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Barriers Affecting Higher Education Institutions' Adoption of Blockchain Technology: A Qualitative Study

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Abstract: Despite the many benefits of blockchain technology in higher education, this technology is not widely adopted by Higher Education Institutions (HEIs). Therefore, instead of providing additional motives for adopting blockchain technology, this research tries to understand what factors discourage HEIs from merging blockchain with their procedures. The methodology used for this research is based upon qualitative research using 14 interviews with administrative and academic staff from the European Union (EU) and Canada. Our findings based on our empirical data revealed 15 key challenges to blockchain adoption by HEIs that are classified based on the technology, organization, and environment (TOE) framework. Theoretically, this study contributes to the body of knowledge relating to blockchain technology adoption. Practically, this research is expected to aid HEIs to assess the applicability of blockchain technology and pave the way for the widespread adoption of this technology in the educational field.

Keywords: blockchain; distributed ledgers; blockchain challenges; blockchain in education; decentralized education; Higher Education Institutions (HEIs)

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1. Introduction

Blockchain is a distributed, immutable database made up of a list of "blocks" that retain data relating to transaction dates, timestamps, volumes, and/or participants [1]. When a user initiates a transaction via a peer-to-peer network, users are identified using a cryptographic identification technique. The transaction is subsequently transmitted to the storage pool of the blockchain network and waits for verification. When a required number of approved nodes (miners) have verified the transactions, the new block will be generated. This is described as reaching a consensus. Each node updates its blockchain ledger copy as soon as a new "block" is generated after consensus. This consensus phase is achieved using a consensus algorithm, and this method is known as mining [2,3]. However, the popular consensus techniques include proof of work (PoW) and proof of stake (PoS) [2,3].

Blockchains come in different types based on their design and structure. The data included in blockchain blocks and the actions carried out by the numerous participants on the blockchain can be regulated according to how the blockchain is configured and how it is anticipated to achieve the intended business objective [4]. Public, private, and permissioned blockchains are the three most popular types. They are commonly used in a variety of cryptocurrency networks, and private and public organizations [4].

Numerous appealing characteristics of blockchain technology exist [5], including decentralization, transparency, traceability, and immutability. Decentralization relates to the fact that updating, storing, or recording data on the blockchain does not require a central node. As an alternative, information can be recorded, maintained, and updated in a distributed manner [5]. Therefore, to establish trust among remote nodes, mathematical techniques are employed rather than using centralized organizations. In addition, blockchain is immutable because it is a distributed ledger that is preserved by multiple nodes. Therefore, network-based hacking can only be successful if 51% of ledgers are altered [5]. Furthermore, blockchain is transparent since every node on the network can see the data being recorded, even when it is being updated [6]. Additionally, blockchain is traceable due to the chronological order of all transactions and the use of a hash algorithm to link a block to two neighboring blocks. Thus, each transaction can be tracked by inspecting the block metadata [3].

In the next section, more detail about the benefits, applications, and challenges are introduced.

2. Benefits and Obstacles of Blockchain Applications in the Higher Education Sector

The benefits of blockchain technology in the education sector range from data management to data verification without sacrificing accuracy [7]. The data are transparently accessible and verifiable around-the-clock [7]. Blockchain technology is typically utilized for the issuing and verification of academic credentials including degrees, transcripts, competencies, achievements, and professional ability that can be validated by employers worldwide [8]. The certification procedure is streamlined by blockchain technology, and thus the employer requires less time to verify the academic results [7]. It aids the education sector by offering a secure platform for exchanging student data, fostering trust, cutting costs, and increasing transparency [7].

Refs. [8,9] outlined several advantages of blockchain technology for education, including high security, improved access control, trust, affordability, identity verification, effective data management, interactivity, and system interoperability, as well as improvements to student assessments, career decisions, accountability, and transparency.

Some HEIs have also used blockchain technology to help in the management of academic degrees and summative evaluation of learning results [10]. The full transcripts, including learning outcomes and content, academic accomplishments, university degrees, experience gained, competitions, and personal interests, can be securely and properly recorded and retrieved using blockchain technology [11]. In addition, blockchain technology could optimize and simplify student activities related to the verification of issued credentials, including degrees, transcripts, student skills and experience, performance, and professional skills. This is because blockchain-based services improve and simplify management tasks when a verification process is required. [10]. Additionally, blockchain-based systems allow students to retain ownership and control over their acquired credentials, eliminating the need for an intermediary to validate them [12]. Moreover, blockchain could support the management and operational tasks of HEIs for payment management (for example, receipts of students' fees), management of international collaborations (for example, automatic validation of awarded points), accreditation activities (for example, a certificate given by the government detailing that the HEI is permitted to perform a specific task) [12]. Furthermore, by removing time-consuming and costly processes, the process of internationalizing of HEIs through student exchange or collaborative programs can be made much easier [9]. Therefore, blockchain enables HEIs to reduce administrative expenses and bureaucratic processes. [10]. Another application of blockchain is using it as an academic publication platform and the "gamification of learning based on blockchain", which would simplify handling granted certificates [12]. Additional potential uses of the blockchain include receiving student loans, research and grant funding, facilitating diploma verification, and creating a virtual Lifelong Learning Passport [12]. Blockchain record-keeping represents another initiative for HEIs. It has numerous use cases, such as permanent certificate protection, validating the accreditation, automatic recognition of credits, and intellectual property management [12]. Furthermore, blockchain technology assists in decreasing degree fraud, for instance by using a digital signature mechanism [13], or by using the time-stamping attribute of blockchain to prevent illegal activities from diploma issuers. In addition, the integrity and immutability attributes of blockchain help in recording diploma data and tracking any updating in records [14].

Despite all these benefits and possibilities to use blockchain by HEIs, there remain several general and specific difficulties [15,16] that make the acceptance rate of this technology rather slow. For instance, according to Park [17] blockchain is still considered an immature technology since it is yet in its early stages of development. Thus, it still has different barriers concerning security, privacy, scalability, and interoperability. In addition, the systems implemented in HEIs contain enormous volumes of student-related data, therefore, there are a growing number of blocks and transactions on the blockchain, which takes a longer time, given that each transaction needs peer-to-peer verification. Furthermore, the consensus protocol for validation of the new blocks consumes a significant amount of power [18,19]. Another significant issue is the lack of interoperability among the various blockchain networks. This is due to the absence of general standards that would enable multiple networks to cooperate. Moreover, there is a concern about difficulties in the integration of HEIs legacy systems with blockchain technology [15,20–22].

Additionally, although blockchain is known for its security and the efforts to make the platform secure and reliable, security is still a demanding issue, and certain blockchain security and weaknesses must be considered [23]. However, there exist other barriers stated in the literature in terms of privacy, shortage of skilled professionals, legal and economic issues, stakeholder awareness, and others [7,15,16,24–26].

