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Revolutionising Higher Education: Case Studies on Education4.0 Integration and Blockchain-Enhanced Education Management

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ABSTRACT

The incorporation of Education4.0 has brought about a significant transformation in the realm of higher education, resulting in the establishment of a dynamic and inventive educational setting for students. In this context, various sophisticated technologies, including Blockchain Technology, artificial intelligence (AI), and others, are being employed to augment Education management. Hence, the present study has directed its attention towards the integration of Education4.0 and the utilisation of Blockchain Technology to enhance Education management in the realm of higher Education in Saudi Arabia. In this particular case study, the primary source of qualitative data was obtained through interviews conducted with a sample of 10 employees employed at various universities in Saudi Arabia. A thematic analysis was conducted on the gathered transcripts, resulting in the formulation of five significant themes. These themes encompass (a) Education4.0 within the context of higher education, (b) the role of technologies in higher education, (c) the opportunities presented by the integration of Education4.0 and Blockchain Technology, (d) the Challenges associated with the fusion of Education4.0 and Blockchain Technology, and (e) the utilisation of other technologies in the management of higher education. Therefore, this study has demonstrated that the integration of Education4.0 and Blockchain Technology has proven to be efficacious in establishing a dynamic and individualised educational encounter for students in higher education. Furthermore, these technologies have demonstrated efficacy in the management of students' data and the mitigation of fraudulent transcripts within the realm of higher education. However, there are a number of difficulties involved in implementing these technologies, including worries about data privacy and a lack of technical staff, among others. The current study has additionally yielded various practical and theoretical implications pertaining to the integration of Education4.0 and Blockchain Technology within the higher Education sector.

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1. Introduction

Over the past decade, the incorporation of artificial intelligence (AI) across various domains has held the potential for significant advancements, including within the realm of higher education. The benefits of digital replacements in the higher Education sector have been widely recognised due to their significant competitive advantage (Hannan & Liu, 2023). Learning and teaching patterns are undergoing significant transformations due to the swift progress in artificial intelligence and its potential application in higher Education as part of the ongoing digital revolution. The implementation of digital tools in forward-thinking educational institutions is driving significant advancements in higher Education (George & Wooden, 2023). The incorporation of these tools within higher Education is evident through the establishment of intelligent and digital universities that leverage artificial intelligence to enhance the capacity for learning by facilitating and reinforcing both machine-based and natural learning processes (Furey & Martin, 2019).

The broader implications of artificial intelligence (AI) in educational institutions offer enhanced guidance in various domains, such as student learning experiences, enrolment management, and student support. The effective utilisation of artificial intelligence (AI) has facilitated the customization of learning paths and enhanced the overall quality of education. According to Haider and Al-Salman (2020), the field of Education is undergoing significant digital transformations in the post-pandemic era. These transformations involve the integration of advanced assistance tools and the digitalization of the higher Education sector. The higher Education system that focuses on artificial intelligence (AI) is perceived as being more efficient, credible, and cost-effective (Schiff, 2022). In addition to its educational implications, it is crucial to consider the potential influence that learning and teaching have on administrative operations. The implementation of intelligent digital assistants has proven to be effective in helping individuals fulfil their academic and non-academic obligations by alleviating their workload and enabling them to meet the requirements of their job responsibilities.

Blockchain Technology has played a pivotal role in the transformation of the higher Education sector. By eliminating the intermediary and expanding their utility for various purposes, they transcend their functionality. The significance of Blockchain 4.0 lies in its ability to decentralise systems and facilitate the integration of digital businesses. examination of various aspects of Blockchain Technology, including its application in business processes, supply chain management, workflow management, as well as asset and financial management (Alladi et al., 2019). Despite its potential utility and significant impacts, the utilisation of Blockchain Technology in the management of Education is currently in its early stages. This implementation is accompanied by various barriers and Challenges that must be effectively addressed to ensure the successful integration of Blockchain into the learning processes within higher Education institutions.

According to the research of Bhaskar, Tiwari, and Joshi (2020), the potential and benefits of incorporating Blockchain Technology in Education are significant. However, the majority of institutions are hesitant to embrace this integration due to the uncertain outcomes it may yield. Hence, there is a compelling need to broaden the potential application of Blockchain Technology within the context of higher education, encompassing its utilisation in areas such as learning, instruction, and administrative functions. In the current era, the Education system of the 21st century

has transitioned predominantly to e-learning methodologies, replacing traditional modes of instruction.

Within this context, the integration of Blockchain Technology in e-learning practices holds the potential to enhance the quality of academic learning and teaching. The integration of these technologies has the potential to establish a robust Education system that encompasses interdisciplinary education, a contemporary vocational Education system, and advanced educational literacy (Lin et al., 2021). The educational initiatives centred around the integration of Blockchain Technology are designed to offer contemporary educational prospects and address the Challenges encountered in current educational projects. The favourable outcomes of the projects suggest that the incorporation of Blockchain functionalities holds promising advantages for the higher Education system.

