Leveraging Blockchain in the Certification Process in the Higher Education Sector

A thesis is submitted in partial fulfilment of requirements for the degree of Doctor of Philosophy

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Declaration

The work described in this thesis carried out in the school of Engineering and Informatics, I hereby declare that this thesis has not been and will not be submitted in whole or in part to another University for the award of any other degree.

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Abstract

The educational system in Saudi Arabia has improved enormously by many means, including the adoption of new education programmes and research and development initiatives. Recently, the higher education sector in Saudi Arabia has emerged as one of the fields in which investments in blockchain-based systems and services are desirable. Distributed ledger technologies, such as blockchain technology have recently gained prominence as it is considered a technological revolution. Yet, with all these facts, there are a variety of issues and important changes occurring in Saudi higher education, in terms of its capacity, research impacts, international links and graduate outcomes. Accordingly, the research selected the education sector that has emerged as one of the fields in which investments in blockchain-based systems and services are desirable, specifically in developing countries.

This research aims to leverage blockchain-based technology in higher education systems in Saudi Arabia, particularly the 'certification process', which is the process of generating and verifying learners' certificates. The focus of this research is on investigating secure, acceptable blockchain-based certification systems that certainly increase awareness about the huge importance of this revolution. This includes the influential factors for users accepting the system and proposing a Decentralized Application for Smart Certificate (DASC).

The users' acceptance of this idea and system is examined using a proposed novel conceptual model indicating the main influential factors affecting user acceptance. To develop the conceptual model, the author first reviewed the extant and commonly used theories in analysing the acceptance usage of technologies along with the nature of blockchain component-related literature to identify the main factors surrounding blockchain technology adoption. This research consists of two main studies. The first study investigated the target user's acceptance of the adoption of blockchain in the certification process of the higher education sector. The second study is an experimental study to test the proposed smart certificate system's prototype (DASC) by collecting target users' feedback.

This research focused on blockchain as an innovation that offers a new paradigm for data integrity, reliability, and authenticity in the certification process in higher education sector. This research supports the Saudi Arabian vision that seeks to build an education system that satisfies market needs and provides sustainable technological opportunities for educational systems. Thus, this thesis proposes an architectural design for validating and sharing a certification system that will guarantee the authenticity of shared higher education certificates by providing high privacy and security aspects in a blockchain network. The contributions of this research will enhance the idea of deploying blockchain in the higher education sector in developing countries, which is expected to be beneficial as it solves some existing issues with the certification process. This research has made several key contributions, including a novel conceptual model to identify the key factors that affect the user's acceptance of adopting blockchain in the certification process. Consequently, in terms of the theoretical implications, this research emphasises the significance of such hypothesized relationships when performing empirical research in the blockchain technology context.

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Publications

The following papers have been published as a direct result of the research discussed in this thesis:

- M. Alshahrani, N. Beloff, and M. White (2020), "**Revolutionising Higher Education by Adopting Blockchain Technology in the Certification Process**," in *2020 International Conference on Innovation and Intelligence for Informatics, Computing and Technologies, 3ICT 2020*.
- M. Alshahrani, N. Beloff, and M. White (2021), "**Towards a Blockchain-based Smart Certification System for Higher Education: An Empirical Study**," *Int. J. Comput. Digit. Syst.*, Aug. 2021.
- M. Alkhammash, M. Alshahrani, N. Beloff, and M. White, (2022), "**Revolutionising the Approach to Smart Campus Architecture through IoT and Blockchain Technologies**", in *Transformations through Blockchain Technology.*
- Aleisa M.A.,Alshahrani M, Beloff N., White M. (2022), **"TAIRA-BSC - Trusting AI in Recruitment Applications through Blockchain Smart Contracts,"** in *2022 IEEE International Conference on Blockchain (Blockchain-2022).*

Glossary

HEI	Higher Education Institutes
HE	Higher Education
DASC	Decentralised Application for Smart Certificate
DLT	Distributed Ledger Technology
MOOCs	Massive Open Online Courses
TAM	Technology Acceptance Model
DOI	Diffusion of Innovation
UTAUT	Unified Theory of Acceptance and Use of Technology
GUI	Graphical User Interface
IoT	Internet of Things
AI	Artificial Intelligence
TU	Trust
FT	Functionality and Transparency
KU	Knowledge and Usability
EAS	Easy to Access and Share
AW	User Awareness
EF	Efficiency
SI	Social Influence
SP	Security and Privacy
FD	Fraud and Dishonesty
GPA	Grade Point Average
ICT	Information and Communications Technologies
DLS	Distributed Ledger System
API	Application Programme Interfaces
ACL	Access Control List
TAIRA-BSC	Trusting AI in recruitment applications through the use of Blockchain Smart Contracts

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Chapter I

1 Introduction

Saudi Arabia is a young, developing nation with a high percentage of young people in the population, where around 40% of the population are below the age of 25 (GASTAT, 2020). Therefore, the government are interested in using higher education to improve the economy and young people's employability. In order to implement this, the current systems in the higher education institutes (HEIs) in Saudi Arabia use the central database technology that is hosted and controlled locally by the IT professional in the institutes (Mukthar & Sultan, 2017), (Tashkandi & Al-Jabri, 2015). However, one of the main problems with these systems is the authentication of the students' certificates and credentials and the employment process is considered as time-consuming transactions that require a lot of effort. Also, the HEI systems do not allow the sharing any of the students' records with any party.

