Opportunities and Barriers of Implementing Quality 4.0 in Higher Education Institutions

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Abstract

The advancement of technology is critical for improving the operations and people of higher education institutions. The continual evolution of forward-moving technology has been taking higher education institutions' abilities to a higher and more attractive level. Therefore, implementing Quality 4.0 practices in higher education institutions can drive innovation through technological advances in various aspects. Quality 4.0 is the fourth generation of quality that leads to digital transformation to achieve excellence, innovation, and performance through developing and executing quality initiatives supported by Industry 4.0 related technologies, such as artificial intelligence and the Internet of Things. The digital transformation will lead to a comprehensive set of practical and important goals in higher education institutions. This paper aims to investigate the opportunities and barriers of implementing Quality 4.0 in higher education institutions. The Quality 4.0 related new technology has the potential of enhancing the environment of education and helps to develop HEIs provided that issues related to digital integration, leadership support, IT staffing capabilities, training, and digital culture are properly addressed throughout the Quality 4.0 implementation journey.

Keywords: Quality 4.0, Industry 4.0, digitalization, Quality Improvement, Higher Education Institutions

I. INTRODUCTION

The past few years had some rapid advancements in mobility, connectivity, scalability, analytics, and data. This rapid development led to the fourth industrial revolution, also known as Industry 4.0. The fourth industrial revolution is known for digitalizing processes and resulting in the industry shift [1]. Organizations are experiencing a transformation because of digital technologies such as mobile devices, social media, Big Data, the Internet of Things, and cloud computing. The digital transformation presents challenges at various levels, namely in data governance, leadership processes, and integrating technologies to convert the organization. These challenges of type and magnitude not imaginable decades ago. [2].

The industrial revolution acts as the critical factor for human growth and development among the different sectors that fuel a nation's economy to make up the gross domestic product's (GDP) main constituent. When there are improvements in the education sector, there is an emergence of skilled and competent professionals who can work in diverse fields and generate increased employment [3].

According to Khan Khan [4], education is a priority for most countries worldwide, and many countries have devoted huge resources to guarantee high-grade education opportunities. The education system is being developed to meet the social and economic demands of the countries. Conventional education and system would no longer work in an era where there is a scope for optimal education through advanced technology [5]. According to Chik and Arokiasamy [6], for taking prime advantage of the set opportunities created by the latest technologies, there is a need to have a similar revolution in education. As the authors mention, proper use of faculty time and investments in facilities would yield the best results when Quality 4.0 is an integral element of the education system.

Quality improvement techniques, such as total quality management (TQM), quality function deployment (QFD), lean, and six sigma (LSS), have widely been implemented within higher education institutions (HEIs). TQM is among the first quality improvement techniques implemented by US and UK universities to improve customer satisfaction and organizational performance [7]. Also, LSS was used to improve the quality of HEIs. For instance, Gupta and his colleagues explored the application of LSS methodology to reduce student dropouts in HEIs [8]. Although these quality improvement techniques have been widely implemented in HEIs, they have not explored the quality related digital transformation in HEIs. This is one of the primary roles of Quality 4.0.

II. THE INDUSTRIAL REVOLUTIONS

The world is witnessing great development in technology and artificial intelligence (AI) in recent years called the fourth industrial revolution. Therefore, it is important to know the previous industrial revolutions to give us an idea of how they were formed and the extent of their impact on the world. Steam engines were responsible for the start of the first industrial revolution. In the 1800s, water and steam-powered machines came into existence to help workers with their regular tasks. The outcome was increased capability and efficiency, leading to increased growth across sectors [9]. Businesses expanded from individual interests to organizations. In particular, transportation and textiles benefited greatly from the process of industrialization [10]. By the late 1800s, the fuel for the second industrial revolution was electricity that greatly increased manufacturing capacity using science and reached mass production. Also, electricity enabled the combination of power sources to machines [11, 12].

In the third industrial revolution, the integrated circuit chip brought about the first computer era in the last few decades of the 20th century. This period was marked by the invention of devices like the transistors that made it highly feasible to automate machines for aiding or replacing human operators [13]. New possibilities were explored considerably, and electronic hardware gained momentum and subsequently became easy to plan and track product flow [14]. After that, the fourth industrial revolution appeared, which led to creative digitalization based on a combination of interacting technology and unlimited access to knowledge and the invention of smart devices, AI, and many new technologies. For example, the Internet of Things (IoT) is an important technology today that permits sharing and analyzing information in real-time [15].

III. INDUSTRY 4.0

According to Radziwill [16], Quality 4.0 comes from "Industry 4.0" - a term created at the Hannover Fair in 2011 to describe the fourth industrial revolution. The author stated that the fourth generation of quality intending to achieve excellence in innovation and efficiency through digital transformation. Also, the quality 4.0 strategy provides an excellent opportunity to have a realignment of quality with the organization's goals.

According to Rojko [17], Industry 4.0 has been developed due to the need to convert regular machines to ones with self-learning and self-awareness that improve the comprehensive performance and maintain suitable alignment with the surrounding environment. The author mentioned that the aim of Industry 4.0 is to construct a smart and open manufacturing platform for information applications that are industrially networked. The main needs of Industry 4.0 are real-time monitoring of data, tracking product positions, and suitably controlling production processes.

