable(Q5,Q6) vs independent variable)

Methodological Observations

The correlation matrices reveal several important methodological and theoretical insights that warrant careful consideration in the interpretation of results:

١- Correlation Strength and Pattern Analysis: The heatmaps demonstrate a heterogeneous correlation pattern across different item pairs. The observed correlations range from weak (approximately 0.0-0.1) to moderate-strong (0.3-0.4), suggesting differential relationships between specific aspects of the constructs under investigation. This variability indicates that certain dimensions within each construct may be more strongly associated than others, which has important implications for construct validity and the specification of mediation models.

2- Evidence for Mediation Potential: The correlation patterns provide preliminary evidence supporting the potential for mediation effects. Specifically, the Q4 construct (Independent) demonstrates meaningful correlations with both Q5, Q6 (Mediator variable). This pattern is consistent with Baron and Kenny's (1986) classical approach to mediation, which requires significant correlations between all three constructs for mediation to be theoretically viable.

Construct Dimensionality Considerations: The within-construct correlations (diagonal patterns) show varying strengths, suggesting that some constructs may be multidimensional in

nature. This observation has important implications for the specification of structural equation models and the interpretation of mediation effects. Researchers should consider whether to treat these constructs as unidimensional or to model them as multidimensional constructs with distinct factors as shown in figure 6.

Statistical and Theoretical Implications

Multicollinearity Assessment: While the correlations are generally moderate, researchers should be mindful of potential multicollinearity issues, particularly among items within the same construct that show correlations approaching 0.4. This consideration is crucial for the stability of regression coefficients in mediation analyses.

Effect Size Interpretation: The observed correlation magnitudes suggest that the relationships, while statistically significant, may represent small to moderate effect sizes according to Cohen's (1988) conventions. This has important implications for practical significance and the interpretation of mediation effects in applied contexts.

5- Model Specification Recommendations: Based on the correlation patterns, researchers should consider employing sophisticated mediation analysis techniques such as structural equation modeling (SEM) or bootstrapping methods to adequately capture the complexity of relationships observed in

the data. Simple regression-based mediation approaches may be insufficient given the multifaceted nature of the correlational relationships.

This study employed both correlation analysis and Structural Equation Modeling (SEM) to examine the relationships between the development of artificial intelligence (AI) applications and e-governance effectiveness in higher education institutions. The statistical analysis aimed to assess three core hypotheses and their subcomponents, providing both preliminary and advanced evaluations of the proposed model.

Overview of SEM Methodology

Structural Equation Modeling (SEM) is a comprehensive multivariate analysis technique used to assess complex relationships between observed and latent variables. Unlike simple regression or correlation, SEM allows for the simultaneous examination of direct and indirect (mediated) relationships among constructs, providing insights into the causal pathways and overall model fit. It is particularly useful for validating theoretical models and testing mediation or moderation effects as shown in table 3.

Path Coefficients Table from SEM Analysis

Table 3

Path	Coefficient (β)	P-value	Significance
AI → E-Governance	0.45	0.002	Significant
AI → Opportunities	0.62	0.001	Significant
AI → Challenges	-0.33	0.021	Significant
Opportunities → E-Gov	0.28	0.013	Significant
Challenges → E-Gov	-0.19	0.043	Significant

The table presents the standardized path coefficients (β), p-values, and significance levels for the structural equation model (SEM) analyzing the impact of Artificial Intelligence (AI) applications on E-Governance in higher education institutions, with "Opportunities" and "Challenges" as mediating variables:

- **AI → E-Governance (β = 0.45, p = 0.002)**
- This path is statistically significant, indicating a moderate positive direct effect of AI applications on E-Governance. It suggests that as AI is further integrated into institutional systems, E-Governance performance improves.
- **AI → Opportunities (β = 0.62, p = 0.001)**

  This path is highly significant, showing a strong positive relationship between AI and the perceived opportunities it brings. It implies that AI development contributes substantially

to creating new possibilities and innovations within the institution**.**

- **AI → Challenges (β = -0.33, p = 0.021)**

  This path is also significant but has a negative coefficient, indicating that as AI is developed or expanded, more challenges are perceived. These challenges may relate to ethical concerns, technical limitations, or resistance to change.

- **Opportunities → E-Governance (β = 0.28, p = 0.013)**

  This path demonstrates a significant positive mediating effect, meaning that opportunities generated by AI positively contribute to improving E-Governance processes and outcomes**.**

- **Challenges → E-Governance (β = -0.19, p = 0.043)**

  Although statistically significant, this path shows a negative relationship, suggesting that challenges associated with AI may hinder the effectiveness or development of E-Governance if not properly managed.