Blockchain technology can be considered a good candidate to resolve these current problems with the certification process in HEIs. Due to the growing interest in distributed ledger technologies such as blockchain, researchers in different areas, including the higher education sector, are investigating possibilities surrounding blockchain adoption. Despite this, no guiding framework has been developed for the application of blockchain and related technologies in the use of certificating systems that issue sharable and authentic student credentials. Existing certificating systems are marked by their lack of speed and low reliability, and, in certain education systems, they produce some integrity issues such as dishonesty (Alogali, 2015), (Hamdan et al., 2018). Therefore, this research offers an investigation of blockchain adoption in this field, focusing especially on the process of producing and sharing higher education certificates.

Moreover, the issues become even clearer when it comes to the process of transferring HE students internationally, where the systems for maintaining the students' records, and certification systems themselves are completely different The process of granting recognition to a degree from a foreign university is known as nostrification; and entails the student having the academic transcript translated into the language and in conformity to the standards of other schools or HEIs, which usually has to be done be authorized organizations, especially for foreign universities (Rauhvargers, 2009).

Blockchain technology can be described as a distributed record of digital events stored across all the participating computers in a linked chain (Nakamoto, n.d.), (Lu, 2019). The blockchain relies on peer-to-peer (P2P) network transactions (Conoscenti et al., 2016). According to Chen et al., blockchain technology is considered as the fourth major invention of the industrial revolution after the steam engine, electricity and information technology and they have named it "The Internet of Value Exchange" (Chen et al., 2018). Blockchain has proven to have a powerful impact on various environments and fields, and the educational sector has recently invested in blockchain-based services (Sharples & Domingue, 2016),(Tapscott & Tapscott, 2017). This proposed research is about leveraging the current higher education systems in Saudi Arabia by adopting blockchain-based technology, specifically, in the process of generating and verifying the learner's accreditations. Recently, the education sector in the Kingdom of Saudi Arabia has emerged as one of the fields in which investments for blockchain-based systems and services are desirable. This has been one of the main direct investment policies featured in Saudi Arabia's Vision 2030 which education sector is considered as a key driver to advance development (KSA MEP, 2018).

As Masaaki Isozu, President of Sony Global Education, said "Blockchain technology has the potential to impact systems in a wide variety of industries, and the educational sphere is no exception when educational data is securely stored on the blockchain and shared among permissioned users (Armonk & Tokyo, 2017). Since 2013, the glamour of blockchain has drastically increased and more interested parties have started to investigate this revolution (Yli-Huumo et al., 2016). The lack of studies in adopting blockchain technology in the field of education is considered as a driving motivation for this research. Deploying blockchain technology to facilitate processes in the education system will increase awareness about the huge importance of this 'revolution'. In the Saudi context, the higher education system can greatly benefit from using blockchain in many of the services provided to the learners and academic staff. Consequently, this research supports the Saudi Vision 2030 in its aim to build an education system that satisfies the market needs and provides sustainable opportunities for the marketplace.

1.1 Background

This section discusses the main background aspects of this research that leads to better understanding of the rationale behind this research. It involves explaining the situation of the higher education sector in Saudi Arabia which is the context of this research. Moreover, it comprises a brief introduction about blockchain technology and the background about the Saudi Higher Education sector that is the basic context for this research.

1.1.1 Blockchain Technology

Blockchain technology has had a powerful impact in various fields in the last few years. Blockchain is a novel that offers a new paradigm for data integrity, reliability, and authenticity in the finance industry and beyond. Previous studies (Rocha & Ducasse, 2018), have noted that the major motivation to deploy blockchain in various fields is that it is considered trustworthy technology that removes the centralisation barrier in transactions between network participants in various industries. In this way, blockchain eliminates the need for a central authority to store and approve network transactions. For this reason, deploying blockchain in the higher education sector is expected to be beneficial as it solves some existing issues, such as printed certificate fraud, the cost of issuing certificates and the time needed to verify issued certificates (Curmi & Inguanez, 2020). However, the extant literature lacks a guiding framework for the integration of blockchain and other relevant technologies in the use of certificating systems that issue authentic and sharable student credentials.

