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ASSESSING READINESS: MODELS FOR THE IMPLEMENTATION OF INTERNET OF THINGS IN LIBYAN HIGHER EDUCATION INSTITUTIONS

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ABSTRACT
The adoption of Internet of Things (IoT) technology in Libyan higher education institutions holds significant promise for transforming teaching, learning, research, and administrative processes. This paper explores the implications of IoT adoption in the Libyan higher education sector, focusing on the opportunities, challenges, and considerations for successful implementation. Drawing upon a comprehensive review of existing literature, theoretical frameworks, and empirical studies, the paper examines the potential benefits of IoT adoption in enhancing teaching and learning experiences, empowering faculty and students, optimizing administrative processes, fostering innovation and research advancement, and contributing to national development goals. Additionally, the paper highlights key challenges related to data privacy, cybersecurity, infrastructure limitations, financial constraints, and capacity building efforts that must be addressed to ensure the sustainable implementation of IoT solutions. Furthermore, the paper discusses the importance of stakeholder engagement, policy support, and strategic planning in overcoming barriers to adoption and maximizing the socio-economic impact of IoT technology in Libyan higher education institutions. Overall, the findings suggest that the successful adoption of IoT technology has the potential to drive innovation, promote digital transformation, and accelerate progress towards a knowledge-based economy in Libya.
Keywords: Internet of Things (IoT), Higher education, Libya, Technology adoption, Socio-economic development.

INTRODUCTION
In contemporary society, Information and Communication Technology (ICT) plays an important role in facilitating efficient operations across various sectors. It encompasses a wide range of tools and resources utilized for communication, information management, and innovation (Selmi, 2023; Saif et al., 2022). Among the emerging ICT technologies, the Internet of Things (IoT) holds immense potential for transforming numerous industries, including higher education (Mohamad et al., 2018; Elkaseh et al., 2015). With predictions indicating exponential growth in connected devices, IoT stands as a driving force behind the Fourth Industrial Revolution (Darren Wall, 2022).

IoT's capacity to interconnect devices and enable data exchange without human intervention offers significant opportunities for enhancing teaching and learning in higher education (Ireda et al., 2019). By integrating IoT into educational settings, institutions can promote communication, advance learning processes, and foster comprehension between stakeholders and virtual or physical objects (Marquez et al., 2016). This technology facilitates active information transfer,

thereby enhancing skill development and expanding learning opportunities beyond traditional boundaries (Ireda et al., 2019).

However, realizing the potential benefits of IoT in higher education necessitates assessing the readiness of academic institutions and stakeholders to adopt and leverage this technology effectively (Chweya & Ibrahim, 2021). Readiness evaluation involves gauging the preparedness of individuals or organizations to undertake a task, considering factors such as skills, resources, attitudes, and knowledge (Kim et al., 2019). It aims to minimize risks, identify improvement areas, and ensure successful implementation (Javahernia & Sunmola, 2017).

In the context of IoT adoption, readiness assessment becomes crucial due to the technology's complexity and the organizational changes it entails (Zhuankhan & Renken, 2023). Factors influencing readiness include technological knowledge, available resources, attitudes, and perceptions toward IoT (Bourrie et al., 2015; Shin, 2014). Given IoT's novelty and potential impact, thorough preparation and planning are essential to address challenges and maximize benefits (Moreira et al., 2018).

Moreover, successful IoT adoption necessitates organizational changes and the development of supporting infrastructure to ensure interoperability, scalability, and reliability (Vermesan et al., 2022; Lee et al., 2021). Without adequate infrastructure, institutions may struggle to harness IoT's capabilities effectively (Zhuankhan & Renken, 2023). Environmental factors, such as regulatory frameworks and market dynamics, also influence an organization's readiness to embrace IoT (Hsu & Yeh, 2016; Peres et al., 2018). Individual perceptions and attitudes toward IoT play a significant role in readiness assessment, as they influence acceptance and adoption behaviors (Gao & Bai, 2014; Yee-Loong Chong et al., 2015a). Hence, understanding stakeholders' attitudes and addressing concerns is essential for successful IoT integration in higher education (Bourrie et al., 2015).