The utilisation of Blockchain technologies has become prevalent within the higher Education system. Prior research conducted by Alammary et al. (2019) and Loukil, Abed, and Boukadi (2021) has focused on examining the constraints and prospects associated with the application of Blockchain in educational contexts. The majority of the studies conducted are systematic reviews that comprehensively examine the theoretical aspects by analysing the existing literature pertaining to the scope and utilisation of these tools and instruments. This study diverges from previous scholarly works by examining these concepts within the specific context of Saudi Arabia. The Education sector in this region is experiencing a significant increase in the utilisation of digital education.

Consequently, the implementation of Blockchain Technology holds great potential for delivering numerous advantages to this sector. According to Alshareef (2022) findings, there exists a potential investment prospect in the Education sector for Blockchain Technology owing to its facilitative capabilities. The preceding investigations conducted within the framework of Saudi Arabiahave relied on survey methodologies (Alsaadi & Bamasoud, 2021). The current study thus introduces a novel contribution by presenting empirical evidence derived from an analysis of a specific case study. The objective of this study is to explore the impact of the digital revolution on the higher Education sector in Saudi Arabia. Specifically, the researcher will investigate the integration ofBlockchain4.0 Technology and its potential to improve Education Management.

2. Literature review

2.1 BlockchainAdoption in Higher Education and the Evolution of Blockchain Computing

The findings of Iftikhar, Vistro, and Mahmood (2021) suggest that in the Malaysian higher Education sector, factors such as perceived usefulness, competitive pressure, and top management support significantly influence the intention of Malaysian higher Education institutions to adopt Blockchain Technology. However, it is crucial to recognise that the particular context of this study within the Malaysian higher Education sector may impose limitations on the generalizability of these findings. The research conducted by Iftikhar et al. (2021) provides significant insights regarding the technological, organisational, and environmental factors that impact the adoption of Blockchain Technology within higher Education institutions.

According to Zheng et al. (2022), the advancement of Blockchain computing has thus far been characterised by three discernible stages. During the early phase, referred to asBlockchain1.0, the primary function of the Technology was to facilitate the programming of digital currencies. Based on the research conducted by Sun, Shahzad, and Razzaq (2022), Bitcoin emerged as the pioneering implementation Of Blockchain Technology within the domain of digital currency.

Following this, the process of evolution led to the development ofBlockchain2.0, which stands out due to the inclusion of programmable smart contracts. Under this paradigm, individuals acquired the capacity to upload and execute self-authored programmes. As stated by Leng et al. (2020), Blockchain2.0 facilitated the dependable and automated execution of uploaded programmes by incorporating features such as self-limitation and security encryption. The most recent stage, known asBlockchain3.0, centres on the notion of programmable social governance, also known as the digital society.

This phase possesses the capacity to accelerate the advancement of sustainable communities. The utilisation of Blockchain Technology facilitates the establishment of a streamlined and user-friendly system for monitoring data, thereby presenting the opportunity to mitigate the expenses incurred in overseeing societal activities. In the foreseeable future, it is plausible to argue that the decentralised computing model of Blockchain Technology has the potential to significantly transform human societies by enabling enhanced collaboration and governance mechanisms.

2.2 Education4.0: Transforming Higher Education

The study conducted by Bonfield et al. (2020) presents a comprehensive analysis of the historical evolution of Higher Education delivery modes and offers valuable insights into the potential future directions of educational delivery methods. The author's work incorporates a wide range of formal and informal sources related to the concept of Education4.0. Likewise, it is evident that Education4.0 is a burgeoning domain that has attracted increasing attention from educational commentators, prominent media outlets, Technology vendors, and governmental entities (Feldman, 2018).

However, it is important to highlight that the existing body of literature lacks a comprehensive array of solutions pertaining to the optimal design of physical spaces, digital services, and curricula within educational institutions, with the aim of adequately equipping prospective graduates for the future. There continues to be a lack of comprehensive guidance pertaining to the planning, instruction, and implementation of Education4.0. It is crucial to acknowledge the wide range of social, economic, and political influences that shape educational contexts across countries and institutions.

Moreover, the planning process is further complicated by external disruptors such as global pandemics (e.g., COVID-19), changes in government policies, and advancements in Technology (Bonfield et al., 2020). In light of the prevailing ambiguity pertaining to the forthcoming trajectory of Higher Education and Education4.0, our literature review has embraced a comprehensive interpretation of the term 'evidence'. A thorough examination of the available literature was undertaken, wherein various sources were analysed and synthesised in order to present a comprehensive overview of the diverse methodologies employed in the context of Education4.0. Recognising and embracing the presence of

diverse approaches without engaging in evaluative comparisons of superiority is of utmost importance (Dawson, 2017).

There has been significant focus at the international level on China's prominent position in the advancement of Artificial Intelligence (AI). The field of artificial intelligence, which falls within the domain of computer science, focuses on the examination of machines' ability to imitate human intelligence and cognitive functions. In the field of artificial intelligence (AI), educational institutions have been utilising different subsets such as Machine Learning, Natural Language Processing, and Computer Vision. The objective is to improve the student experience, teaching methods, and learning outcomes by employing personalised predictive analytics, intelligent digital assistants, and enhanced security measures. The Education sector in China, under the supervision of the Chinese Ministry of Education, is recognised as one of the most comprehensive globally.