1.1.2 Saudi Arabia: Higher Education Background

The educational system in Saudi Arabia has been improved enormously in many ways including the adoption of new education programmes and research and development initiatives. One of the main goals of Ministry of Education in Saudi Arabia is to develop an integrated services system which supports the education process by raising the efficiency of performance and adopting modern support technologies (MOE, 2017). The number of Saudi universities have gradually increased from ten universities in 1999 to twenty-six public universities in 2017. The number of universities is expected to grow in anticipation of the drastic increase in population to 35.9 million by 2020, in comparison to 29.2 million back in 2012 (Statista, 2018). The number of university students in Saudi Arabia grew to reach about 1.7 million students in 2016, whereas in 2009 the number of students was 850,000 and less than 650,000 in 2006. These facts demonstrate that there are variety of important changes occurring in Saudi higher education, in terms of its capacity, research impacts, international links and graduate outcomes (ICEF, 2018). In the Saudi's Higher Education sector, using systems based on blockchain technology will help the universities and colleges to improve the services provided to their students and in turn this will add value to the society. Such systems will allow the learners and prospective employers to have a complete picture about a learner's achievements, skills and potential.

The goal of my research is to encourage the implementation of digitally decentralized certification systems, where the learners have their continuous record of achievements. I argue that this can be achieved by adopting a blockchain based system where the adoption of such new and innovative technology would significantly benefit learners and alumni; and this dissertation will demonstrate its applicability. While the higher education sector in Saudi Arabia pursues adopting new technology, there are, in fact, significant challenges and barriers associated with using blockchain-based technology in higher education systems. This research focus on emphasising these challenges along with the perceived benefits of blockchain in the education sector.

1.2 Research Problem

In Saudi's higher education systems, the current procedure of generating and verifying certificates and transcripts has some issues that need to be solved and opportunities that need to be obtained. Starting with the learner's accreditations, transcripts and certificates being generated as hard copies, which means that it is a long time before these documents are received by the learners. Also, it could mean that the academic transcript might be missing a description of the skills achieved by the learner during his/her study; and this could include creativity, motivations and leadership potential.

Blockchain can be the solution to solve all the problems mentioned above as characterising the current educational system in the higher education institutes. Building an educational platform based on blockchain will inherit all the features of this technology. Such a platform would allow learners to have transparent and accountable digital records of their academic achievements and the ability to share them with the network of appropriate parties including school administrators, other educational institutions, and prospective employers. All the learner's trusted records and achievements would be verified by the institute which generated that record. In addition, a blockchain platform allows the user to post their ideas and notes on the chain; and they can use this feature to copyright their ideas and keep them timestamped and archived.

By using a blockchain platform, the learners will be able to keep authenticate records for all their accreditations whereby the platform can be used as a permanent e-portfolio of their intellectual achievements. This system mitigates against dishonesty and helps both the learner and employer (Sharples & Domingue, 2016). Blockchain technology could benefit the educational system in many ways, including hosting a register of courses, receiving certificates, awarding accreditation and holding information about certification by other educational institutes (which may represent as 'badges')(Grech, Camilleri, & Inamorato dos Santos, 2017).

1.3 Research Questions

The **Overall Research Question** for this research that will be answered by conducting this study is as follows:

RQ. How can the certification systems in Saudi's HEIs be enhanced by leveraging the decentralised ledger technology embodied by blockchain technology to generate more immutable and transparent Smart certificates?

In order to answer this broad question, the researcher defined the specific questions that help to provide a complete answer to the overall research question; and that are mapped with the thesis chapters in Table 1.1.

SQ1- What research topics have been addressed and studied in current research on blockchain-based technologies utilised in higher education, including the benefits brought by blockchain technology to resolve the current problems in the higher education sector?

SQ2- What are the influential key factors affecting the user's intention to adopt blockchain technology for the certification process in the context of Saudi Arabia?

SQ3- What are the issues and problems in the current higher education systems that could be solved by a blockchain-based system?

SQ4- What are the logical and functional requirements for the architecture model for the Decentralised Application for Smart certificates (DASC)?

SQ5- How can testing a blockchain-based certification system improve the user acceptance towards the adoption of blockchain technology in the certification process?

Table 1.1. Mapping Research Questions with Thesis Chapters

Overall Research Question (RQ)	***Sub questions***	***Matching the Thesis Chapters***
	SQ1	Chapter 2: Comprehensive Analysis of the Current studies
	SQ2	Chapter 3: Conceptual Model and Influential Factors
	SQ3	Chapter 4: 1st Study- Survey: Current Systems Issues
	SQ4	Chapter 5: The prototype DASC
	SQ5	Chapter 6: 2nd Study- Testing and Evaluating DASC

In the following chapters, each research question will be addressed; and then, the last chapter of this thesis will summarise the findings of all the aforementioned research specific questions.

1.4 Research Scope

This research is focused on examining and analysing the adoption of blockchain technology on the certification process in the HEIs in Saudi Arabia, specifically in two academic institutes in Riyadh, the capital city. In particular, it emphasizes how blockchain, as cutting-edge technology, can leverage higher education from the perspectives of three main stakeholders, namely:

- Higher education students
- Top-management in academic institutes (KSU and IMSIU Universities), and
- Prospective employers in the marketplace.

This research investigates the certification process that is responsible for generating and authenticating the students' credentials and certificates. Moreover, the scope of this research involves investigating and analysing the influential factors that influence those stakeholders' intention to adopt blockchain technology for the certification process before and after they test the prototype DASC developed in this study as a proof-of-concept.