Overall, the adoption of IoT in higher education holds promise for enhancing teaching and learning experiences. However, realizing its full potential requires careful assessment of readiness among academic institutions and stakeholders. By evaluating factors such as technological knowledge, infrastructure, and individual perceptions, institutions can effectively plan for and implement IoT initiatives, thereby fostering innovation and improving educational outcomes.

The integration of Information and Communication Technology (ICT), particularly the Internet of Things (IoT), into higher education has become increasingly vital, especially in the wake of the COVID-19 pandemic. While developed nations have made significant strides in adopting smart educational technologies, developing countries like Libya face challenges in implementing these advancements due to infrastructure limitations and other constraints. In Libya, government initiatives and partnerships with technology companies aim to modernize the education sector by

incorporating ICT into higher education institutions. These efforts include collaborations with telecom enterprises to provide cloud services and digital skills training programs. However, despite these endeavors, challenges persist in fully integrating ICT into the education system.

One major obstacle is the lack of readiness among stakeholders, including decision-makers, educators, and students. While there is recognition of the importance of ICT in education, there remains a gap in understanding and embracing new technologies. Moreover, concerns about security and privacy pose additional barriers to the widespread adoption of emerging technologies like IoT. To address these challenges, comprehensive readiness assessments and strategic planning are necessary. Organizational-level analysis and evaluation of technical and non-technical factors are essential to ensure the successful deployment of IoT and other technologies in higher education. Moreover, efforts to enhance the digital skills of educators and students are crucial to bridge the readiness gap and facilitate the effective use of ICT tools.

Despite the challenges, there are significant opportunities for leveraging IoT to enhance teaching and learning experiences in Libya and other developing countries. By providing access to educational resources, facilitating resource sharing, and improving instructional systems, IoT has the potential to lower costs and expand educational opportunities for students. However, it is essential to acknowledge that the successful adoption of IoT in higher education requires a holistic approach that considers both technological and human factors. By addressing concerns about security and privacy, enhancing digital literacy, and fostering a culture of innovation, higher education institutions can harness the full potential of IoT to transform teaching and learning processes. Overall, while challenges remain, the integration of IoT into higher education holds immense promise for enhancing educational outcomes in Libya and other developing nations. By addressing readiness gaps, promoting digital literacy, and fostering a culture of innovation, higher education institutions can leverage IoT to create more inclusive, responsive, and effective learning environments.

The Fourth Industrial Revolution (4IR) is ushering in significant changes across various sectors worldwide, including higher education. To adapt to the evolving market demands, higher education institutions must equip students with the necessary skills, which requires embracing modern technologies (Azah Mansor et al., 2020). However, Libyan higher education institutions face unique challenges in transitioning to e-learning, despite relatively widespread access to high-speed Internet (Hammoud, 2023; The Libya Observer, 2019). Issues such as suboptimal e-learning platforms and technological infrastructure, coupled with increasing enrollment numbers and inadequate funding, underscore the pressing need for innovative solutions (Ghawail et al., 2021; Gadour, 2021; Salman & Soliman, 2022; Maatuk et al., 2022; Busneneh & El-Bazzar, 2021).

In this context, the effective adoption of Information and Communication Technologies (ICT) and advanced systems like the Internet of Things (IoT) becomes paramount for modernizing

educational processes and resource management (Mansor et al., 2020; Kamar et al., 2016). While access to technology is not the primary barrier in Libya, comprehension among key stakeholders remains lacking, leading to resistance to digital transformation (Azevedo & Almeida, 2021; Moreira et al., 2018). This resistance is particularly strong in less developed countries, where the adoption of IoT is still lagging (Aamer, 2022; Ali et al., 2023; Al-Emran et al., 2020).

Despite the growing recognition of the importance of ICT in higher education growth, there is a notable gap in understanding readiness factors for the adoption of IoT, especially at the organizational level in Libyan higher education institutions (Ramadan et al., 2019; Salem & Mohammadzadeh, 2018). Therefore, there is an urgent need for research to address this gap and develop a comprehensive readiness model that supports the adoption of IoT in Libyan higher education. This proposed study aims to examine the determinants influencing the readiness of Libyan higher education institutions to embrace IoT technology. By identifying these factors and developing a readiness model, the research seeks to contribute to both academic discourse and practical insights for policymakers and educational leaders. Ultimately, the goal is to facilitate digital transformation in the Libyan higher education sector, aligning with broader efforts to modernize educational infrastructure and enhance the quality of education.