However, the barriers to the adoption of blockchain that HEIs may encounter have not yet been fully investigated, a gap that this paper attempts to fill. The need for such research is justified by the fact that quite a few HEIs have implemented blockchain-based solutions and these solutions often were unsuccessful in gaining acceptance among both the HEIs' academic and administrative staff [17]. Therefore, a study to understand the key obstacles and challenges to adopting blockchain by HEIs could pave the way for the widespread adoption of this technology in the higher education field. Even though there are a handful of studies on blockchain technologies in the higher education field, they have either focused on expectations, possibilities, and applications of this new technology, for example in [26–32], or they are literature reviews that are not original research such as in [29]. Although the literature has discussed some of the obstacles to the application of blockchain in higher education, it is still fragmented. Other researchers proposed solutions for some issues related to the adoption of blockchain in the education sector [24,25,30,32–34]. However, this type of research focused only on a specific issue.

Ref. [17] investigated the adoption of blockchain in academia between 2017 and 2020. The study was constructed upon a review of blockchain projects, related literature, and qualitative study: interviews, focus groups with academics, university administrators, librarians, startup founders, and IT specialists from the United States of America (USA), the European Union (EU), Russia, and Belarus. The following issues are identified as the main difficulties and impediments to blockchain acceptance in academia: usability and security concerns, legal issues, conflicts of values, and a critique of the political aspects of blockchain governance. However, this study ignored some important obstacles such as privacy and sustainability. In addition, there is a lack of a clear classification of different types of challenges. Ref. [20] conducted qualitative research to investigate the key benefits and challenges of applying blockchain in education via interviews with 9 HEIs in the USA. Some of the key barriers identified include data protection laws such as the General Data Protection Regulation (GDPR) [35] which poses obstacles for application developers and scalability challenges that arise due to slow speed blockchain transactions and the scaling trilemma. In addition, the issues of market acceptance and innovation highlight blockchain-in-education as an immature technology that authority bodies within HEIs frequently ignore or perceive cautiously. However, this study employed a small sample size and did not focus on other challenges.

Refs. [15,36] present systematic reviews of research exploring blockchain-based educational applications. Thus, these reviews focused on the educational applications that have been built with blockchain technology, and on the advantages that blockchain technology could bring to education. However, ref. [15] discussed briefly and generally issues of adopting blockchain technology in education, for example, the security issue in ref. [15] was discussed in just one line. In addition, several challenges were neither discussed nor reported such as lack of standardization, sustainability, legal issues, lack of skills, and more. Therefore, it did not provide a complete review of all the blockchain challenges in education. Furthermore, the reported challenges were not classified or organized using any type of classification framework. Ref. [16] is another literature review that presented a systematic overview of blockchain projects and solutions in higher education. In addition, the challenges of implementing a specific blockchain-based platform named EduCTX were reported. However, the reported challenges were related to implementing a specific educational solution for managing certificates, and it is, therefore, not a complete review of all the technical, organizational, and environmental challenges of the adoption of blockchain in the education sector.

Most articles on the blockchain are constructed as either a proposed solution [24,25,30,32,33] or a systematic literature review [15,34]. There is a lack of research papers using qualitative methodology [36] and exploring the concerns underlying the adoption of blockchain. Therefore, this paper aims to fill the gap: it aims to identify and categorize the technical, organizational, and environmental concerns and barriers to blockchain adoption as observed by academic and administrative staff working in HEIs in the EU and Canada. In addition, the research will help academics, policymakers, and managers interested in gaining knowledge about this promising technology to assess the applicability of the blockchain in the higher education field. Furthermore, this research uses the technological, organizational, and environmental TOE framework [37] to classify the challenges. TOE explains factors that influence the adoption of technology [37]. The TOE framework has been widely utilized to analyze the challenges and obstacles of technology adoption. Tornatzky and Fleischer [37] claim that the TOE presents challenges and opportunities for technological innovation. In their book, the technological perspective represents the technological barriers faced by the organization adopting a technology, such as security, and scalability. The organizational perspective includes organizational drawbacks such as lack of adequate skills. Environmental contexts examine the challenges of the environment in which the organization provides essential services such as laws and regulations.

The qualitative research method is used in this study to answer the research question: "What are the obstacles and challenges to the adoption of blockchain technology in higher education institutions?". Semi-structured interviews were used to collect data from individuals (N = 14) working in higher education institutions in the EU and Canada. In addition, the data collected were analyzed using a thematic analysis approach.

The rest of the paper is organized as follows. The Methods section describes the methodology used. The Results section focuses on analyzing and presenting the findings obtained from the participants. The findings are followed by the discussion and future research section. Finally, Section 5 discusses limitations and challenges.

3. Methods

The purpose of this study is to identify and categorize the concerns and barriers to blockchain adoption as observed by academic and administrative staff working in HEIs in the EU and Canada. The guiding research question of this study was: "What are the obstacles and challenges to the adoption of blockchain technology in higher education institutions?". This paper draws on results from a qualitative study including semi-structured in-depth interviews with individuals (N = 14) from five countries. The methodology, participants, ethics, data collection, and data analysis procedures will be described in this section.

3.1. Research Approach

The qualitative research method with semi-structured interviews is used in this study firstly to find patterns in the participants' thoughts and attitudes [38]. Secondly, this approach is suitable when seeking insights from participants that are involved with blockchain technology. Lastly, understanding people's actions in complex social situations [39], provides detailed and in-depth information on the topic of study. Moreover, as stated by

Bryman [38], qualitative research is an inductive approach to the relationship between theory and study, incorporating an analysis of the social world where social traits are the result of interactions between individuals. Therefore, the qualitative method was used to study and understand the perspectives and perceptions of challenges in blockchain technology from academic and administrative staff and to obtain detailed information. Following Kaplan and Maxwell [40,41], the study will take an inductive approach, with empirical data collected through semi-structured interviews that will serve as the basis for the study's analysis.

3.2. Participants

We used a purposeful sampling process [42] to reach a balanced sample and to delve into the perspectives of the academic staff (professor/associate professor, researcher, and Ph.D. student), on one hand, and the administrative staff (IT division manager, developer, and decision-maker), on the other. Eligibility criteria for participation required that potential participants: (1) be in charge of blockchain technology or involved in blockchain projects or research; (2) be willing and able to participate in a 45–90 min individual virtual interview. The participants were identified on the professional networking site LinkedIn by online searching for experts working on blockchain projects in HEIs. Although no specific demographics were considered at the time of participant selection, we followed contact suggestions that added more respondents from the same country as Sweden to the study. After deciding which participants to contact, 105 invitations briefly outlining the study's scope were sent via LinkedIn, which resulted in 14 participants who agreed to grant us an interview, with the majority based in Europe (see Table 1) and one in Canada.

Table 1. Key summary details for each of the 14 interviewees.