1.5 Research Objectives

This research aims to leverage blockchain-based technology in higher education systems in Saudi Arabia, particularly the ‘certification process’, which is the process of generating and verifying learners’ certificates. This process can be described as providing a fully authenticated picture of students’ achievements and potential; whereby a student’s profile can act as a continuous record of his/her achievements. The blockchain-based certification system will provide users with the ability to launch immutable data and transactions controlled by parties with authorized access. Once the data has been posted in the blockchain, all the parties can see it with the guarantee that no alteration can be made to the block thereafter. The sharing of the student’s data on the private blockchain network will require obtaining their permission before the data can be accessed by other users on the network, such as ex-employers or other HEIs. Moreover, this study aims to identify what topics have been already studied and addressed regarding the use of blockchain in the higher education sector. Also, this study will also expose the success factors, opportunities and challenges influencing Saudi universities’ adoption of blockchain technology.

The objectives of this research are as follows:

RO 1. Studying the current state of the art in Distributed Ledger Technology (DLT) research along with the existing studies and systems; including deeply researching blockchain technology and outlining all the key concepts and relevant terminology.

RO 2. Investigating the existing certification systems from the perspectives of students, employers, and top managers in the academic institutes.

RO 3. Clarifying the issues and problems involved in the process of generating and verifying the students’ certificates in the field of higher education.

RO 4. Exploring the challenges from the point of view of the students, employers and top managers in the academic institutes, regarding the adoption of a blockchain-based certification system.

RO 5. Developing a novel conceptual model showing the influential factors affecting the user’s intention to adopt blockchain technology for the certification process. Users include higher education students, prospective employers, and top managers in the academic institutes.

RO 6. Proposing a Decentralised Application for Smart Certificates (DASC) as a proof-of-concept for the adoption of blockchain in certification systems.

The proposed blockchain-based student certification system is aimed at addressing these existing problems. Specific higher education institutes in Saudi Arabia were used as a case study to present a certificate validation and sharing framework that guarantees authenticity through leveraging the privacy and security features of a blockchain network.

1.6 Research Contributions

Blockchain technology is an innovation that has been adopted by various domains and higher education is one of the fields that aims to reap the benefits of the features of DLT. The previously mentioned research problems and motivations for adopting blockchain technology to solve them all support the rationale for this research. This study provides new knowledge about blockchain adoption in developing countries as the case study involves users from Saudi Arabia. The following section details the contribution to knowledge provided by this research, which includes developing and testing the DASC prototype.

1. **The proof-of-concept blockchain-based prototype system for higher education institutions in Saudi Arabia was developed:** The major contribution of this study is to propose a DASC prototype for leveraging the higher education field with blockchain services. Provision of the DASC prototype will involve providing an architecture model for a distributed and shareable system for HEIs' certificating systems that could satisfy the requirements of students, prospective employers and HEIs. This solution includes all the following features: Firstly, it records the learner's data, and shares these data with all the authorized parties including college and university administrators and prospective employers. Also, it verifies all the learner's certificates, achievements, and the earned training courses. The DASC aims to provide prospective employers with a clear picture of the learners' capabilities allowing prospective employees to be more efficiently matched to the employers' needs. Moreover, it will help colleges and universities in Saudi Arabia to share data about the learner's skills and abilities so that teaching staff can more easily design and implement unique teaching methods for each learner. This research contribution has been published in peer reviewed conference (Alshahrani, Beloff, & White, 2020). Finally, the DASC is considered as single repository of information that

may consolidate learners' digital certificates, transcripts, and achievements (represented as 'badges') from different educational institutions.

2. **The conceptual model was proposed for showing the influential factors for the adoption of blockchain by higher education in the context of Saudi Arabia:** The focus of this model is to address the issue of obtained credits for all the learner's completed academic achievements not only on the certificates issued. The factors influencing adoption of blockchain in this context have been inherited from the extant and commonly used theories in analysing the acceptance of technologies including: the Technology Acceptance Model (TAM), the Diffusion of Innovation (DOI) theory and the Unified Theory of Acceptance and Use of Technology (UTAUT). Moreover, to develop the conceptual model, the authors first studied the nature of blockchain component-related literature to identify the potential factors surrounding blockchain technology adoption. This involves incorporating factors that have not been previously considered in the technology acceptance models mentioned above.

   2.1. **The factors that affect the user's acceptance of blockchain-based certification systems in the context of Saudi HE was validated:** This is the result of the 1st study of this research which was designed to collect data from the users (students, prospective employers, and top managers in academic institutes). This part of the research contributes to investigating the key factors influencing the users' acceptance and intention to adopt blockchain technology in the certification process. The findings for this contribution are illustrated as the revised conceptual models in Chapter 4 and have been published in peer reviewed journal (Alshahrani, Beloff, & White, 2021).

   2.2. **The influential factors of user's behaviour towards intention to adopt a blockchain-based certification system after testing the prototype DASC were measured:** This is the finding for the 2nd phase of the study, which investigates the same influential factors from the user's perspectives after they experienced the proposed proof-of-concept prototype DASC. This part contributes by measuring the factors affecting the user's intention to adopt a blockchain-based certification system after they tested the DASC and comparing these results with the findings from the 1st study. The findings for this contribution are illustrated in the revised conceptual models in Chapter 6.