As stated by Hermann, Pentek [18], There are principles for Industry 4.0. These principles are interconnection, information transparency, technical assistance, and decentralized decisions. Interconnection refers to devices, sensors, machines, and individuals' ability to connect and subsequently communicate with each other through the concepts of IoT. Information transparency with Industry 4.0 gives a chance to operators through providing a large volume of information required for making suitable decisions. Also, technical assistance supports individuals to aggregate and visualize the available information comprehensively so that critical problems can be solved easily, and informed decisions can be taken. Therefore, technical assistance can create a safe environment for co-workers.

According to Lasi, Fettke [19], data and smart analytics are the core of Industry 4.0 capabilities. Industry 4.0 is primarily driven by the digitization of service and product offerings and integration of horizontal and vertical value chains, and development of digital business models. Industry 4.0 considers internal operations while in a vertical manner it integrates processes across a large area. Integration of methods of data collection helps organizations to generate data and refine services. The authors mentioned it is significant to focus on the preconditions required to achieve by introducing a new concept such as the stability of the processes to be undertaken, stepwise investment in processes, and a good knowledge of different processes.

Abdulrahim and Mabrouk [20] noted that the fourth industrial revolution has a deep influence on higher education. The revolution has ensured that the universities have the preparation for facing the challenges cropping up as a result of the COVID-19 pandemic. Digital learning is replacing traditional learning owing to the pandemic. This holds the potential to bring improvement in students' learning outcomes and enhance the faculty members' capabilities while conducting their various academic, administrative, and research activities.

IV. QUALITY 4.0

Within the context of Industry 4.0, the word Quality 4.0 applies to the future of operational performance and quality. It is important to accept the future of quality to ensure excellence by quality. Therefore, it becomes essential that quality professionals help their organizations establish the vital link between their ability to thrive in challenging times and quality excellence utilizing the quality principles. The primary objective is to enable growth and transformation through enterprise efficiencies, better performances, innovation, and unique business models [21]. According to Küpper, Knizek [22], Quality 4.0 is characterized by evolving collaboration,

culture, competency, and leadership. It is about using technologies and the influence of digitalization in processes, people, and quality practices. Quality 4.0 brings about several benefits such as real-time process monitoring, data collection, and analytics. Emblemsvåg [23] pinpointed that quality management has evolved considerably since the beginning of industrialization. Quality 4.0 can be perceived as the application of the digital technologies of Industry 4.0 to quality management. This new generation has an essential role to play in the future of quality. For instance, Fonseca, Amaral [24] mentioned that the European Foundation for Quality Management (EFQM) 2020 model is an updated and comprehensive business model encompassing sustainability with Industry 4.0. It has its focus on the transformation of organizational efficiency, with verity theoretical and functional foundations. This model connects a technologically unbiased and strategic perspective to Industry 4.0 and provides an integrated business excellence framework for Quality 4.0.

V. THE RISE OF DIGITALIZATION IN HEIs

The HEIs have experienced rapid and drastic transformations as a result of digital transformation. The evolving changes are the combination of novice communication technologies and a new connection of people with information. There seems to be an acceleration towards a digital transformation that has the ability to generate a new vision of the future. Logically, HEIs need tools to achieve changes and develop suitable strategies [25]. The education industry is now tapping into the digital revolution, with key transformations brought into the process of learning and teaching [26, 27]. The authors mentioned the HEIs work to use advanced technology that is now undergoing a massive transformation. The digital transformation is witnessing an increased focus on digital classrooms, the IoT, and AI, all of which provide customized learning experiences to learners at different levels [28]. Castro Benavides, Tamayo Arias [29] agree that digital transformation in HEIs will improve the student experience and enhance the campus environment-and teaching-and learning methods. Bond, Marín [30] pinpointed those intensive professional developments for educators, students, and staff almost utilize innovative technology in education. Also, evaluating the digital transformation's effectiveness is important to correct the path and find out its strengths and weaknesses with the continual use of such technological tools and procedures.

VI. BARRIERS TO IMPLEMENT DIGITALIZATION IN HEIs

With the initiatives taken to implement new technologies in HEIs, there is a wide range of critical issues to be resolved with immense efforts and essential decision-making. Daniel [31]mentioned that it is for sure that HEIs transformation is underway in the present times, as education leaders are starting on their digital journey. At the same time, current efforts for transformation are focused on the building blocks of experience, such as digitized learning content and administration efficiency. Recognizing this and resolving this matter remain pivotal for better educational outcomes [32]. There are several challenges in integrating technology in higher education, and they come in various forms. Also, it is essential to handle them with diligence and care for ensuring positive outcomes [33]. Some notable challenges are data security, infrastructure, lack of IT staffing, digital integration, data governance, creation of data-enabled culture, and adaptation to change [33, 34].