Participant No.	Job Title	Years of Experience	Country
P1	Professor in Informatics	13	Sweden
P2	Associate professor in Software/IT	7	Canada
P3	Ph.D. student in Blockchain Systems	3	Norway
P4	Professor/European research project coordinator	12	Spain
P5	Associate professor/Co-creator European Blockchain project	10	France
P6	Professor in Computer Engineering	7	Spain
P7	professor in Construction Management/Blockchain researcher	6	Sweden
P8	Associate professor in Blockchain courses	8	Sweden
P9	Professor in Informatics and Information Systems	11	Sweden
P10	University IT manager	4	Sweden
P11	University IT developer	5	Sweden
P12	Computer Science department manager	2	Sweden
P13	University top manager	3	Sweden
P14	University administration employee	3	Sweden

3.3. Data Collection

In this study, semi-structured interviews were used to collect data. The semi-structured interviews help to provide a deeper understanding of the challenges associated with the use of blockchain and to provide insight into the thought processes of the research participants [38]. These insights are necessary to obtain a full picture of the challenges in adopting blockchain in HEIs. Following Yin [43], interviews are guided conversations in which the "why" of the case to be studied is analyzed. These are "open-ended in nature" but keep the interviewee in focus if they stray off-topic. In a semi-structured interview, a wide form is used for the different profiles interviewed, but in which the interviewee depending on their experience and knowledge about the blockchain and the institution, can answer some questions from the full question list.

The 14 interviews with the respondents who agreed to participate in this research were conducted between January and June 2022. All interviews were conducted in English and lasted between 45 and 90 min, as the respondents were only available to a limited extent. Interviews were conducted online due to differences in geographic location. Online communication tools such as Zoom and Microsoft Teams were used to conduct the interview. To ensure the quality and accuracy of the data, the interviews were recorded using an internal recording feature from online communication tools. Subsequently, the audio file was saved and transcribed with the guidance of the transcription application Otter.ai for those conducted in English via Zoom, and those conducted via Microsoft Teams were automatically transcribed by the transcriptions native feature.

The interview started with a very broad question: "Tell me about your experience in blockchain technology."; examples of specific questions from the interview protocol include "How does your institution apply blockchain and in which field?", "Which processes need to be changed to adopt a blockchain solution?", and "What kind of problems may data immutability cause in your organization?", see Appendix A. Given the responses of the participants, extra probing questions, and follow-ups were utilized to collect further information and data concerning the challenges that the participants perceived as most relevant. All participants received the questions in the same order.

3.4. Ethical Considerations

Ethical considerations were taken when conducting this qualitative study. According to Bryman [38], the ethical principles that can harm participants are lack of informed consent, invasion of privacy, and deception. Therefore, before the start of the study, the participants obtained full consent according to the ethical considerations of the research, and they agreed to participate in the study on their initiative. In addition, the participants' privacy and the confidentiality of the data generated during the procedure were ensured. Furthermore, to maintain the quality and integrity of the research, the interviewer remained neutral throughout the process and avoided being predisposed to the results. Additionally, the interviewer had no prior ties to any of the interviewees. Finally, as stated by Bryman [38], the participants take part in the study voluntarily, with confidentiality and anonymity, and they are informed about the consent form, which includes information about the study's goal, how the data gathered will be used, and their rights will be respected before, during and after the interview.

3.5. Data Analysis

In this study, the collected data were analyzed using a thematic analysis approach according to Creswell's six steps [40]: Organizing/preparing data, first reflection, data coding, identity themes and descriptions, the connection of themes, descriptions, and final interpretations. The raw data obtained during the interviews were organized and transcribed. The transcribed data were read many times to ensure that the generated text was understood, and the recordings were heard. This ensures that the generated script is correct. The interview tapes were also viewed again to ensure the accuracy of Otter.ai and Microsoft team auto-transcription data. Nvivo 12 was selected for use as a qualitative analysis tool. Subsequently, to acquire a visual understanding of the data, a word frequency query was employed. After that, the transcribed data were encoded, broken down into pieces of similarity, and categorized. Finally, the categories of data identified were examined for any unnecessary information.

According to Bryman [38], the authors focused on frequently reported subjects that recur in multiple interviews, as well as similarities and contrasts between interviews, to discover themes. Table A1 shows how the themes have been identified and coded. Respondents' answers were analyzed, and keywords were searched to identify commonalities between the different answers, and then the theme name was used as a general categorization to meet the different respondents' answers. The keywords are highlighted to facilitate the identification process.

4. Results

According to data analysis, 15 themes appeared as the main barriers and challenges to the adoption of blockchain in HEIs. These themes were then categorized based on the TOE framework, see Table 2. The participants are all named from participant (P1) to participant (P14) to fulfill the ethical consideration and maintain their anonymity. The details of each theme are presented comprehensively in the following subsections.

Table 2. Identified barriers for blockchain adoption in HEIs (n = 15).

TOE Context	Technological Barriers	Organizational Barriers	Environmental Barriers
Themes	- Immaturity - Poor usability - Lack of scalability - Limited interoperability and standardization - Integration complexity - Security - Privacy - Immutability and lack of flexibility - Data unavailability	- Lack of adequate skills - Financial barriers - Lack of management commitment and support	- Legal issues and lack of regulatory compliance - The market and ecosystem readiness - Sustainability concerns

4.1. Technological Barriers

The first context in the TOE framework refers to the technological barriers. This theme consisted of five sub-themes: (1) immaturity; (2) poor usability; (3) security issues; (4) privacy; (5) lack of scalability; (6) limited interoperability; (7) integration complexity; (8) immutability and lack of flexibility; and (9) unavailability.

4.1.1. Immaturity

The participants' concerns about blockchain adoption in higher education are diverse and based on their level of experience in the technical aspects of blockchain. However, they stated in general that there is a lack of blockchain knowledge necessary for adopting a blockchain-based solution in their institution. One of the participants did not consider immaturity a challenge. Three participants provided relevant information about immaturity. For instance, A participant (P1) stated that:

> *"We need the staff to understand this technology, they need to adopt this for their needs, change the infrastructure or the platform, there are different types of blockchain, how they can decide which type is the best to adopt, which information can be stored on the blockchain and which type."*

In addition, the participants believed that the university needs to identify where to apply this technology, which is linked to the knowledge about technology and its requirements by university staff. In this regard, one of the participants (P3) said:

> *"The adoption of blockchain is subject to the need to use blockchains and the limitations of this technology. So, it is good in some respects and it is not so good in other aspects, probably they haven't identified a use case and the requirements blockchain can meet."*

Furthermore, the participants believed that the majority of employees are not interested in adopting blockchain; they have heard about it without really knowing what it is. In this regard, a participant (P7) stated that:

"If there's not a critical mass of a team or many people are interested or working with blockchain, the things can't come to fruition easily. I mean, most people have heard what blockchain is now. But it is not known what it is, and I think most people still think of Bitcoin. But blockchain technology could be used at the university's administrative level."