3. **The Methodological Contribution:** The methodological contribution in the thesis is the use of mixed-method design to investigate and test the area of user's acceptance of innovative, complex, and not easily understandable technology. This research sought to collect and analyse data from potential users for the proposed blockchain-based certification system as it proposed a systematic framework for technology acceptance among different types of users. Involving the most critical users in the certification process, namely students, top management, and employers, represents the comprehensive approach to investigating the impact of the proposed framework. This framework was gauged in the research instruments (questionnaires and interviews) that involved items that measure the proposed hypothesised relationships and significant aspects of the proposed factors to assess their influence on the targeted users. In view of the research method, the study is expected to use questionnaires under the quantitative approach and interview analysis under the qualitative approach.

   Using the qualitative approach will allow the researcher to validate data on quantitative grounds. Moreover, taking the qualitative research approach will also allow the researcher to validate the data from past papers and observational analysis. Using the mixed method approach significantly contributes to the study by adding reliability to the study by covering each method's limitations. Additionally, a questionnaire for before and after testing of the porotype has been collected and analysed from the perspective of employers as the main driver of this research, as adoption of this system would potentially enhance the employment process. This methodology might be useful for future research in areas such as the use of medical devices in-home use like smart sensors, improvement of the manufacturing process with the adoption of new complex technologies and maintaining workers' feel about and more examples in the context of new unfamiliar technologies that have been introduced to the process which users beforehand performed it somehow differently.

4. **Fitting the specific blockchain case scenario to the broader context of Smart Campus:** A 'Smart Campus' is a physical or digital environment in which humans and technology-

enabled systems interact to create more immersive and automated experiences for university stakeholders (Jones, n.d.). This contribution includes developing a comprehensive guiding framework for emerging IoT and blockchain technologies deployment in the smart campus environment, particularly in relation to security and privacy aspects, as well as to the mitigation of known problems with IoT and blockchain in existing applications. This study proposes a novel architecture framework for the IoT and blockchain applications deployed within a smart campus environment, comparing the main technologies involved; it has been reviewed and published in (Alkhammash, Alshahrani, Beloff, & White, 2022). To sum up, it demonstrates how Blockchain technology fits in a bigger domain and different scenarios.

1.7 Thesis Organization

The following section explains how the thesis is organized to demonstrate the process of conducting the research and creating and evaluating the conceptual model and the DASC prototype in order to answer the research questions and make a contribution which fills the knowledge gap identified. Each chapter in this research will be briefly outlined along with the major tasks undertaken in each one.

Chapter One: Introduction

The introduction chapter introduces the research area and briefly addresses the background of this research. It explains the research problem behind the research topic as well as the rationale for conducting the empirical study. Further the research aim, objectives and research questions were discussed along with clear mapping of the research questions onto the thesis chapters. Also, this chapter emphasises the significance of the research and contribution to knowledge. Lastly, the outline of this study is represented.

Chapter Two: Literature Review

The second chapter discusses the research background, technical concepts, components, theoretical models and existing systems from previous studies that are related to the research topic and problems. Also, it includes an intensive survey of the current blockchain technology platforms involving the recent and updated features in the DLT domain. The literature regarding the existing and developing blockchain-based systems in various fields and domains beyond the financial field is reviewed and critiqued. Moreover, this chapter provides the reader with a good background about the well-known technology acceptance models and theories that are the base infrastructure for the proposed conceptual model.

Chapter Three: Research Methodology, Model and Hypotheses

Chapter three discusses the methodology adopted for the execution of the current research. The discussion includes an overview of the various research designs available; their philosophical assumptions and the rationale behind the researcher's choices. The selection of the case study; empirical data collection and analysis and the adopted strategies for ensuring the reliability and validity of the data are described. The detailed steps taken to analyse the collected data in the two studies in this research are also provided. The chapter additionally describes how the information was stored and the ethical considerations followed to conduct the study.

Chapter Four: User perceptions regarding intention to adopt and accept blockchain technology

This chapter discusses and analyses the empirical data collected from the students, top managers in academic institutes and prospective employers, in relation to the proposed conceptual framework. Empirical data is analysed through various stages including descriptive statistics, and inferential analysis. This chapter includes the findings used to evaluate the hypothesised relationships between the proposed influential factors and the users' intention to adopt a blockchain-based certification system that are supported by the interview data collected from the top managers in the academic institutes. Moreover, it presents the revised conceptual models for the students' and employers' samples along with a summary of the supported research hypotheses to show the strength and the direction of each relationship.

Chapter Five: DASC Architectural Design

This chapter explains the architectural design of the DASC that is proposing to solve the current issues with the certification process and investigate the potential for the adoption of blockchain technology. This chapter addresses the structure of the Decentralised Application of Smart Certificates (DASC), its components and its logical representations that are specifically designed to support efficient smart certificates for the higher education institutes. It highlights a proposed solution to overcome current problems in the field of higher education, especially in the certification process.