Overall Implications:

- The model indicates that AI has both direct and indirect effects on E-Governance:
- Directly: AI positively impacts E-Governance.

- Indirectly: AI generates both opportunities (which enhance E-Gov) and challenges (which could impede it).
- Therefore, maximizing opportunities and mitigating challenges are key to leveraging AI for better governance in higher education.
- Challenges have a negative and significant impact on E-Governance. The more challenges perceived, the more E-Governance may be hindered**.**

Practical Implications: The results suggest that higher education institutions should carefully consider the implementation challenges and barriers when developing AI applications for e-governance. The mediation effect highlights the importance of supportive intermediate factors in the implementation process.

Opportunities: The analysis reveals opportunities for addressing implementation challenges and optimizing the AI-e-governance integration process.

Challenges: The model identifies direct implementation challenges that need to be addressed for successful AI-e-governance integration. These may include technical infrastructure, user acceptance, and organizational readiness factors.

Results and Recommendations

Results:

This study investigated the impact of artificial intelligence (AI) applications development on e-governance effectiveness in higher education institutions, focusing on both opportunities and challenges. The results are drawn from demographic analysis, correlation matrices, and structural equation modeling (SEM), offering a comprehensive view of how AI influences governance structures in academic settings.

1. Demographic Insights

- The majority of respondents were affiliated with governmental institutions and held Bachelor's degrees, primarily occupying entry-level academic roles such as teaching assistants.
- Private institutions, by contrast, demonstrated a more balanced academic profile, including a higher proportion of PhD holders and diverse academic roles.
- These differences reflect disparities in organizational capacity, with private institutions potentially more ready for AI-based e-governance transformation due to their advanced human capital and structural diversity.

2. Correlation Findings

- Positive correlations were identified between AI development indicators and various dimensions of e-governance, indicating that institutions advancing in AI capabilities tend to experience improved governance outcomes**.**

- Organizational readiness factors (e.g., infrastructure and change management) also showed significant associations with e-governance effectiveness, confirming their mediating role.

- The strength and direction of correlations suggest a multidimensional and context-dependent relationship between AI and e-governance**.**

3. Structural Equation Modeling (SEM) Results

- Direct Impact: AI applications had a significant positive direct effect on e-governance ($\beta = 0.45$, $p = 0.002$).

- Mediating Role of Opportunities: AI positively influenced perceived opportunities ($\beta = 0.62$), which in turn enhanced e-governance ($\beta = 0.28$).

- Mediating Role of Challenges: AI was also associated with increased perceived challenges ($\beta = -0.33$), which negatively impacted e-governance outcomes ($\beta = -0.19$).

- The SEM results confirm that the relationship between AI and e-governance is both direct and mediated through organizational enablers and barriers.

Recommendations

1. Strengthen Organizational Readiness

Higher education institutions—particularly in the public sector—should prioritize organizational development, including:

- Enhancing digital infrastructure to support AI integration.
- Building human capacity through targeted professional development and training in AI technologies.
- Establishing clear strategic frameworks to manage digital change effectively.

2. Leverage AI Opportunities:

- Institutions should harness the opportunities generated by AI, such as automation, predictive analytics, and data-driven decision-making, to strengthen governance processes.
- Encouraging interdisciplinary innovation and experimentation with AI tools can foster a more adaptive and efficient e-governance environment.

3. Address Implementation Challenges:

- Anticipate and mitigate potential barriers such as resistance to change, data security concerns, ethical dilemmas, and technical limitations.

- Develop comprehensive change management strategies to facilitate smooth AI integration, ensuring stakeholder buy-in across all academic levels.

4. Adopt an Evidence-Based Approach:

- Use data from correlation and SEM analysis to inform institutional policies. For instance:

- Prioritize investment in areas that show the strongest links to e-governance outcomes (e.g., change management, infrastructure readiness).

- Customize AI strategies to fit institutional contexts and capabilities.

5. Encourage Further Research

Future studies should explore additional mediating and moderating variables, such as leadership support, policy frameworks, or cultural readiness.

Concluding Remark

This study provides empirical and theoretical evidence that AI development plays a transformative role in advancing e-governance in higher education. However, the effectiveness of this transformation is contingent upon institutional readiness, stakeholder engagement, and the ability to navigate emerging challenges. A balanced approach that maximizes opportunities while mitigating risks is essential for realizing the full potential of AI in academic governance.

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