The previous idea is shared with participant (P5), but they offered a broader vision of this issue, relating it with the dynamicity of the technology, which makes it even more difficult. A participant (P5) noted that:

"Maturity is a problem with Blockchain technology. Because this technology changes a lot, it is a dynamic topic."

However, the participant (P4) did not consider immaturity as a challenge:

"There are already some blockchain-based solutions that are mature and that can be applied. So, I don't think it is immaturity the reason that they are not widely adopted."

To sum up, immaturity is considered a challenging issue among the majority of interviewees for different reasons ranging from lack of knowledge, absence of a concrete use case, low interest, and dynamism of the technology.

4.1.2. Poor Usability

Another challenge extracted from the participants' explanations of the barriers to adopting blockchain in HEIs was the poor usability of blockchain-based applications and solutions. Poor usability was considered by participants as a challenge for different reasons. For instance, participants believed that blockchain solutions were difficult to use and need to be adapted to different users such as administrators, lecturers, and students. In this regard, a participant (P1) stated that:

"Administrative and scientific staff, end-users, professionals and students need to use easily blockchain-based solutions. They must therefore have usable interfaces and useful tools to use and configure these solutions."

One participant even considered the low usability as one of the obstacles to the acceptance of blockchain from different users. A participant (P3) explained:

"Everyone in the organization must have the ability to use blockchain applications easily. I think that somehow usability is one of the most important challenges in the adoption of blockchain in HE."

More specifically, due to blockchain dynamics, algorithms or techniques used in blockchain-based solutions can become obsolete over time and no longer usable, which presents a challenge. A participant (P5) noted that:

"Algorithms can be useless, not good, or they cannot be used sufficiently in 10 years. This means that they will not be usable."

4.1.3. Lack of Scalability

An important problem stated by most of the participants was scalability. Based on the participants' explanations, educational systems have collected large amounts of data on many students which increases the number of blocks and transactions. Therefore, transactions in the blockchain require more time because each transaction needs peer-to-peer verification. Thus, a key challenge of blockchain, especially for public blockchains, is the network's technical scalability. In this regard, two participants emphasized the effect of using the public blockchain type on scalability, for instance, a participant (P1) said:

"In the public blockchain, each node in the blockchain network should verify the block, which means low transaction speed and high energy consumption. And then the blockchain in general scales up. it is very important to think about the scalability of the system in this setting."

Another participant (P6) noted that:

"The high number of transactions causes problems in our university due to the heavy network load, especially in the examination period."

Five participants believed that a lack of scalability is not a problem for private blockchain networks, since network nodes are intended to manage transactions within a trusted system. In this regard, a participant (P6) stated that:

"Slow transactions are associated with public blockchains because it supports a lot of nodes, if we use a small private blockchain, then transaction time should not be a problem, but the universities are not ready today to develop a private blockchain in terms of experts, software and hardware."

Additionally, the participants believed that the scalability concerning the speed of blockchain transactions is not a problem for certain blockchain applications. Confirming this point, one of the participants (P2) stated that:

"Slow blockchain transactions for issuing credentialing may be a minor issue but handling educational tokens or attempting to pay university fees may present a much more significant issue."

Another participant (P3) also confirmed this point and stated that:

"Slow transactions could be a problem for real-time applications or public-facing applications where an end-user expects to read the data instantly."

Further, three participants believed that the scalability problem can be avoided by applying proper settings and technologies. In this regard, a participant (P9) said:

"Many new blockchain systems provide high throughput and fast confirmation latency and low energy consumption. If the use cases are properly analyzed, the correct system can be determined with the right combination of properties and trade-off achieved."

4.1.4. Limited Interoperability and Standardization

According to the participants, the lack of interoperability between various blockchain networks is an important obstacle to implementing blockchain solutions in HEIs. The participants believed that there is no single dominating ledger technology in the first place but rather a multiplicity of platforms and technologies. Therefore, there is no clear standardization for blockchain. In this regard, a participant (P12) explained:

"The absence of common standards is because the majority of projects employ a variety of blockchain platforms and solutions, each with its own set of protocols, programming languages, consensus mechanisms, and data security measures."

Additionally, the participants referred to other aspects of the interoperability issue. For instance, a participant (P12) stated that:

"The issue of interoperability arises at different levels, such as the interoperability between blockchains and data, business processes, systems with different consensus algorithms and different platforms."

However, one of the participants believed that despite the interoperability problem, several solutions allow interoperability between diverse blockchain networks. In this regard, a participant (P10) stated that:

"Ark is a solution that offers universal interoperability. Cosmos is another alternative that uses the Inter blockchain communication (IBC) protocol to enable blockchain to operate outside the silos and to transmit files."

4.1.5. Integration Complexity

Two participants considered the integration of blockchain solutions with legacy systems as a challenge for their educational higher institutions. In this regard, a participant (P11) stated that this challenge could arise when:

"The HEIs decide to use blockchain system, so they must entirely restructure their older system or develop a method to effectively integrate the two systems."

In addition, a participant (P13) emphasized that integration complexity could occur when there is a need to:

"Restructure or align the business processes and create interfaces to facilitate data communication and sharing among blockchain and related legacy systems, such as the Enterprise Resource Planning system (ERP)."

According to the participants, the integration problem is worsened by the lack of qualified developers required to integrate different systems. HEIs frequently lack access to the required skilled team to share in the integration process. A participant (P5) suggested a solution to this issue:

"The lack of experts is the reason why integration is a challenge in HEIs, but this issue can be mitigated by depending on a third party."

4.1.6. Security Issues

Although blockchain is recognized for its security, participants considered security as a challenging issue. In this context, a participant (P1) mentioned several types of security attacks and errors on the blockchain that could influence educational applications:

"Keeping educational material on blockchain may cause a risk since errors in the application, platform, or data input can occur. In addition, users often do not sufficiently protect their private keys. Furthermore, data leakages that possibly will cause a security risk can happen as a result of many upgrades."

In addition, based on the participants' opinions, a lack of knowledge about using blockchain was the main cause of certain types of attacks. In this regard, a participant (P8) reported other types of attack:

"I think that the social engineering attack may occur due to the lack of user knowledge on blockchain."

Additionally, the 51% rule regarding attacks was reported by the participant (P7):

"Hackers can alter portions of a blockchain and roll back transactions if they succeeded to attack 51% of nodes, this may cause a delay in initiating a new transaction, which causes a crash in the network."

The risk of data loss is another security issue revealed by the participant (P1):

"If a student loses his/her private key information necessary to establish ownership, he/she will lose all his/her information on the blockchain, and he/she can't get this information again, he/she may lose his/her academic credentials."