Chapter Six: Testing DASC and evaluating the user's intention to adopt blockchain

Chapter Six includes the findings and discussion from the analysis of the collected data after the users have experienced a prototype DASC. It discusses and analyses the empirical data collected from the students, top managers in academic institutes and prospective employers in relation to the proposed conceptual framework in order to assess the significance of the factors. The users in this phase have experienced testing the prototype DASC to emphasis the main functionalities that are provided by a blockchain-based certification system. Empirical data are analysed through various stages including descriptive statistics, and inferential analysis. Furthermore, it presents the revised conceptual models for the students' and employers' samples along with a summary of the supported research hypotheses to show the strength and the direction of each relationship.

Chapter Seven: Conclusion and Future Work

The last chapter of this thesis includes a conclusion for the entire research findings. It shows how the research findings answered the main research question and achieved the aim and objectives of the research. Moreover, this chapter contains a discussion on the novelty of the developed conceptual model and the critical factors it identifies, the proposed DASC, and the contribution to knowledge. This chapter also addresses the recommendations derived from the results and which guide future implementation. Also, potential future work that involves the actual implementation of DASC and AIBSC is suggested. In addition, the author indicates how the study could be developed in further research. The author concludes by addressing the recommendations for future studies extended from this thesis.

1.8 Summary

This chapter has provided an introduction to this research along with a brief background of blockchain technology. Furthermore, the research problem and the motivations that drive this research have been addressed. Moreover, the chapter illustrates how the overall research question and sub questions to be addressed are followed throughout this thesis. The aim and objectives of this research have been presented, and the contributions to knowledge made by the research have been discussed. Finally, the whole thesis design and structure has been briefly provided along with a description of each chapter.

Chapter II

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2 Literature Review

This chapter aims to present the current literature review on the subject and has been divided into six main parts. The first part addresses blockchain definition, history, domains, types, architecture, characteristics, benefits and challenges. Then, in the second and third parts blockchain technical infrastructure and platforms are discussed in detail to cover the most recent research. The fourth and fifth parts of this chapter emphasize the current literature about using blockchain technology in the field of higher education along with details of successful applications of systems in education based on based on distributed ledger technology (DLT). Moreover, this chapter includes a detailed exploration the known models and theories about new technology adoption.

2.1 Blockchain Background

Blockchain technology, although commonly associated with cryptocurrencies, has had a tremendous impact among many other distributed applications domains. Blockchain characteristics, such as the distribution of data storage among independent nodes and the use of consensus algorithms offering immutability and transparency, remove the need for a central authority and make blockchain a trustworthy technology. Most features associated with blockchain are related to the concept of providing transparent and secure applications. Such technology helps protect blockchain-based applications from any tampering with transaction data, while also providing many other features and solving numerous system problems (Rahmadika & Rhee, 2018). The following section discusses in detail the concepts and nature of blockchain technology from the existing literature review.

2.1.1 History, Concept and Definition

Blockchain Technology is recognized as a revolutionary invention that can be described as a distributed record of digital events stored across all the participating computers in a linked chain. The blockchain relies on peer-to-peer (P2P) network transactions (Conoscenti et al., 2016). According to Chen et al., blockchain technology is considered the fourth industrial revolution after the invention of the steam engine, electricity and information technology, and is named 'the Internet of Value Exchange' (Chen et al., 2018). Since 2013, the attractiveness of blockchain has drastically increased and more interested parties have started to investigate this revolution (Yli-Huumo et al., 2016). As stated by Gartner (Panetta, 2018), the business value-add of blockchain will grow from slightly more than $360 billion by 2026, to reach around $3.1 trillion by 2030.

Blockchain has proven to have a powerful impact on various environments and fields, and the educational sector has recently become one of the desired fields for investment in blockchain-based services. The blockchain technology revolution has recently become a very rich research topic for both academic and industrial fields. Blockchain started with the concept of creating cryptocurrency: mainly, Bitcoin. Bitcoin is defined as a decentralized digital currency that is formed by the public transaction ledger known as blockchain (Kondor et al., 2014). In 2008, blockchain was invented by Satoshi Nakamoto, and was also known as distributed ledger technology (DLT) (Chen et al., 2018). The ledger is stored on all the peers on the network, and relies on peer-to-peer network technology. This way, blockchain is considered a DLT. Therefore, we can consider the blockchain as a series of blocks which in total maintain the complete transaction records in a named public ledger (Zheng et al., 2017).

Blockchain technology is considered one of the most rapidly developing technologies in the last few years and is known as the main technology for bitcoin cryptocurrency. Blockchain is identified as a distributed database that is shared between a peer-to-peer network, where all the participants need to agree for a new block to be added to the chain (Sharples & Domingue, 2016). Current research shows that blockchain applications are not applied only for cryptocurrencies. Blockchain technology can be used in many other environments and domains where there are several transactions performed and maintained. Blockchain technology's main goal in any domain is to launch a decentralized environment that eliminates the presence of any third party that may control the transactions and data (Yli-Huumo et al., 2016).