LITERATURE REVIEW

The Internet of Things (IoT) represents a paradigm shift in connectivity, allowing everyday objects to communicate and exchange data over the internet. This interconnectedness enables unprecedented levels of efficiency and automation across various sectors (Rahmani et al., 2022; Debnath & Chettri, 2021; Gazis, 2021). One of the earliest examples of IoT dates back to 1982, with a Coca-Cola vending machine at Carnegie Mellon University, illustrating the concept's long-standing history and evolution (Greengard, 2023; Foote, 2022).

IoT technologies encompass a diverse array of components, including radio frequency identification (RFID), cloud computing, wireless sensor networks (WSNs), and near-field communication (NFC). These technologies enable devices to communicate, interact, and exchange data seamlessly, leading to the creation of smarter, more connected systems and products (Malekshahi et al., 2020; Gillis, 2022).

RFID, a fundamental IoT technology, utilizes radio waves to identify and track objects equipped with RFID tags. These tags consist of electronic components such as antennas, memory, and modulation circuits, enabling them to transmit and receive data when activated by RFID readers (Xu et al., 2023; Lubna et al., 2022). RFID finds extensive applications in logistics, supply chain management, asset tracking, and inventory control, offering advantages over traditional manual systems and barcodes (Mezzanotte et al., 2021).

The wireless sensor network (WSN) is another crucial IoT technology that comprises small, low-power sensors communicating wirelessly to monitor and transmit data. WSNs are utilized in diverse applications such as environmental monitoring, military sensing, and industrial automation, offering real-time data collection and control capabilities (Yellampalli, 2021; Singh et al., 2018). These networks employ various topologies like star networks, mesh networks, and hybrid networks to facilitate communication and data exchange among sensor nodes (Macharla, 2021).

The management of vast amounts of data generated by IoT devices presents significant challenges, often addressed through advanced machine learning algorithms for data analysis and pattern recognition. Despite these challenges, IoT technologies continue to proliferate across industries, revolutionizing how we monitor, control, and interact with our environment (Yellampalli, 2021; Bajaj et al., 2020).

The global IoT market is witnessing exponential growth, with projections indicating substantial revenue increases in the coming years. Factors driving this growth include the demand for inventory management, supply chain optimization, and operational efficiency across various sectors (RFID Market, 2022; Alsop, 2020; Das, 2019). As IoT technologies become more ubiquitous, they are expected to reshape industries and society, offering unparalleled opportunities for innovation and advancement.

The Internet of Things (IoT) has revolutionized various industries by connecting everyday objects to the internet, enabling them to send and receive data. Key IoT technologies include Radio Frequency Identification (RFID) for object tracking, Wireless Sensor Networks (WSNs) for remote monitoring, and IoT middleware for managing data flow and ensuring compatibility between devices and cloud-based applications. Near-Field Communication (NFC) facilitates short-range wireless communication between devices, while cloud computing provides scalable and cost-efficient computing resources over the internet. In agriculture, IoT enables precise monitoring of environmental conditions and resource management for improved yield. Wearable IoT devices enhance health tracking and social connectivity in wearable technology. Healthcare benefits from IoT solutions through remote patient monitoring and improved operational efficiency. Smart homes leverage IoT devices for environmental control and security enhancement. Industrial automation utilizes IoT for productivity optimization and safety improvement. Retail experiences improved customer satisfaction and operational efficiency with IoT applications. Finally, IoT contributes to the development of smart cities by optimizing operations, enhancing sustainability, and improving citizen services through data-driven decision-making and automation.

The Internet of Things (IoT) holds immense potential for higher education institutions (HEIs), offering opportunities for innovation and transformation. However, alongside these opportunities come several challenges that need to be addressed for successful implementation. One significant

constraint is the need for robust cybersecurity measures to protect sensitive data and prevent cyberattacks, given the interconnected nature of IoT devices (Aqeel et al., 2022; Chanal & Kakkasageri, 2020). Additionally, concerns about privacy and data protection must be carefully considered, as IoT devices can collect and transmit sensitive information (Aqeel et al., 2022; Chanal & Kakkasageri, 2020). Interoperability issues among IoT devices pose another challenge, as the lack of standardization can lead to compatibility issues and increased costs (Rana & Singh, 2021; Lynn et al., 2020; Noura et al., 2019).