On the other hand, participants considered blockchain a secure technology, and the security issues may arise from the surrounding circumstances of blockchain. In this regard, a participant (P9) stated:

"I don't think it is a problem or a challenge, because we can have cyber-attacks and other security issues in any system. It depends on how the system is built and secured."

In addition, they considered the attacks that often occur on the centralized and legacy systems integrated with the blockchain solutions. The participant (P3) said:

"In the media, you hear about attacks on the blockchain system. In some cases, these attacks can't break the blockchain or the peer-to-peer system itself, but this attack affects, for example, the centralized platforms that are often used to exchange money."

Further, participants claimed that the security issues can be avoided if the HEI implements a proper type of blockchain with appropriate settings. Concerning this point, a participant (P3) stated:

"We know several security issues in the blockchain. But I think private blockchains, d the Hyperledger Fabric or other security solutions are less vulnerable to security threats."

4.1.7. Privacy

A majority of the participants (eight participants) believed that preserving privacy while ensuring security on the blockchain presents a challenge in several educational usage scenarios that handle sensitive data. In this regard, a participant (P1) stated:

"When we adopt a blockchain, we must think a lot about protecting the student's private data. Students' data will no longer be regarded as private if it is preserved in a public ledger."

The participants considered public blockchains inappropriate for storing personal data, and a private blockchain or consortium could be suitable. Confirming this point, one of the participants (P2) stated that:

"I think we can preserve privacy by choosing the right blockchain solution. For example, the public type is not suitable to store data. Although the data is encrypted, there are various tools to decrypt it."

Additionally, the participants placed emphasis on the regulations and laws in different countries for securing personal information that should be considered by the HEIs intending to adopt blockchain. For example, the European General Data Protection Regulation (GDPR) [35] is an important regulation in the EU. According to the participant (P3):

"GDPR does not allow the storing of private data in an immutable storage system, such as a blockchain, additionally, the data must be anonymized."

Therefore, these issues must be solved before blockchain can be applied to register students' personal information.

In addition, the participants mentioned blockchain's immutability feature as a privacy problem. In this regard, a participant (P5) explained:

"In blockchain, it is not allowed to change or remove data, even for legitimate reasons, which is in opposition to the freedom to be forgotten under the GDPR."

However, some participants did not consider privacy as an issue. This is due to various privacy-preserving solutions to address the privacy concerns in the blockchain. In this regard, a participant (P11) stated that:

"Privacy-preserving techniques such as zero-knowledge proofs (ZKP) are becoming increasingly popular for blockchains so this should not be an issue any longer."

4.1.8. Immutability and Lack of Flexibility

The participants (seven participants) explained the immutability feature of blockchain as one of the obstacles against the adoption of this technology by HEIs. In this regard, a participant (P1) stated that:

"Because a block in a blockchain is copied in several nodes, it cannot simply be modified. No one can alter a student's credentials once they are stored on a blockchain."

Another participant (P4) considered immutability a double-edged sword:

"Immutability is a key feature for building more trust between all individuals involved in the chain, but it would eliminate the ability for students' records to be altered for valid purposes."

Additionally, the participants believed that the immutability of blockchain can be problematic, as it conflicts with GDPR. A participant (P7) explained that:

"Immutability prohibits removing educational data for legal reasons. Although data can be modified by authorized authority, the original data will still be kept in the blockchain forever, which disputes with the GDPR's right to be forgotten."

Confirming this point, a participant (P6) said:

> *"If I've signed a contract with the university and I would like to resign or request a salary increase, the old contract will be stored in blockchain, even if it is no longer valid. Moreover, we should create a new block in the chain."*

However, the participants (five participants) believed that immaturity is not a problem itself since it is only related to specific applications. In this regard, a participant (P4) stated that:

> *"It depends on the application you are using. I don't think it is a problem. For example, in issuing certificates."*

However, the revocation of certificates is one of the major obstacles. Although this is an uncommon operation, it can be required in special circumstances. On the other hand, the participants considered immutability as a useful feature to reduce fraud and plagiarism. In this regard, the participant (P7) stated that:

> *"Blockchain immutability could help detect plagiarism in the student's assignments stored in blockchain."*

4.1.9. Data Unavailability

Another obstacle reported by the participants is the unavailability of data. In this regard, a participant (P14) stated that:

> *"Holding data in the hands of the students themselves could cause this data unavailable and can influence the educational applications that depend on this data."*

In addition, the participants explained the problem of data ownership rights in blockchain since the data are distributed and stored on the distributed ledger. A participant (P12) explained that:

> *"Currently, data handling is the responsibility of the educational institution's administration division. But the blockchain minimizes the duties of the management department because all data are stored there. Then, additional issues emerge: Whose owns the data? Who has the right to utilize it?"*

The participants believed that other technical factors could affect the availability of data such as limited block size and transaction throughput. Confirming this point, a participant (P9) stated:

> *"The availability of data in the blockchain depends on several technological factors, including the specific block size, the network's communication speed, the proof-of-work protocol."*

4.2. Organizational Challenges

The second context in the TOE framework refers to the organizational barriers. This theme consisted of three sub-themes: (1) lack of adequate skills; (2) financial barriers; and (3) lack of management commitment and support.

4.2.1. Lack of Adequate Skills

A majority of the participants believed that the lack of qualified blockchain resources, engineers, and developers is one of the key obstacles to adopting blockchain in HEIs. In this regard, a participant (P1) stated that:

> *"Blockchain is a new technology, so one of the reasons to hinder adoption of this technology is the shortage of qualified staff who can work on this type of technology."*

Similarly, the participant (P3) said that:

"There is a lack of expertise and competencies required to handle student data in a blockchain network. So, this could be one of the causes of the lack of trust in this technology. In Sweden, there are developers of smart contracts. For example, we work on our project with an expert on Hyperledger. But they're not enough for all blockchain projects."

The participants believed that the type of blockchain platform or solution could affect the number of available specialists and professionals. A participant (P6) stated that:

"The type of blockchain technology utilized has an impact on the number of specialists and professionals that are available. For instance, Ethereum has a large developer community."

Additionally, the participants emphasized the importance of raising awareness and educating academic staff about the advantages, applications, and maintenance of blockchain solutions. Concerning this point, the participant (P7) stated:

"The crucial step for the effective application of blockchain technologies could be to prepare the academic and administrative staff on how technology can be managed and maintained."

Another participant (P5) stressed this point and said:

"I am also co-creator of a big blockchain educational project with 20 partners. We have developed reports on the lack of required skills to implement this project since there is a shortage of administration staff and experts."

4.2.2. Financial Barriers

An important problem stated by the participants was the cost associated with the adoption of blockchain in HEIs. They agreed that the transaction costs must not be passed over when blockchain technology is applied. The participants presented this obstacle from different angles such as the cost of infrastructure, computational energy, adding new features, and handling of the data.