It comprises a vast network of over 518,000 schools, serving a student population of approximately 276 million. The exploration of integrating big data and artificial intelligence capabilities is actively underway to facilitate tailored and personalised learning experiences in order to effectively manage the extensive educational landscape (Zhang & Zou, 2019). According to Almeida and Simoes (2019), the concept of Education4.0 encompasses a new educational framework that aims to address the Challenges and possibilities brought about by the fourth industrial revolution. Education4.0 is characterised by a central focus on experiential learning, which entails actively encouraging students to engage in hands-on experimentation in order to explore and comprehend various concepts. The primary objective of this study is to investigate the influence of emerging technologies, specifically serious games and Industry 4.0, on the progression of higher Education within the framework of Education4.0.

2.3 BlockchainTechnology in Education: Potentials and Challenges

The educational accomplishments of students are rendered irrelevant in both local and international labour markets due to the presence of political and economic instability. Consequently, graduates from these countries are compelled to pursue employment opportunities that are unrelated to their areas of expertise (Alnafrah & Mouselli, 2021). As a result, individuals' income is substantially impacted, and the educational process experiences a decline in its practical efficacy and sustainable developmental influence. Therefore, it is crucial to ascertain a resolution to this matter within the present conditions and accessible resources.

The progression of Technology presents promising opportunities for tackling the difficulties linked to record management. One of the significant technological advancements in this domain is Blockchain Technology. The advent of this Technology has resulted in a significant and profound change in the realm of digital transactions, particularly in scenarios where there is a lack of trust among the participants within the network. The inherent characteristics of blockchain, including immutability, transparency, and security, provide economic entities with the ability to confidently engage in interactions and carry out transactions. Numerous studies within the academic literature have put forth proposals for employing Blockchain Technology as a means to address the Challenges related to the issuance and verification of certificates and academic records within higher Education institutions (HEIs) (Abbas et al., 2019).

However, it is important to highlight that the predominant focus of these investigations has been on countries with high or medium-income levels, possessing strong technological infrastructure, and relatively stable economic and political conditions devoid of armed conflicts (Sepe et al., 2023), Blockchain is a decentralised network that utilises specific consensus algorithms in order to create a sequential chain of blocks that store immutable transaction records. The origins of its establishment can be attributed to the rise of digital currencies, as initially presented by Alnafrah and Mouselli (2021). It can be asserted that Blockchain Technology effectively mitigates the problem of trust deficits among participants in the market. The aforementioned Technology has undergone significant advancements, resulting in a reliable means of ensuring the integrity of transactions and facilitating the interconnections between various economic entities.

The Blockchain Technology is widely acknowledged as an innovative and transformative tool that has the capacity to have a substantial impact on various industries, including healthcare, supply chain management, the Internet of Things (IoT), finance, electoral systems, property and real estate administration, e-government, higher education, and numerous others (Salah, Ahmed, & ElDahshan, 2020). The potential of Blockchain Technology spans multiple industries, presenting prospects for increased transparency and worldwide accessibility. The capacity to create a transparent and unchangeable record of transactions promotes trust, particularly in sectors where transparency is of utmost importance, such as healthcare and supply chain management (Pal, Tiwari, & Haldar, 2021).

Moreover, Blockchain Technology possesses the capacity to expand the provision of financial services and resources to marginalised populations on a global scale, thereby generating novel economic prospects and markets. Nevertheless, Blockchain Technology encounters certain obstacles, particularly in terms of scalability, as the networks expand. This necessitates the implementation of robust measures to ensure optimal speed and efficiency. Furthermore, the dynamic and frequently ambiguous regulatory landscape can present Challenges for enterprises and stakeholders aiming to leverage the advantages of Blockchain Technology, given that adherence to regulatory standards may vary considerably across different geographical areas. The ability to effectively manage and address both the opportunities and Challenges associated with Blockchain Technology is crucial to fully harnessing its potential to revolutionise diverse industries.

2.4 Blockchainfor Education Management: Security and Privacy Considerations

The presence of essential security prerequisites is a fundamental aspect of any Internet of Things (IoT) system, as outlined by Radoglou Grammatikis, Sarigiannidis, and Moscholios (2019). The requisites in question encompass Confidentiality, Integrity, Availability, and Authentication, with each possessing distinct definitions and implications. Confidentiality refers to the guarantee that only authorised entities have the privilege to access and view private information while simultaneously ensuring the privacy of such data. An illustration of compromised confidentiality can be observed in the occurrence of a data breach, which results in the disclosure of private information to the general public. Integrity refers to the assurance that information remains unmodified or uncorrupted by unauthorised entities. One example of a security breach that poses a threat to the integrity of a system is the Man-in-the-Middle attack. In this type of attack, the targeted individual is redirected to engage with a fraudulent website

instead of the authentic one. Availability is the state of being able to promptly access information by authorised entities whenever necessary. Denial-of-Service (DoS) incidents have a detrimental impact on availability as they result in the unavailability of data to authorised users.

Authentication refers to the procedural mechanism employed to verify the identities of individuals or entities who are seeking authorization to access specific information. There are multiple factors that can compromise the effectiveness of authentication, including the use of weak passwords or the practice of reusing passwords. These actions can make it easier for attackers to crack passwords and gain unauthorised access. As a result, there is a growing popularity in the adoption of standards that endorse passwordless authentication, such as the FIDO protocol (Alfandi et al., 2021). These elements are essential prerequisites for any system. However, the implementation of these components within an IoT system presents various challenges, as outlined in the study conducted by Radoglou Grammatikis et al. (2019). The primary objective is to establish security measures for entities within the IoT system while minimising any negative impact on their functionality. Moreover, as previously mentioned, components within the Internet of Things (IoT) framework possess restricted storage, processing capabilities, and computational resources. This introduces an extra level of intricacy to the security considerations.