Reliability is crucial for IoT devices to function effectively, as any malfunctions can result in safety concerns and data loss (Khan et al., 2021; Moore et al., 2020; Dey et al., 2019). Furthermore, the initial setup, maintenance, and upgrading of IoT infrastructure can be expensive, posing a financial constraint for HEIs (V-Soft Digital, 2022; Pham et al., 2016; Haroon et al., 2016). Energy consumption is another consideration, as IoT devices often operate on battery power and can drain resources (Haroon et al., 2016). Moreover, the massive amount of data generated by IoT devices presents challenges for data processing and storage, requiring efficient management strategies (Sadeeq et al., 2021; Moreira et al., 2018).

Network connectivity issues, including coverage, bandwidth, and latency, and reliability, can also hinder the effectiveness of IoT implementations (Haroon et al., 2016). Additionally, a lack of understanding among decision-makers and stakeholders about the benefits and implications of IoT technology may lead to resistance and inertia (Pappas et al., 2021; V-Soft Digital, 2022; Shin, 2017). Concerns about security, privacy, and the reliability of new technologies can further contribute to risk aversion (Shin & Jin Park, 2017). Hidden costs associated with IoT implementations may also deter adoption (Nawi et al., 2023; Hacid et al., 2023; V-Soft Digital, 2022; Shin et al., 2017).

Despite these constraints, it is essential to recognize the transformative potential of IoT in higher education. With proper planning, investment, and collaboration, HEIs can leverage IoT technologies to enhance learning experiences, improve operational efficiency, and address emerging challenges. By addressing the constraints and harnessing the opportunities presented by IoT, HEIs can position themselves at the forefront of educational innovation and prepare students for the demands of the digital age.

Higher Education in Libya

Higher education in Libya has undergone significant development over the years, marked by an increase in the number of universities and technical institutions. The system is primarily funded by the government, allowing for free education and contributing to a high enrollment rate. However, despite this growth, the quality of education faces challenges, including inadequate infrastructure, limited financial resources, and difficulties in adapting to modern teaching methods.

The COVID-19 pandemic further highlighted the need for technological integration in education, prompting Libyan universities to shift towards e-learning. However, the transition revealed significant shortcomings in technological infrastructure and the effectiveness of traditional e-learning platforms.

To address these challenges, there is a growing recognition of the importance of incorporating Information and Communication Technology (ICT), particularly the Internet of Things (IoT), into higher education. IoT technology offers the potential to enhance e-learning systems by facilitating interconnectivity, improving reliability, and creating dynamic, interactive learning environments.

The Libyan government has shown commitment to modernizing the education system, with initiatives aimed at incorporating ICT and enhancing technological infrastructure. However, successful implementation requires robust infrastructure, reliable communication systems, and adequate training for faculty members.

Furthermore, understanding the needs and behaviors of the new generation of learners, who are digitally savvy and demand flexibility in accessing educational resources, is crucial for effectively integrating IoT into higher education in Libya.

In summary, while Libya's higher education system has made strides in expanding access to education, there is a pressing need to address challenges related to quality and technological integration. Embracing IoT technology presents an opportunity to overcome these challenges and elevate the education system to meet the needs of students in the digital age.

New Generation of Learners

The emergence of the new generation of learners, often referred to as digital natives or Generation Z, brings with it a set of expectations and preferences that shape their educational experiences. These individuals, born and raised in an era of rapid technological advancement, exhibit a high level of comfort and proficiency with digital technologies. They are accustomed to using mobile devices and the internet for various aspects of their lives, including education.

In Libya, as in many other parts of the world, there has been a significant increase in mobile phone usage among younger generations. The accessibility of smartphones and tablets has facilitated connectivity and technological proficiency among the youth population. This trend presents an opportunity for higher education institutions in Libya to leverage emerging technologies like the Internet of Things (IoT) to enhance the teaching and learning experience.

The widespread use of smart devices among students can facilitate the adoption of IoT-enabled educational tools, thereby modernizing the higher education system in Libya. By incorporating

IoT technology, institutions can create more efficient, accessible, and relevant learning environments that align with the expectations of digital-native learners.