The participants reported the cost associated with consensus protocols that consume a surge of power and resources such as storage, bandwidth, and computing. In this regard, a participant (P3) stated that:

"Because the blockchain blocks must be copied on each node of the blockchain network, most blockchains, especially public blockchain, need extremely high storage capacity and energy consumption costs because the computing resources required to achieve cryptography."

Another participant (P9) mentioned the cost of energy and gas consumption associated with the use of the Ethereum platform:

"We use a lot of electricity. The Ethereum network gas charge is extremely expensive. whatever you do, you must pay for the gas."

Additionally, the participants reported the cost associated with employing developers and skilled engineers to develop a blockchain-based application. Confirming this point, a participant (P4) stated that:

"It is a difficult and expensive task to find qualified developers, they expected to have different skills such as building blockchain platforms, including Ethereum and Hyperledger, experience in blockchain programming languages, and experience in building mobile or web applications."

The participants believed that the cost of adopting blockchain is reliant on the type of blockchain, the application, complexity, and the blockchain platform used. In this context, a participant (P5) explained that:

"The entire cost of transacting on the Ethereum blockchain platform is expensive, Stellar platform is a blockchain intended to reduce the transaction costs."

In addition, the type of blockchain affects the cost. The participant (P11) stated that:

> *"Developing a distributed application on a public blockchain like Ethereum, will be significantly less expensive than building it on a private platform."*

Furthermore, the participants mentioned other types of costs such as those mentioned by participant (P7):

> *"When building a blockchain application from scratch, the price will rise, including those for infrastructure upgrades, smart contracts, transaction fees, cryptography, and consensus algorithms."*

On the other hand, one of the participants (P5) believed that blockchain can reduce the cost by for example automating some administrative tasks:

> *"When universities start their projects, they need years and costs to finish their project but then they will get a benefit, and decentralization can also help reduce costs of administration."*

Another participant (P8) believed that all other types of projects and technologies are associated with a cost:

> *"Normally, all projects cost money and the IT department in the universities has a budget."*

4.2.3. Lack of Management Commitment and Support

The participants reported that the lack of awareness and commitment of senior management may hinder an HEI's willingness to implement blockchain technology. In this regard, a participant (P8) stated that:

> *"Without the support of my institution's top management, it will be very difficult to manage and allocate resources and budget that could help to implement the project successfully."*

In addition, the participants emphasized that the lack of managers' enthusiasm about blockchain technology can hinder the blockchain's adoption by educational institutions. Confirming this point, a participant (P13) said:

> *"Our project staff felt encouraged as the university showed high-level support for implementing the project."*

Additionally, the participants believed that clear policies, rules, and guidance from top management can simplify the adoption of blockchain. In this regard, a participant (P9) stated that:

> *"In my institution, The transition to the blockchain was difficult for personnel because clear standards and rules are absent."*

4.3. Environmental Challenges

The third context in the TOE framework refers to the environmental barriers. This theme consisted of three sub-themes: (1) Legal issues and lack of regulatory compliance; (2) the market and ecosystem readiness; and (3) sustainability concerns.

4.3.1. Legal Issues and Lack of Regulatory Compliance

An important problem stated by a majority of the participants was the legal issues and/or lack of regulatory compliance. For example, the GDPR right to be forgotten is incompatible with the blockchain's immutability. In this regard, a participant (P7) stated that:

> *"Blockchain's immutability prohibits removing educational data for legal reasons. Although data can be modified by authorized authority, the original data will still be kept in the blockchain forever, which disputes with the GDPR's right to be forgotten."*

The participants believed that the basic conflict that occurs when evaluating blockchain compliance with GDPR is the protection of personal data. In this regard, a participant (P1) explained this issue:

"It is difficult for us to determine whether the data stored on the blockchain is sensitive. If the data are personal data, the GDPR must be respected, another issue is whether the data can be correctly anonymized to conform to GDPR."

To comply with regulations, the participants refer to the need to adapt internal processes and enforce new laws and policies in the HEI. Concerning this point, a participant (P1) said:

"We need to re-engineer some processes such as the process for verifying records or issuing certificates. I can say that we need to adapt internal laws or procedures to the new application."

The participants mentioned that the lack of standardization presents another related legal issue that must be solved to facilitate the adoption of blockchain by HEIs in the EU. In this regard, a participant stated that:

"I think the big problem is the regulation. it is even a European problem. We do not have a unique registration system in Europe, some standards are used such as Alternative Trading Systems ATS or other standards. but they try currently to develop a standard for the decentralized identity."

The participants believed that many regulation-based issues related to blockchain need to be solved such as intellectual property, and copyright. The participant (P10) stated that:

"I think today's laws and regulations work well for organizations. But If you look at saving certificates, you may encounter problems with the non-fungible token (NFT), and there are large question marks related to intellectual property and copyright."

Another participant (10) considered government interference and laws as a challenge in blockchain adoption:

"Another problem is government intervention, as countries increasingly recognize that blockchain applications in the financial sector will lose government control over the economy and financial institutions."

4.3.2. The Market and Ecosystem Readiness

Two participants reported the market and ecosystem readiness as a barrier to the adoption of blockchain in HEIs. The participants believed that external stakeholders such as governments, other universities, and industries are underinformed on the benefits and the application of the blockchain. In this regard, a participant (P1) stated:

"The stakeholders have a lack of knowledge in this area because it is a new technology. So, they need to raise the awareness about the benefits of this technology."

The participants emphasize the significance of educating external stakeholders on the benefits of blockchain for financial and social development. Confirming this point, a participant (P11) stated that:

"There is a gap regarding how and where a blockchain can be applied, as well as its outcomes and advantages, which requires significant training for other stakeholders involved in the blockchain projects."

In addition, the participants stressed the crucial role of government collaboration with universities and other stakeholders to facilitate blockchain adoption in HEIs. The participant (P1) said:

"The government in Sweden could be an important partner in helping blockchain adoption and increase trust on this technology, for example, by collaboration with universities, and industries."

4.3.3. Sustainability Concern

The participants considered sustainability as one of the obstacles against the adoption of this technology by HEIs. Here, the participants mentioned the sustainability of education and environmental sustainability. Regarding education sustainability, a participant (P12) stated that:

> *"The lack of blockchain technology's alignment with a clear philosophy of educational sustainability is the primary cause of the low level of real implementations of this technology in education."*

Additionally, the participants mentioned high blockchain power consumption as a challenge that impacts environmental sustainability in terms of climate change and a higher carbon footprint. In this regard, a participant (P14) stated that:

> *"The Proof-of-work (PoW) protocol consumes a considerable amount of power. So, I think this causes a risk of climate change and a greater carbon footprint."*

On the other hand, the participant (P4) claims that blockchain can reduce bureaucracy in terms of time and cost:

> *"Bureaucracy steals significant time and consideration away from the necessary activities in higher education. In Sweden, almost half of the budget is devoted to administrative tasks in several HEIs."*

5. Discussion and Future Directions

The purpose of this study was to explore the concerns about the adoption of blockchain in HEIs from the perspectives of academic and administrative staff. A total of 15 barriers were identified by the 14 participants. These barriers were divided into three contexts based on the TOE framework: technological, organizational, and environmental. The technological challenges are as follows: (1) immaturity; (2) poor usability; (3) security issues; (4) privacy; (5) lack of scalability; (6) limited interoperability; (7) integration complexity; (8) immutability and lack of flexibility; and (9) unavailability. In the organizational context, there is (10) a lack of adequate skills; (11) financial barriers; and (12) a lack of management commitment and support. Additionally, in the environmental context, there are (13) legal issues and lack of regulatory compliance; (14) market and ecosystem readiness; and (15) sustainability concerns, see Figure 1.