The proliferation of Internet of Things (IoT) devices across various applications has led to a significant escalation in security and privacy concerns (Waheed et al., 2020). The exponential increase in cyber threats has resulted in the insufficiency of current security and privacy protocols, thereby making every individual on the Internet vulnerable to exploitation by malevolent entities. As a result, the application of Machine Learning (ML) algorithms has become increasingly prominent in extracting accurate insights from complex and vast databases. This allows for the prediction and detection of vulnerabilities in systems based on the Internet of Things (IoT). Furthermore, there has been a growing interest in the utilisation of Blockchain (BC) methodologies in modern Internet of Things (IoT) applications. This is due to the potential they hold in resolving the existing security and privacy issues. Numerous research studies have been conducted to examine the effectiveness of machine learning algorithms or the suitability of Blockchain techniques in addressing these challenges.

2.5 The Integration of Education4.0 and Blockchain: Synergies and Opportunities

The rapid development and coexistence of Education4.0 with advancing Technology can be achieved through different strategies. One notable approach involves incorporating Blockchain Technology into the Education sector, which can serve a range of purposes. The primary objective of promoting global integration in Education involves the creation of a cohesive educational domain and the improvement of collaborations between educational institutions and relevant parties. While the initial utilisation of Blockchain Technology in Education4.0 was primarily confined to the financial sector, its extensive characteristics render it highly compatible with the present era. The emergence of Blockchain Technology signifies a significant transformation in the technological landscape, as it introduces elements of trust and transparency. This has led to the displacement of outdated systems with more advanced and innovative alternatives. One significant obstacle revolves around the urgent requirement for innovative research initiatives that can provide novel perspectives on the transformative capacity of Blockchain Technology in the field of education, along with effective approaches for its optimal implementation and utilisation (Lutfiani et al., 2021).

The Blockchain Technology has emerged as a groundbreaking and transformative innovation that has had a profound impact on various industries, most notably finance, supply chain management, and healthcare (Verma, 2023). Fundamentally, it functions as a distributed and decentralised system of recording transactions, meticulously documenting them across a network of interconnected computers. In this particular system, every individual entry, commonly known as a "block," consists of a ledger containing various transactions. Once these blocks are integrated, they establish a connected sequence of data that is immutable and arranged in chronological order. The emergence of Blockchain Technology has been identified as a crucial and promising element within the framework of Industry 4.0 (Kim, Park, & Lee, 2020). The potential of this phenomenon to induce significant changes in the operational dynamics of the business realm and the wider economic system is widely recognised. Significantly, it presents numerous prospects for the advancement of established businesses and the emergence of entirely innovative enterprises, while simultaneously presenting substantial Challenges to traditional business models (Khan & Salah, 2018).

Without a doubt, Blockchain Technology has the potential to bring significant changes to the global business landscape, potentially leading to a fundamental transformation in the way the business sector functions. However, in order to fully exploit the vast potential of Blockchain Technology, it is imperative to address and resolve various Challenges pertaining to its adoption and practical implementation.

3. Methodology

3.1 Strategy and Procedure

This study adopts a deductive approach for primary data collection, although the data is not in numerical form. The data is obtained through interviews, which are used for analysis and deriving results. The researcher has employed an interview protocol in order to gain a comprehensive comprehension of the variables under investigation and to make a novel contribution to the existing body of literature through the provision of fresh insights and illustrative examples. The primary objective of this study was to examine the importance of Blockchain Technology in the realm of Education and investigate its advantages within a specific sector. The researcher has undertaken interviews with employees of a university in Saudi Arabiaand analysed their perspectives on innovative and advanced technologies within educational institutions. The researcher has chosen to focus on university employees in the Education sector, as this sector has recently received significant attention from the government. It has been provided with various prospective projects and additional integrations to support the fulfilment of Saudi Arabia's economic vision for 2030 (Allmnakrah & Evers, 2020). For this study, a sample of 10 respondents was selected, using random sampling.

The researcher has adhered to ethical guidelines throughout every stage of this research endeavour. In this particular field, the researcher devised an initial document that served as an introduction, wherein the researcher provided an elaboration on their introduction, the research itself, and the objective of data collection. Subsequently, the researcher appended a consent form to the email. Subsequently, the researcher exclusively attended to the emails that were received as responses accompanied by completed consent forms and proceeded to reply to them, requesting a suitable timeframe for conducting the interviews. Subsequently, the researcher adhered to the established research protocols and procured data from the participants through their voluntary engagement.

Furthermore, the researcher developed a set of interview questions (see Appendix A) based on a thorough review of the existing literature. These questions were carefully designed to elicit comprehensive information pertaining to the specific concepts of interest. The interview questions consisted of a combination of semi-structured and structured formats. In addition, the researcher employed a combination of physical and online methodologies, specifically Zoom meetings, to facilitate interviews. This approach allowed for the inclusion of a wider range of participants, thereby enhancing the diversity of the collected data.