However, realizing the full potential of IoT in higher education requires more than just technological integration. It necessitates a comprehensive assessment of organizational and individual readiness. Institutions must ensure that faculty members are equipped with the necessary skills and knowledge to effectively utilize IoT-enabled educational tools. Additionally, they must address infrastructure challenges and privacy concerns to create a conducive environment for IoT implementation.

Overall, the new generation of learners in Libya presents both opportunities and challenges for higher education institutions. By embracing emerging technologies like IoT and adapting to the evolving needs of digital-native students, institutions can enhance the quality and relevance of education in Libya, ultimately preparing students for success in the digital age.

Models Underlying with the Research

The landscape of modern business, shaped by rapid technological advancements and evolving market conditions, demands a structured approach to digital transformation and organizational change. To aid firms in navigating this complex journey, several maturity models have been developed by renowned research bodies and scholars. These models provide frameworks for assessing and guiding the adoption of technologies like the Internet of Things (IoT) and driving innovation within organizations. Let us investigate some of these prominent maturity models:

1. Gartner's IoT Maturity Model: Developed by Gartner, this model outlines the stages and dimensions of IoT evolution. It helps Chief Information Officers (CIOs) understand, track, and maximize the business impact of IoT investments across their organizations. The model progresses through various maturity levels, guiding organizations from initial sporadic IoT initiatives to seamless integration within processes. It emphasizes aspects like technology, processes, standards, and governance, ensuring alignment with strategic objectives and delivering tangible business value.

2. IoT Capability Assessment Model: Created by the IoT Institute, this model evaluates firms' readiness and capabilities for adopting IoT technologies. It assesses capabilities across dimensions like strategy, infrastructure, data analytics, security, and integration with existing processes and systems. By identifying strengths and weaknesses, firms can develop strategic roadmaps for IoT deployment and ensure alignment with business objectives.

3. Schumacher's Industry 4.0 Maturity Model: Focused on the manufacturing sector in the context of Industry 4.0, this model assesses digital transformation across nine dimensions. It measures factors like strategy, leadership, customer integration, product customization, operations

automation, culture, people, governance, and technology adoption. By assigning scores and providing recommendations, the model helps manufacturers navigate Industry 4.0 advancements.

4. Axeda's Connected Product Maturity Model: Developed by Axeda, this model evaluates product manufacturers' capabilities for connecting and managing products over the Internet. It assesses connectivity and intelligence across six levels, from unconnected to differentiated value. By identifying their current stage and areas for improvement, manufacturers can develop strategies for advancing their products' capabilities and creating new value propositions.

5. The TDWI Readiness Model for IoT: Created by TDWI, this model focuses on the data aspects of IoT adoption. It assesses dimensions like data readiness, analytics readiness, data infrastructure readiness, IT, development, and operational readiness, and organizational readiness. By identifying strengths and weaknesses in these areas, organizations can prioritize investments and develop comprehensive plans for advancing their IoT capabilities.

Each of these maturity models offers a structured approach to assessing and guiding organizations' adoption of IoT technologies, driving digital transformation, and fostering innovation. By leveraging these frameworks, firms can navigate the complexities of business transformation and ensure their agility, responsiveness, and leadership in their respective domains.

Theories ln the Literature

In the aspect of Libyan Higher Education Institutions (LHEIs), the adoption of Internet of Things (IoT) technology represents an important juncture poised to redefine educational paradigms and infrastructural frameworks. As Libya progresses towards embracing digital transformation in its academic landscape, understanding the intricacies of technology adoption becomes imperative. The theories of technology adoption serve as foundational pillars, offering insights into the multifaceted dynamics shaping organizational and individual readiness for technological innovation. For instance, the Diffusion of Innovation Theory (DoI) elucidates the diffusion process within social systems, highlighting the role of early adopters and innovation characteristics. In a Libyan context, where fostering a culture of innovation and overcoming resource constraints are paramount, the DoI theory provides valuable insights into the socio-cultural dimensions of technology adoption.