Figure 1. The challenges reported by the study's participants.

The findings of the current study showed that technological challenges received more attention from participants than the other two contexts, where nine technological challenges, three organizational challenges, and three environmental challenges were reported by participants, see Figure 2. This is due to the technological innovation and immaturity of the blockchain, and the growing desire to find solutions to various technical issues to make it a secure, stable and sustainable technology [1].

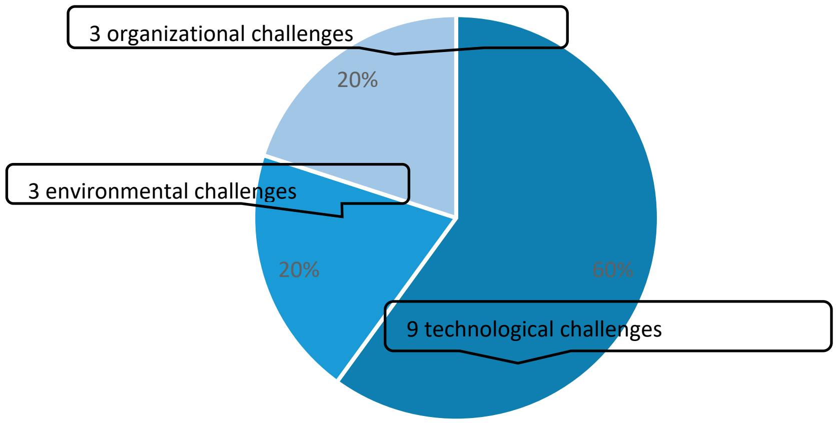

Figure 2. The number of challenges identified in each context of the TOE framework.

The current findings of this study support previous studies and reviews that also found an increased number of studies focused on technological barriers [1]. However, this indicates a gap regarding the organizational and environmental concerns that affect the implementation of this technology in the higher education sector. For example, the lack of commitment by senior management impedes the adoption of blockchain since senior management's lack of involvement and awareness could limit an institution's enthusiasm to embrace blockchain technology [18,20,44]. In addition, this will negatively influence different blockchain project management activities such as resource management [34]. Therefore, more research is needed on organizational and environmental barriers.

Additionally, there is no consensus among the study's participants regarding some of the barriers and challenges that are identified in Section 3. This may be explained based on the participant's experiences in certain contexts and project settings, see Table 1. The findings of the current study showed that several challenges especially the technological challenges are raised according to the application, project complexity, blockchain network type, blockchain platform, and technical solutions used. In this regard, several barriers can be overcome by applying appropriate settings and using proper solutions and techniques. For example, a lack of scalability is not a problem for private blockchain networks [45]. However, several previous studies described a specific context and settings in which the challenges were identified such as in [12,46] while others identified challenges in a more general context and settings such as in [1,16,26,47–50].

Similar to the findings reported by [48,49], the participants in the current study considered privacy as one of the most challenging issues. This difficulty in preserving privacy reported by the participants might be due to the complex interconnection between privacy issues and other issues such as lack of adequate skills and legal issues. For instance, to preserve privacy it is necessary to ensure the blockchain solutions adhere to strict data protection laws such as GDPR that require adequate skills in HEIs to determine what kind of information should be stored on-chain, which can be accessed by the public, and what data we must store off-chain ensuring their confidentiality. In this regard, the most challenging issues reported by the participants were privacy, legality, and lack of adequate skills, see Figure 1. However, although the negative impacts of legality and lack of adequate skills issues, and their strong relationship with other concerns, very few studies have handled these issues [1]. Therefore, further research is recommended on these two barriers.

Furthermore, immaturity was reported as an important challenge for blockchain adoption in higher education. The blockchain, according to Zheng et al. [21], is still considered an immature technology as it is still in the early stages of development. Thus, several technical concerns appear as a consequence of immaturity [51,52]. Confirming this point, the findings of the current study showed that blockchain still suffers from certain immaturity problems in different aspects such as poor usability of blockchain-based applications and solutions. Similar to our findings, Gabrielli et al. [4] also reported that the importance of the usability aspect was stressed by participants in group interviews, where the majority of participants showed interest and trust in using the blockchain solution if the user experience was good. However, the participants in their study were only moderately satisfied with the prototype's usability and suggested additional enhancements to the user experience. Kosmarski [12] also reported low satisfaction of participants with the complexity and poor user experience of the studied blockchain-based applications. Therefore, blockchain's usability should be enhanced through new user-friendly interfaces that fulfill the needs of users. Meanwhile, students, academics, and administrative staff should receive training on how to use it.

Interoperability and complexity in integration were also found to be significant challenges. This confirms the role of interoperability in technology adoption found by previous research. Astill et al. [53] claimed that in the absence of common standards, various blockchain platforms cannot effectively collaborate and interact well with each other without middleware software to facilitate this process. Similarly, Chen et al. [3] emphasized difficulties that could occur when processes need to be reformed and/or aligned, and other interfaces must be designed to enable data transmission and sharing between blockchain processes and connected legacy systems, such as the enterprise resource planning system. In addition, the complexity increases as HEIs often lack access to the expected blockchain expertise to take part in the integration process. To sum up, the findings revealed that the easier the HEIs can integrate blockchain technology within their legacy infrastructure, the higher their willingness will be to do so.

According to the apparent findings in this study, the participants reported several security attacks on the blockchain. Like the findings of the current study, Cernian et al. [54], Xu [55], and Guo et al. [56] claimed that despite the privacy and security offered by blockchain technology, malicious attacks and data leakage present a risk, making it challenging to trust this technology. In addition, the blockchain's lack of standardization compromises its security as there is no decision-making central authority [25]. Similarly, Juricic et al. [57] reviewed several security attacks on the blockchain, such as the Eclipse attack and the 51% rule regarding attacks. Therefore, HEIs must be aware of how data can be accessed and used securely.