According to Benavides, Tamayo Arias [35], rapid technological advancement permeates HEIs that the Industrial Revolution 4.0 brings. The authors mentioned that the digital transformation approaches to HEIs had aroused interest in the complex relationships between the actors in the education domain that is increasingly supported by technology. Therefore, the holistic dimension of digital transformation is missing in many cases. García-Morales, Garrido-Moreno [36] mentioned that the present COVID-19 pandemic had compelled the education sphere to consider the digitalization of HEIs and undergo radical transformations. Also, the system at the university level is striving to remain competitive while providing high-quality education in the light of digital transformation and accelerated change brought about by disruptive technological innovations. The authors stated that the HEIs authorities face several barriers while using various tools and platforms such as video conferencing, learning platforms, and instant messaging tools.

Lääts, Kask [37] highlighted that digital transformation implications for the higher education domain are multi-faceted, with possible problems faced by the actors. The interplay between openness for change of HEIs and technology determines how challenges crop up while utilizing the different advanced tools for learning and teaching in the contemporary era. The sustainability of the universities is a concern against increasing digitalization. Bejinaru Bejinaru [38]explained that due to an accelerated pace of the growth of communication technology, digital society had become a real and specific challenge. The intellectual capital of HEIs is a significant challenge for the successful implementation of digital tools and procedures that support education. The students' digital skills are not up to the mark for embracing the striking changes brought about by the digital transformation of the higher education system.

According to Aldosari [39], AI is being used in many HEIs worldwide. The author indicates that there is a lack of understanding of the mechanisms used to apply AI. Therefore, the professionals across HEIs need better training through planning, designing, developing, and implementing digital skills

and gain the trust to use AI within HEIs. The potential of AI in augmenting education quality is explored by [40]. However, there are many challenges in using AI in HEIs. These include a considerable high cost of AI technology, vulnerability to varied cyber-attacks, and lack of flexibility. Irrespective of the numerous benefits brought about by AI in the education sphere, the challenges are critical, drawing policymakers' attention.

O'Doherty et al. [41] opined that the chief barriers that negatively impact the development and implementation of online learning methods include, absence of institutional strategies time constraints, inadequate infrastructure, poor technical skills and support and negative attitudes of all involved. Solutions that can address these concerns include better educator skills, rewards and incentives for the time involved with developing and delivering online content, and improved institutional strategies. El Turk and Cherney [42] mentioned that administrators and faculty members at HEIs

perceive the structural barriers to implementing the online education system: a lack of government policies guiding online classes, frequent failures in technology, lack of control over cheating, slow access to the internet, and lack of awareness. In addition, decisions makers perceive specific barriers that stem from the digitalization of higher education. It would be a pivotal step to blend conventional and online education instructions for better educational outcomes. Lloyd et al. [43] indicated that in many institutions of higher learning there is an increased demand and need for online courses. However, the number of faculty members involved in developing and teaching such courses does not keep pace with the growth of online learning. The factors associated with a minimal provision of online courses are interpersonal barriers, cost/benefit analysis barriers, technology and training barriers, and institutional barriers. Administrative decisions are to be informed by such barriers for articulating solid policies. Table 1 show the summary of barriers to use digitalization transformation in HEIs.

Table 1. Summary of Barriers to Implement Digitalization Transformation in HEIs

Author	Major Findings
Castro Benavides et al. [35]	- Lack of infrastructure. - Lack of technological constraints. - Lack of financial support. - Barriers to compliance, security, and data protection and regulations.
García-Morales et al. [36]	- Specific communication abilities for an online setting, and inadequate computer skills. - Lack of collaboration. - Lack of infrastructure.
Laats et al. [37]	- Lack of top management support. - Lack of organizational culture. - High cost of technologies. - Resistance to change.
Bejinaru, R. [38]	- Absence of technologies resources. - Lack of vision. - Lack of infrastructure.
Aldosari, S. A. M. [39]	- Lack of information technology - Lack of train professionals - Follow a traditional approach to education. - Lack of availability education technology
O'Doherty et al. [41]	- Resistance to change - Time limitations - Lack of technical skills - Lack of infrastructure - Lack of institutional strategies

Author	Major Findings
El Turk, S., & Cherney, I. D. [42]	• An online course requires more commitment and development from faculty. • Lack of compensation. • Lack of technological infrastructure investment. • Resistance to online education methods.
Lloyd et al. [43]	• Lack of quality. • There are no rules or guidelines in place for online courses. • Lack of faculty involvement in course decision-making. • Lack of instructor training. • Lack of technology support. • Technology failures frequently. • Software or systems that change frequently. • Workload has increased. • Inability to adhere to a schedule.

VII. CONCLUSION

The future of higher education seeks greater security, collaboration, and technology-driven ideas. This paper aims to explore the opportunities and barriers of implementing Quality 4.0 in HEIs for improving their performance with the help of digital transformation. New technology will be influencing the environment of education and help—to develop HEIs. Educational institutions worldwide are taking initiatives for transforming and prospering in the fourth revolution of technology. Higher education policymakers and leadership teams seek to achieve the world of digitalization that provides learners with the knowledge and skills they need.

Many education initiatives aim to align knowledge, industry, and humanity. The implementation of Quality 4.0 in HEIs is worthy of attention due to weaknesses in digital integration, leadership support, IT staffing capabilities, training, and digital culture.

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