Furthermore, the Theory of Reasoned Action (TRA) and the Theory of Planned Behavior (TPB) investigate individual attitudes and subjective norms, elucidating the cognitive processes underlying technology acceptance. By leveraging these theories, researchers can uncover the cognitive barriers and facilitators influencing educators' and administrators' readiness to embrace IoT solutions in LHEIs. Similarly, the Technology Acceptance Model (TAM) and its extensions offer a comprehensive framework for assessing the perceived usefulness and ease of use of IoT technologies. In the Libyan context, where technological infrastructure may vary across

institutions and regions, TAM provides a lens to evaluate the alignment between technological capabilities and user expectations.

Moreover, the Unified Theory of Acceptance and Use of Technology (UTAUT) synthesizes various adoption theories, emphasizing performance expectancy, effort expectancy, social influence, and facilitating conditions. In Libya, where technological investments must be aligned with educational objectives and stakeholder needs, UTAUT offers a holistic perspective on technology adoption readiness. Additionally, the Technology Readiness Index (TRI) and the Technology-Organization-Environment (TOE) Model provide nuanced frameworks for assessing individual and organizational readiness, considering factors such as optimism, innovativeness, technological infrastructure, and regulatory environments.

By integrating these theories into the research framework, scholars can navigate the complexities of IoT adoption in LHEIs, identifying barriers, enablers, and strategies for fostering a conducive ecosystem for technological innovation. Through empirical investigations and contextualized analyses, researchers can tailor interventions to address the unique challenges and opportunities shaping technology adoption in Libyan higher education. Ultimately, by leveraging insights from technology adoption theories, Libya can embark on a transformative journey towards building a digitally resilient and innovation-driven educational landscape.

The adoption of Information Technology (IT) innovations within Higher Education Institutions (HEIs) in Libya is a multifaceted process influenced by a variety of factors beyond users' perceptions of the technologies themselves. Organizational variables play a crucial role in shaping adoption decisions, as highlighted by research (Yang et al., 2015; Bharadwaj & Menon, 2000). However, existing technology adoption theories, such as the Technology Acceptance Model (TAM), Unified Theory of Acceptance and Use of Technology (UTAUT), Diffusion of Innovations (DOI), and Technology Readiness Index (TRI), have limitations that hinder their applicability in the complex context of HEIs. TAM, for example, focuses primarily on user perspectives and may overlook broader organizational and environmental factors (Malatji et al., 2020; Ajibade, 2018; Hamad, 2014; Islam et al., 2014). Similarly, UTAUT, while comprehensive, may lack adequate explanations for individual behavior and belief development (Williams et al., 2015; Oliveira & Martins, 2011).

In contrast, the Technology-Organization-Environment (TOE) framework offers a more holistic perspective, considering technological, organizational, and environmental contexts (Zhu and Kraemer, 2005). This flexibility makes it particularly suitable for analyzing IoT adoption (Zhuankhan & Renken, 2023). The TOE framework's emphasis on three fundamental dimensions technological, organizational, and environmental sets it apart and ensures a comprehensive understanding of adoption factors (Oliveira & Martins, 2011). Additionally, its adaptability allows for the inclusion of context-specific factors, making it ideal for diverse settings (Al Hadwer et al.,

2021; Li, 2020; Baker, 2012). Numerous studies have validated the TOE framework's theoretical robustness and empirical applicability, making it a valuable tool for examining technology adoption in various contexts (Aboelmaged, 2014; Leung et al., 2015; Alsheibani et al., 2020).

However, critics argue that existing theories, including TAM, UTAUT, DOI, and TOE, may not adequately address emerging technology adoption in HEIs. Suggestions include incorporating additional factors, particularly human aspects, into the frameworks (Alghatrifi & Khalid, 2019). The integration of human factors specialists into technological development projects can address disparities in information and enhance decision-making (Heath and Porter, 2019). Furthermore, readiness assessments, encompassing individual and organizational factors, are crucial for successful technology adoption (Hashim et al., 2021; Liu et al., 2019).

Moreover, while existing theories offer valuable insights into technology adoption, the TOE framework emerges as a robust choice for examining IoT adoption in Libyan HEIs due to its comprehensive nature and adaptability. However, incorporating supplementary factors and considering individual and organizational readiness can enhance the framework's applicability and deepen understanding of IoT adoption processes.