According to Chen et al., the development of blockchain can be divided into three stages: Blockchain 1.0, 2.0 and 3.0. Blockchain 1.0, the first stage was about developing a digital currency called bitcoin as a first innovation of blockchain based technology cryptocurrency's application (Golosova & Romanovs, 2018). Until now, Bitcoin is considered as a popular application among the different blockchain-based technologies (Yli-Huumo et al., 2016). According to Zheng et al., Bitcoin's capital market has reached 10 billion dollars in 2016 and gained a huge reputation among currently used cryptocurrencies (Zheng et al., 2017). Blockchain 2.0, observed the expansion toward using blockchain in other financial applications, such as cash transactions, stocks, bonds, loans, smart property and smart contract. Blockchain 3.0, is the current incarnation as more environments and areas have been developed under the blockchain infrastructure. The developers for this stage have tried to understand the concept of Bitcoin as a blockchain-based application and applied it in other fields (Chen et al., 2018). As stated by Golosova and Romanovs, (2018), over the past years the history of blockchain has witnessed five innovations namely: Bitcoin, blockchain expanded into other fields, smart contracts, Proof-of-Stake as a consensus algorithm and blockchain transactions scalability with keeping the security aspect maintained.

2.1.2 Blockchain Types and Domains

There are three main types of blockchains: public (permissionless), private (permissioned) and consortium blockchains (Turkanović et al., 2017), (Zheng et al., 2017). In a public blockchain, any participant can access and add to this permissionless blockchain where all nodes are allowed to join the blockchain network e.g. Bitcoin and Ethereum blockchains (Turkanović et al., 2017; Neudecker & Hartenstein, 2018). In this kind of blockchain, developed cryptographic methods are used to protect the network data and transactions (Zilavy, 2018). All the participants in this type of blockchain could have roles in creating a consensus with the idea of keeping all records of the chain visible to all the network's nodes (Zheng et al., 2017). Furthermore, public blockchain depends on a shared public ledger stored among all the network nodes. Any participant can join the blockchain and validate the blocks, and these are called 'miners' (Boudguiga et al., 2017).

Miners are defined as any network participant (user) who tries to solve the complex mathematical problem necessary to validate a transaction and add it as an encrypted block to the chain. They also show the 'proof-of-work' for this addition (see a more detailed discussion of this in the section on consensus protocols) (Boucher et al. , 2017). While the nature of public blockchain is to be open to all the participants, the anonymity of the nodes should be maintained by encrypting some of the chain transactions (Turkanović et al., 2017; Zheng et al., 2017).

However, public blockchains depend on computationally advanced version of consensus, scalability and the amount of transactions per second (TPS) in these kinds of blockchain are still low, which is considered as a main threat to industry uses (Zilavy, 2018).

The private blockchain is considered as a centralized network controlled by one organization where only predefined list of participants can access and make transactions in the chain. Private blockchain has been defined by IBM as: 'Blockchain where an invitation to participate is required and which must be validated by either a network starter or by an agreed and accepted form of consensus.'(Zilavy, 2018). As stated by Zilavy, (2018), Hyperledger Fabric is one of famous private blockchain that is known to be supported by IBM. Consortium blockchain is a type that combines public and private blockchain. The participants of this blockchain are predefined nodes which will be able to use and participate in the distributed consensus process (Turkanović et al., 2017; Zheng et al., 2017).

Private and consortium are both considered as permissioned blockchains since they cannot be used by any node except the invited ones. On permissioned blockchain, most of the transactions are 'off-chain'; where the transaction occurs on the network but without being stored on the blockchain. The benefit of using this type of blockchain is scalability. Since permissioned blockchain depends on a predefined list of nodes, they can maintain the increase of the transactions by scaling up the computing power (Golosova & Romanovs, 2018). Moreover, permissioned blockchains may prefer some consensus algorithms which are different to those in permissionless blockchains (Zheng et al., 2017).

2.1.3 Blockchain Technical Architecture

Blockchain technical architecture provides a basic understating of how blockchain technology performs its transactions. To understand the concept of blockchain the researcher first need to break it down to clarify the meaning of 'block' and 'chain'. Blockchain consists of series of blocks where each block represents digital information. The complete linear sequence of the blocks record all the transactions that have happened on the network to be added to the chain at regular intervals to eventually form a (usually) public ledger (Zheng et al., 2017) , (Golosova & Romanovs, 2018). In the chain, each block acts as parent block for the succeeding block, except the first block in the chain, which is called ' the genesis block' and has no parent block (Zheng et al., 2017). Furthermore, a block holds other information such as, the hash value of the previous block (parent), time stamp, block reward, block number, Merkle Tree root hash, and Nonce (Rahmadika & Rhee, 2018). The way the blocks structure in the blockchain allows a group of transactions to be simultaneously validated (Dini, Hirsch, & Carboni, 2018a). As shown in Figure 2.1, the block structure contains of all the above information.