Further, the sustainability of education presents one of the challenges reported by the participants. According to Park [17], the primary explanation for the low level of real applications of blockchain technology is its lack of alignment with a philosophy of educational sustainability. This means that blockchain technology would have brought many more advantages if there were a conspicuous philosophy of sustainable and distributed development of education, where the main goal is beyond the bounds of bureaucratic efficiency, scientific evidence, and the "learning is earning" type of financial incentives and social control [17]. Results from this study also revealed environmental sustainability concerns in terms of climate change and a higher carbon footprint due to the high blockchain electricity consumption. These results share a similar sentiment with the findings of Park [17] in his study. However, other aspects of blockchain sustainability such as social and economic areas can be studied in the future.

Similar to the findings reported by refs. [14,28], the participants in the current study considered the adoption of blockchain technology an expensive project, and it is important to consider different associated costs including the cost of infrastructure, handling data, time of slow transactions, adding new features, and the cost of power. Similar to the findings of the current study, Delgado-von-Eitzen et al. [16] reported the cost associated with consensus protocols that consume a surge of power and resources such as storage, bandwidth, and computing. In addition, findings from this study stated the costs associated with employing a developer and skilled engineers to develop a blockchain-based application. This is in line with the findings of a study by Grech et al. [22] that also reported the cost of educating and training HEI staff [12]. Similar to the findings reported by refs. [14,28], the participants in the current study emphasized that the cost of adopting blockchain is reliant on the type of blockchain, the application, complexity, and the blockchain platform used.

The market and ecosystem readiness were the only factors that were found to have an insignificant effect on blockchain adoption. This might be due to the challenges in establishing a collaboration with external stakeholders such as governments, other universities, and industries or challenges in participating in blockchain consortia [58]. Therefore, Steiu [20] highlights the importance of training and raising awareness of academic governance authorities on the benefits, deployment, and management of blockchain solutions as an essential step in boosting market adoption in higher education globally.

The challenges of adopting blockchain can be divided into general barriers that are common in all sectors or specific to the field of study. For example, scalability, immutability, interoperability, and lack of standardization challenges are common in all fields such as in education [26,43], the supply chain field [59,60], and health care [61,62]. On the other hand, each field has its own specific obstacles based on the requirements of the application of blockchain in this field. For example, connectivity and availability are challenging issues in the automotive sector [2]. In addition, the importance of each challenge depends on the field of application, for example, interoperability and integration are critical issues in the supply chain field. However, identifying the barriers and obstacles to implementing blockchain depends on understanding the context and settings of the intended blockchain application.

6. Challenges and Limitations

There are some limitations that the present study faced. One of the limitations is the small sample size. In addition, the nature of a qualitative study is that it does not seek to be generalizable; therefore, the results cannot be assumed to apply to all HEIs across various contexts [63]. In addition, we only employed one research method for data collection. This indicates that no other complementary approach was used to verify the results. Having a mixed method to triangulate the qualitative results with quantitative ones may have given us a high degree of internal validity. Employing various approaches in data collection could assist the researchers in confirming the reliability and validity of the collected data. In addition, this research provided the participants' perceptions and experiences about the challenges in implementing the blockchain in HEIs in the EU and Canada. In such studies, assessing the impartiality and neutrality of the participants' responses is challenging, and the presented descriptions may be insufficient. Therefore, further surveys are suggested regarding the attitudes of academic and administrative staff toward blockchain by HEIs while designing and implementing the blockchain technology applications.

7. Conclusions

Although blockchain technology can yield several benefits, its application in the higher education sector remains in the early stages due to different challenges. This study presents an attempt to deeply explore, identify, and categorize the perceptions of academic and administrative staff toward the barriers in applying blockchain in HEIs. According to the findings in the current research, several barriers have led to the low adoption rate of blockchain in HEIs. The findings indicated 15 challenges based on the TOE framework classified into the following three perspectives: technological, organizational, and environmental. The technological challenges are as follows: (1) immaturity; (2) poor usability; (3) security issues; (4) privacy; (5) lack of scalability; (6) limited interoperability; (7) integration complexity; (8) immutability and lack of flexibility; and (9) unavailability. In the organizational context, there is (10) a lack of adequate skills; (11) financial barriers; and (12) a lack of management commitment and support. Additionally, in the environmental context, there are (13) legal issues and lack of regulatory compliance; (14) market and ecosystem readiness; and (15) sustainability concerns.

This study showed that technological challenges received more attention from the participants than the other two contexts. This reflects a gap in terms of organizational and environmental challenges that will bear a negative impact and increase resistance to the acceptance of this technology in the higher education sector. Therefore, further research is required from an organizational and environmental perspective.

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Appendix A

Table A1. Sample of coding.

Respondent	Theme		
	Immaturity	**Financial Barriers**	**Legal Issues**
Respondent 1	"There is a huge amount of transactions as in all the institutions, this is a big problem, a big **challenge**, also **immutability**, because, as you know, you can't change the information in the block."	"We need a high speed and we need a high consumption of energy. So, it is **not easy to afford** this in our organization. So you need to this will reflect on the cost."	"Basic challenge slides besides other challenges, for example, related to the privacy because the blockchain does not go on with the GDPR, for example, all the incidents, the GDPR so this is one of the big challenges related to the privacy and the legal issues."
Respondent 3	"**Immutability** can be seen as a strength in case you want to be tamper-proof or prove something. But there are some, especially from the GDPR perspective. For instance, it can be a **problem** to have something somewhere that you cannot erase."	"The cost of running the actual servers in terms of energy and it has been shown that permission has blockchain like Bitcoin consumes a lot of energy. So the **problem** is if you get to the sizes like that the **cost**, it's huge."	"And like uncertain about where the **regulation** stands like, what should you be doing? I believe so, yeah, I'm a bit more on the technical side. I can only imagine the **challenges** from a **legal perspective**, to be honest, if I must be compliant."
Respondent 4	"I think it's just still **no maturity** of the technology. I don't think so because there is already a major technology in the field that can be used. So probably it's more about complexity and adoption. So, if it's not widely adopted, you have the **problem** of critical mass that you are."	"It depends because the issue here is that with permission fewer networks, so the technology is complex so then you will have to pay to participate in that and you need some engineering **cost** if even if you are using permissionless."	"I mean you have the Spanish **legal** system. So you have the degrees and how you admit them and everything. So just publishing them in an online repository like a blockchain network is not a **problem** at all. Probably the users would accept that or that that that this is published there, but I don't see any **legal constraints**."
Respondent 7	"The **immutability** of records doesn't matter here. But maybe **it matters** not for the grades, but maybe for the evolution of the assignments. So if some assignments are submitted."	"The cost for that I know. I think that's the problem. The most **crucial problem** is to find dedicated people to work in that in Sweden there are specific smart contract developers."	"I serious things to talk about. It's not just, you know, a private person doing whatever they want with their own money, so to speak, but they won't evolve this we do have to have specific **legal frameworks** specifically for blockchain. So the GDPR framework in the European Union is **not enough**."

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