Following the completion of the interviews, the researcher promptly transcribed the interviews and cross-referenced the transcriptions with the recorded audio of the interviews to validate the accuracy and fidelity of the transcribed content. Following the completion of transcript generation, the researcher employed a manual approach to conduct thematic analysis. This involved the development of a framework and the identification of key terms, concepts, and strategies that were frequently referenced by the participants in their responses to the interview questions. The findings section of the study provides a comprehensive depiction of the main core codes developed through thematic analysis, as well as the prominent key concepts that were discussed and explored during the interviews.

4. Results

Thematic analysis was employed to assess the beliefs, thoughts, and perceptions of the selected sample regarding the integration of Education4.0 and Blockchain Technology in educational administration within the higher Education sector. In order to achieve the objective of this study, NVivo software was utilised to identify key themes. This study encompasses various themes and sub-themes, which will be elucidated in the following sections.

- Theme I: Education4.0 in Higher Education
  - *Theme Ia: Strategies or Principles*
- Theme II: Technologies in Higher Education
  - *Theme IIa: Blockchain Technology in Higher Education*
  - *Theme IIb: Privacy and Security Considerations in Blockchain Technology*
- Theme III: Education4.0 and Blockchain Technology Opportunities
  - *Theme IIIa: Academic Qualifications' Authentication*
- Theme IV: Education4.0 and Blockchain Technology Challenges
- Theme V: Other Technologies in Higher Education Management

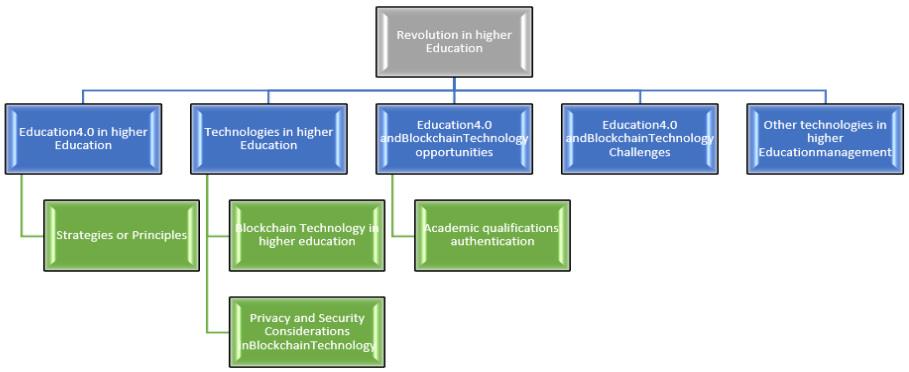

Figure 4.1. *Mind map*

- ***Theme I: Education4.0 in Higher Education***

Based on the perspectives of six participants, Education4.0 has emerged as a novel and impactful paradigm within the realm of higher education, leading to significant transformations in educational management. Seven participants highlighted the significance of integrating innovative and digital technologies, specifically the "Internet of Things" (IoT), into educational practises and instructional approaches. Based on the perspectives of the participants, Education 4.0 has facilitated the advancement of a learning environment that is characterised by adaptability, interactivity, and personalization. This, in turn, has been observed to enhance the students' overall learning capacities. In this context, one of the participants said:

"Integration of Education4.0 has transformed the higher education. It has helped the students to develop important technical skills to utilize advanced learning technologies such as big data, AI, robotics and others."

- ***Theme Ia: Strategies or Principles***

The study participants held the belief that the "Fourth Industrial Revolution" has exerted an impact on various service sectors, including the Education sector. Five participants expressed that the integration of contemporary technologies, optimal methodologies, and inventive pedagogical approaches has facilitated the adoption of Education4.0 within the higher Education domain in Saudi Arabia. When asked about the primary principles or strategies within the framework of Education4.0, one of the participants emphasised four fundamental constituents in this regard. He quoted:

"In order to design new projects within educational innovation, four essential factors of Education4.0 should be taken into account which include information and communication technologies (ICT), learning methods, infrastructure and competencies."

- ***Theme II: Technologies in Higher Education***

When queried regarding the integration of diverse technologies within the higher Education domain, five respondents expressed that the advent of Education4.0 has fostered the adoption of sophisticated technologies such as the Internet of Things (IoT), big data, blockchain, and other similar innovations within the realm of higher education. In support of this argument, one of the participants said:

"During covid-19, different digital technologies such as Blockchain and big data have helped us in Education Management. We also utilized virtual settings such as Zoom, Skype and others for delivering lectures."

- ***Theme IIa: Blockchain Technology in Higher Education***

Seven participants expressed that the decentralised infrastructure of Blockchain has proven beneficial in safeguarding data. This Technology has been observed to be efficacious in safeguarding data integrity, even in the event of a specific node's failure to reach completion. The participants held the belief that the implementation of Blockchain Technology has brought about significant transformations within the higher Education sector. This argument was supported by one of the participants as he claimed:

"Blockchain applications in e-learning are effective in developing secure digital certificates and badges which are verified easily and are presented on the associated digital portfolio. Moreover, I have also utilized smart contracts to promote peer-to-peer collaboration and learning. This Technology is also utilized by the university administration for Education Management."