FINDINGS

The widespread adoption of new technologies like the Internet of Things (IoT) faces significant barriers due to a lack of understanding and awareness among decision-makers, faculty staff, and the community. This inadequate comprehension can lead to a lack of preparation and organizational resistance to digital transformation (Azevedo & Almeida, 2021; Moreira et al., 2018). Therefore, there is a critical need to thoroughly examine and formulate strategic approaches to address these concerns, particularly in educational institutions where IoT solutions can enhance capabilities (Moreira et al., 2018). Scholars have focused on understanding the variables influencing IoT technology's acceptability by decision-makers, emphasizing the importance of organizational modifications to yield consumer value (Zhuankhan & Renken, 2023).

Scholarly research has explored IoT adoption across various sectors, including healthcare, industry, and education, employing technology adoption theories such as TAM, UTAUT, UTAUT2, and TRI to understand individual-level factors influencing adoption (Almazroi, 2023; Alhasan et al., 2023; Shaqrah & Almrs, 2022). Similarly, in the organizational context, theories like DOI and the TOE framework have been utilized to explore IoT adoption dynamics, considering factors such as organizational readiness and external influences (Ali et al., 2023; Madni et al., 2022).

However, there is a scarcity of research on organizational preparedness for successful IoT implementation, especially in developing countries (Arsenijević et al., 2018). Studies have noted a lack of attention to IoT adoption, particularly in educational contexts (Ali et al., 2023; Al-Emran

et al., 2020). Additionally, existing research often overlooks crucial factors like the necessity of digital strategies, stakeholder commitment, and technological challenges like data management (Carcary et al., 2018).

Furthermore, there is a paucity of research specifically focused on the Libyan context, with existing studies often neglecting organizational, technological, and environmental factors influencing IoT adoption (Ireda et al., 2019; Ahmed et al., 2022). This gap underscores the importance of comprehensive analyses encompassing both technical and non-technical elements to realize the full potential of IoT adoption (Zhuankhan & Renken, 2023).

Moreover, while IoT adoption holds immense potential, addressing barriers to adoption, especially in developing countries like Libya, requires a holistic understanding of organizational readiness and challenges. Comprehensive research incorporating both technical and non-technical factors is essential to ensure successful IoT implementation and maximize its benefits in higher education institutions.

CONCLUSION AND RECOMMENDATIONS

In conclusion, the adoption of Internet of Things (IoT) technology in higher education institutions presents significant opportunities for enhancing teaching, learning, and administrative processes. However, numerous challenges hinder the widespread implementation of IoT solutions, particularly in developing countries like Libya. This review has highlighted the importance of understanding organizational readiness and addressing both technical and non-technical factors to facilitate successful IoT adoption.

While existing research has explored individual and technological aspects of IoT adoption, there is a notable gap regarding organizational preparedness and the holistic consideration of factors influencing adoption. Studies often overlook crucial elements such as the necessity of digital strategies, stakeholder commitment, and technological challenges like data management. Additionally, the Libyan context remains underexplored, with limited research focused on the factors shaping IoT adoption in higher education institutions.

To address these gaps and promote effective IoT adoption in Libyan higher education institutions, several recommendations emerge:

1. Conduct Comprehensive Research: Future studies should undertake comprehensive analyses that encompass both technical and non-technical factors influencing IoT adoption. This includes organizational readiness assessments, stakeholder engagement strategies, and technological challenges unique to the Libyan context.

2. Develop Digital Strategies: Institutions should develop clear digital strategies that align with their educational objectives and facilitate the integration of IoT solutions. These strategies should outline goals, implementation plans, and mechanisms for stakeholder involvement and support.

3. Foster Stakeholder Engagement: Engaging key stakeholders, including decision-makers, faculty members, and administrative staff, is crucial for successful IoT adoption. Institutions should prioritize stakeholder involvement throughout the adoption process, ensuring buy-in and support at all levels.

4. Address Technological Challenges: Organizations must address technological challenges such as data management, security concerns, and infrastructure requirements to ensure the seamless implementation of IoT solutions. This may involve investing in robust IT infrastructure, cybersecurity measures, and staff training programs.

5. Promote Research and Collaboration: Encouraging research and collaboration in the field of IoT adoption can foster innovation and knowledge sharing. Institutions should facilitate interdisciplinary collaboration, research partnerships, and knowledge exchange initiatives to advance understanding and best practices in IoT adoption.