- ***Theme IIb: Privacy and Security Considerations in Blockchain Technology***

Six participants expressed the view that sensitive information is contained within Blockchain data, thus necessitating the implementation of data encryption measures to safeguard said data. Three participants additionally emphasised the susceptibilities inherent in smart contracts. The authors asserted that the implementation of effective coding practises is necessary in order to safeguard smart contracts. The implementation of this approach has the potential to yield positive outcomes within the realm of Education Management systems. In this context, one of the participants stated:

"The compliance of essential laws such as 'The Saudi Arabia Personal Data Protection Law (PDPL),' is crucial to ensure the protection of data, using Blockchain Technology."

- ***Theme III: Education4.0 and Blockchain Technology Opportunities***

Based on the perspectives of the participants, it can be observed that the integration of Education4.0 and Blockchain Technology has resulted in a significant transformation of the Education system. According to the authors, Blockchain Technology has been instrumental in improving the practise of record-keeping. The implementation of this Technology has also facilitated the management of registration, transfer evaluations, and student records within university registrar offices. Three participants additionally expressed that the utilisation of Blockchain Technology has facilitated the process of verifying the accreditation of colleges. In this regard, one of the participants stated:

"Blockchain Technology is effective in protecting intellectual property (IP). It has also helped us in Education Management, mitigating fraudulent transcripts and degrees."

- ***Theme IIIa: Academic Qualifications' Authentication***

Eight participants reported that the utilisation of Blockchain Technology has facilitated the authentication of academic qualifications for them. The integration of "student information system" and "document management system" has been highlighted as a means to enhance the overall management of education. Four participants in the study expressed the view that Blockchain Technology effectively improves the transparency of all transactions within the university campus. One of the participants also advocated the significance of blockchain, as he said:

"Integration of Blockchain Technology within the higher education, has resulted in automation of services and processes, which lead to the formation of smart contracts. This is found to be significant in saving resources for the longer run."

- ***Theme IV: Education4.0 and Blockchain Technology Challenges***

The implementation of Education4.0 and Blockchain Technology presented various Challenges to the participants involved. Seven participants reported that a prevalent issue frequently observed was the deficiency in technical skills. According to the authors, the successful realisation of Education4.0 and Blockchain Technology necessitates the presence

of competent technical personnel and a comprehensive understanding of the subject matter in order to achieve desirable results. While discussing about the Education4.0 and Blockchain Technology challenges, one of the participants said:

"Different Challenges are faced during the implementation of Education4.0 and Blockchain Technology in higher Education Management. A few of these Challenges include data privacy, integration and scalability. However, technical complexity of the Blockchain Technology can also impact its overall implementation."

- ***Theme V: Other Technologies in Higher Education Management***

The participants underscored the need to integrate more sophisticated technologies in order to enhance the management of higher education. Regarding this matter, four of the participants expressed their belief that artificial intelligence (AI) Technology has the potential to be efficacious in data management and mitigating bias. Simultaneously, it was also posited that the utilisation of big data holds potential in enhancing transparency within the realm of higher Education administration. In support of this argument, one of the participants said:

"In my opinion, different technologies such as AI, IoT, big data and others can also be incorporated to enhance Education Management."

Figures 4.2 and 4.3 show the project map and the tree map for the formulated themes.

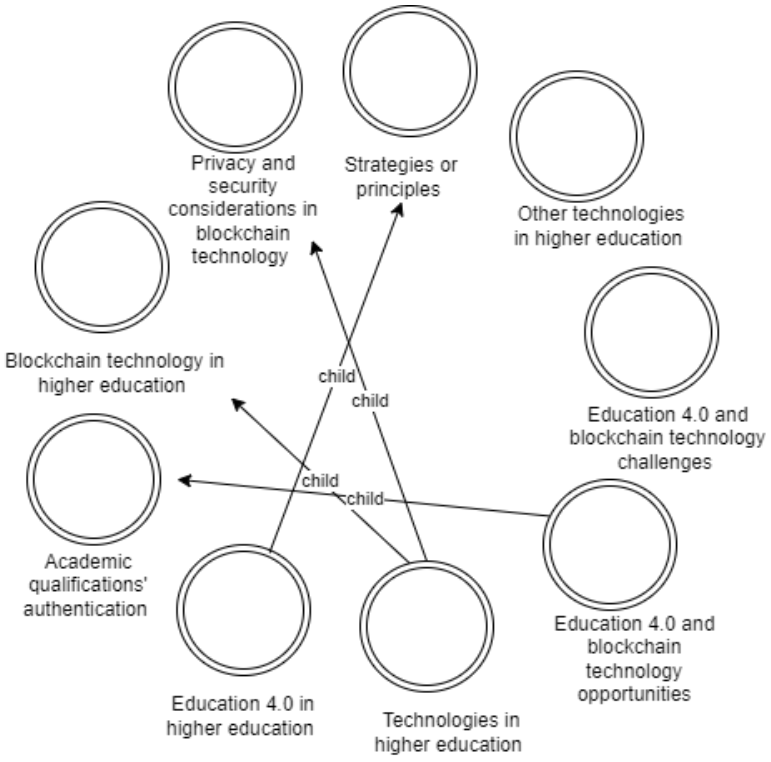

Figure 4.2. *Project map*

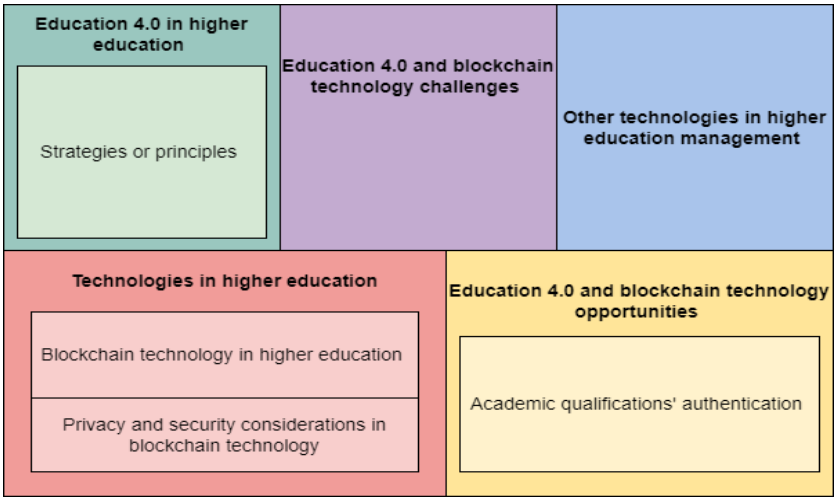

Figure 4.3. *Tree map*

5. Discussion

The primary objective of this study is to investigate the impact of the digital revolution on the higher Education sector in Saudi Arabia. Specifically, it aims to assess the implementation of Education4.0 and Blockchain Technology as means to improve Education Management. To achieve this objective, qualitative data was gathered from a sample of 10 employees employed in Saudi Arabian universities. Following a meticulous examination of the gathered data, distinct themes and sub-themes were formulated in order to effectively address the pertinent concerns.

The findings derived from this study demonstrate that the incorporation of Education4.0 has brought about a significant transformation within the realm of higher education. The integration of various digital tools and technologies, such as artificial intelligence (AI), big data, and blockchain, has been observed in the higher Education system. This integration aims to enhance the learning environment for students. These technologies have demonstrated efficacy in fostering a personalised and interactive learning environment, thereby enhancing students' overall learning capabilities and skills. In the higher Education sector, the management of Education is widely recognised as a critical factor in ensuring the accessibility of necessary resources. The integration of Blockchain Technology has witnessed a significant rise in recent years owing to its decentralised infrastructure.

Based on the perspectives shared by the study participants, it has been observed that the implementation of Blockchain Technology has proven to be efficacious in the management of students' data and the prevention of fraudulent degrees within the higher Education sector, resulting in favourable outcomes. Additionally, it was asserted that the utilisation of Blockchain Technology has proven advantageous in safeguarding intellectual property (IP), a critical aspect of efficient Education administration. During the COVID-19 pandemic, various Challenges were identified in the realm of educational administration, including issues related to time delays, inefficiencies in management, and other related concerns.

Therefore, the participants employed Blockchain Technology and big data analytics as a means to address these challenges. These technologies facilitated the timely execution of the necessary operations. Furthermore, the implementation of smart contracts in this context has also contributed to the conservation of significant resources, resulting in efficient outcomes. Furthermore, the utilisation of Blockchain Technology has proven to be efficacious in enhancing transparency within the realm of educational administration in the higher Education sector of Saudi Arabia. This can also serve as an incentive for the broader administration of the relevant sector to integrate these technologies in order to enhance the educational environment for both educators and learners. The participants identified four key factors that were deemed crucial for the purpose at hand. These factors encompassed learning methods, competencies, information and communication Technology (ICT), and infrastructure (Miranda et al., 2021).

Further, participants emphasised the significance of adhering to crucial data protection laws and regulations, such as the Personal Data Protection Law (PDPL), in order to ensure the efficient and secure integration of Blockchain Technology. Despite the study's success in elucidating various prospects pertaining to the incorporation of Blockchain Technology and Education4.0 in higher Education administration, it has also identified several obstacles encountered during the implementation of these technologies. One example of a potential issue is the insufficient presence of competent technical personnel, resulting in suboptimal execution of Blockchain Technology, thereby posing a potential disruption to the broader landscape of Education Management (Mohammad & Vargas, 2022).

Simultaneously, the presence of inadequate data privacy measures integrated into the implementation of Blockchain Technology can also impact the overall outcomes of Education Management. Consequently, this study has placed significant emphasis on the establishment and execution of efficacious data protection policies during the integration of Blockchain Technology within the realm of higher Education administration. This study has additionally offered significant recommendations regarding the integration of other technologies, such as the Internet of Things (IoT), big data, and artificial intelligence (AI), to enhance the management of Education in the higher Education sector.

These technologies are widely recognised for their efficacy in facilitating robust data management and safeguarding essential educational resources for future utilisation. Hence, the current study has successfully yielded various theoretical and practical implications, specifically emphasising the utilisation of advanced technologies in the management of Education within the higher Education sector.