6. Tailor Solutions to Context: Recognizing the unique challenges and opportunities within the Libyan context, institutions should tailor IoT solutions to meet specific organizational needs and priorities. This may involve conducting pilot projects, evaluating outcomes, and refining implementation strategies based on local insights.

7. Build Capacity: Building staff capacity in IoT technology and its applications is essential for successful adoption. Institutions should invest in training and professional development programs to equip staff with the necessary skills and knowledge to leverage IoT solutions effectively.

By implementing these recommendations, Libyan higher education institutions can overcome barriers to IoT adoption and harness the transformative potential of this technology to enhance teaching, learning, and administrative processes. With careful planning, stakeholder engagement, and strategic investments, IoT adoption can contribute to advancing educational outcomes and supporting sustainable development in Libya.

The implications of effectively adopting Internet of Things (IoT) technology in Libyan higher education institutions are multifaceted and extend beyond the immediate aspect of academia. Successful integration of IoT solutions has the potential to bring about transformative changes in teaching, learning, research, and administrative processes, ultimately contributing to the advancement of the education sector and the broader socio-economic development of Libya.

Enhanced Teaching and Learning Experiences: By leveraging IoT devices and applications, educators can create immersive and interactive learning environments that cater to diverse learning styles and preferences. IoT-enabled classrooms equipped with smart boards, sensors, and connected devices can facilitate real-time data collection, personalized learning experiences, and collaborative activities. This can lead to improved student engagement, retention, and academic outcomes.

Empowerment of Faculty and Students: The adoption of IoT technology empowers faculty members and students to explore innovative teaching and learning methodologies. Faculty can leverage IoT-enabled tools and platforms to deliver dynamic and engaging instructional content, conduct research, and collaborate with peers globally. Similarly, students can access resources, participate in virtual labs, and engage in experiential learning activities that enhance their critical thinking, problem-solving, and digital literacy skills.

Efficient Administrative Processes: IoT solutions offer opportunities for streamlining administrative processes and enhancing institutional efficiency. From campus management systems and facility monitoring to student services and resource allocation, IoT-enabled applications can automate routine tasks, optimize resource utilization, and improve decision-making processes. This can lead to cost savings, improved operational effectiveness, and enhanced service delivery for students, faculty, and staff.

Innovation and Research Advancement: IoT technology serves as a catalyst for innovation and research advancement in higher education institutions. Researchers can leverage IoT-enabled sensors, data analytics, and machine learning algorithms to collect, analyze, and interpret large volumes of data across various domains. This facilitates interdisciplinary research collaborations, enables data-driven decision-making, and drives innovation in areas such as smart agriculture, healthcare, environmental monitoring, and urban planning.

Alignment with National Development Goals: The adoption of IoT technology aligns with Libya's national development goals and aspirations for economic diversification, innovation, and digital transformation. By investing in IoT infrastructure and human capital development, higher education institutions can contribute to the country's efforts to build a knowledge-based economy, foster entrepreneurship, and address socio-economic challenges. Moreover, IoT adoption can enhance Libya's global competitiveness, attract investment, and create new opportunities for economic growth and job creation.

Socio-Economic Impact: Beyond the education sector, IoT adoption has broader socio-economic implications for Libyan society. By producing a skilled workforce equipped with digital competencies, higher education institutions can drive economic development, spur technological innovation, and promote social inclusion. Moreover, IoT-enabled solutions have the potential to

address pressing societal issues such as healthcare delivery, environmental sustainability, and infrastructure development, thereby improving the quality of life for citizens across the country.

Challenges and Considerations: Despite the significant potential benefits, the widespread adoption of IoT technology in Libyan higher education institutions is not without challenges. Concerns related to data privacy, cybersecurity, infrastructure limitations, and financial constraints must be carefully addressed. Moreover, capacity building efforts, stakeholder engagement, and policy support are essential for overcoming barriers to adoption and ensuring the sustainable implementation of IoT solutions.

Finally, the implications of IoT adoption in Libyan higher education institutions are far-reaching and encompass various aspects of teaching, learning, research, administration, and socio-economic development. By embracing IoT technology and addressing associated challenges, Libyan universities can position themselves as hubs of innovation, knowledge creation, and societal transformation, driving progress towards a more prosperous and sustainable future for the nation.

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