6. Conclusion

In the contemporary landscape of Education and information and communication Technology (ICT), higher Education institutions are integrating Education4.0 and various technological advancements, including blockchain, the Internet of Things (IoT), and big data. These technologies have been identified as advantageous in the realm of Education Management, as they assist higher Education administrators in the maintenance of student data and the preservation of their privacy. These technologies have been identified as effective in mitigating fraudulent transcripts within the context of higher education, thereby fostering an environment conducive to innovation and productivity in learning.

Additionally, these technologies are also efficacious in resource management, facilitating the achievement of the desired objectives within the affiliated educational system. Nevertheless, the implementation of these technologies is accompanied by various challenges, including a shortage of skilled technical personnel and inadequate measures to ensure data privacy. The importance of adhering to data protection laws and regulations cannot be overstated as a means to mitigate these challenges. This study has additionally underscored the integration of supplementary, cutting-edge technologies to enhance educational administration within the realm of higher education.

7. Implications of the Study

This research has been efficient in promoting different theoretical as well as practical implications within the context of implementation of Education4.0 and Blockchain Technology in higher Education sector. A few of these implications are presented below:

7.1 Theoretical Implications

This study holds significance in both practical and theoretical domains. The present research has successfully emphasised the significance of Education4.0 and Blockchain Technology in the realm of educational administration in the higher Education sector. Hence, the outcomes of this investigation have proven to be efficacious in enhancing the broader body of literature pertaining to the domain of Education4.0.

Further, this study has also identified the potential advantages and obstacles associated with the integration of Education4.0 and Blockchain Technology in the field of Education Management. This methodology has proven effective in discerning significant resolutions to the corresponding challenges. Simultaneously, this study has also elucidated the primary components of Education4.0 that necessitate consideration when designing a cutting-edge learning environment for students. Furthermore, this research has also underscored the integration of Blockchain Technology as a means to safeguard the confidentiality of student data and facilitate efficient record management.

Additionally, this study will serve as a catalyst for future researchers to direct their attention towards exploring other technological advancements, such as the Internet of Things (IoT), big data, and artificial intelligence (AI), within the realm of educational management in the higher Education sector. Furthermore, this will augment the significance of the present study.

7.2 Practical Implications

The findings derived from this research have underscored the importance of Blockchain Technology in the domains of record-keeping and Education Management. Consequently, these findings possess the potential to effectively motivate university top executives to integrate cutting-edge technologies, including blockchain, IoT, big data, and other relevant tools, into their data management systems. This approach may also prove effective in incentivizing the higher Education sector to integrate training programmes aimed at enhancing technical skills among their employees, thereby resulting in favourable outcomes. Furthermore, the adoption of a decentralised infrastructure based on Blockchain Technology would prove advantageous for the higher Education sector in mitigating the occurrence of fraudulent cases.

Simultaneously, the present research can also prove efficacious in enhancing the comprehension of Blockchain Technology and Education4.0 among diverse higher Education students and institutions. This, in turn, can contribute to heightened adoption of various advanced technologies, including big data and IoT, thereby fostering innovative outcomes. However, this study will also prove to be efficacious in fostering the advancement and execution of data protection policies within the realm of higher education.

8. Limitations of the Study

Various limitations have been identified in the present study, although their influence on the overall efficacy is deemed insignificant. One of the limitations inherent in this study pertains to the relatively limited sample size. In order to accommodate the qualitative nature of the study and the constraints of limited resources, a sample size of 10 respondents was selected for this study. As a consequence, there was an escalation in research bias. Furthermore, the scope of this study was limited to an in-depth examination of Blockchain Technology, specifically within the realm of Education Management in higher Education institutions. The reason for this can be attributed to the study's restricted scope. Additionally, it is important to note that this study employed a cross-sectional design, which was necessitated by the limited timeframe available for its execution. The adverse effects of this phenomenon had a detrimental impact on the overall efficacy of the present investigation.

8.1 Future Research Suggestions

Future researchers may implement significant strategies to address the limitations inherent in this study. To achieve this objective, future investigations may consider integrating quantitative research methodologies. Additionally, this method will aid in the acquisition of data from a more extensive sample, thereby mitigating potential research bias. Simultaneously, it is worth considering the inclusion of other technologies, such as artificial intelligence (AI), big data, and the Internet of Things (IoT), in future research pertaining to the management of higher education. In the future, it is recommended that additional longitudinal studies be undertaken to investigate the incorporation of Education4.0 and other technological advancements in educational administration, specifically within the higher Education sector.

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Appendix A

Interview Questions

In your opinion, how has Education4.0 transformed the higher Educationsector? What strategies or principles are considered for this transformation?

What technologies are being incorporated in the higher Educationsector to improve Educationmanagement?

How doesBlockchainTechnology influence Educationmanagement within the context of higher education?

In your experience, what privacy and security considerations are needed to be considered while implementing theBlockchainTechnology in higher Educationmanagement?

In your opinion, what opportunities are provided for the higher Educationinstitutions and students due to the integration of Education4.0 andBlockchainTechnology?

How hasBlockchainbeen effective to ensure the academic qualifications' authentication by reducing diploma fraud issues?

Have you faced any Challengesconcerning the implementation of Education4.0 andBlockchainTechnology in higher Educationmanagement? If yes, can throw some light on your experience?

In your opinion, what other advanced technologies can be used for Educationmanagement in higher Educationsector? Can you provide some suggestions in this regard?