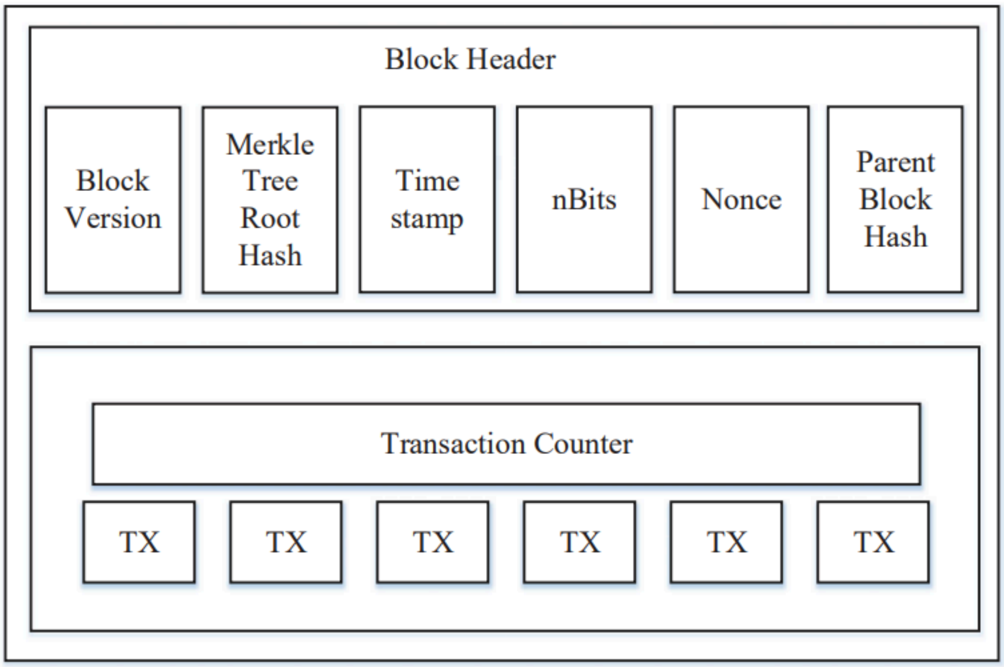

Figure 2.1 Block Structure (Zheng et al., 2017)

In blockchain a node is defined as any computer that installed by a core blockchain client and which controls a modified full version of the chain ledger (Turkanović et al., 2017; Zheng et al., 2017). In a blockchain decentralized environment, each node in the network has a copy of the transactions, which embodies the concept of authenticity, security and accuracy (Chen et al., 2018; Rahmadika & Rhee, 2018).

2.1.4 Blockchain Characteristics and Properties

The blockchain revolution has reached huge importance in both industry and academic fields due to its features and properties that could support numerous domains. According to different literature researches, there are three main characteristics for blockchain technology namely, immutability, decentralization and traceability.

Blockchain's **immutability** (**unchangeable**) property means the inability to alter or remove the content of any block in the ledger after the consensus has been agreed and content has been posted in the chain (Rahmadika & Rhee, 2018; Zheng et al., 2017). As stated by Chen et al., (2018) there are two explanations for knowing blockchain technology is immutable. First, recording transactions in the chain is linked with the same hash key that links the parent block with the child block. As result, any manipulating or altering of any transaction would be easily identified by all the participants (nodes); given that these nodes are definitely using the same validation algorithm. Secondly, blockchain is DLT means every node in the network has a copy of the public ledger simultaneously synchronized among all the nodes. In order to attempt successful altering to any transaction, at least 51% of the stored ledgers have to be changed (Chen et al., 2018).

The second main characteristics of blockchain is known as decentralized technology. **Decentralisation** eliminates the existence of centralized organizations that conduct all the processes of transaction validation, storage, maintenance and transmission on blockchain (Chen et al., 2018). The blockchain builds based on the structure of distributed system with the lack of any central controlling party to rely on (Yli-Huumo et al., 2016). As a consequence of this structure, It is possible to place trust in transactions among the nodes on the blockchain as all of these can be clearly seen by all the participants that are done throughout mathematical methods (Chen et al., 2018).

According to Chen et al., (2018) **traceability** is another major characteristic provided by the DLT. Traceability is the ability to trace and follow the linked blocks by their hash keys. The reason behind this trackable feature of the transactions in the chain, is the sequential order of transactions that guarantees each block is connected to two other blocks (Chen et al., 2018; Zheng et al., 2017; Golosova & Romanovs, 2018). The blockchain's properties are not limited to the features mentioned above. It is important to mention, that blockchain brings transparency to each and every data block added to the chain (Armonk & Tokyo, 2017).

2.1.5 Blockchain Benefits

The aforementioned blockchain characteristics indicate some of the beneficial impact of using of this technology. According to Sharples and Domingue, (2016) and Yli-Huumo et al., (2016), some of the major benefits that blockchain is perceived to offer are trustworthiness, anonymity, immutability, authenticity, reliability and accessibility. In blockchain-based systems the ability to store more data and share resources among all the participants suggest that these systems are flexible, secure and resilient (Turkanović et al., 2017). Some of these benefits have already been mentioned above as blockchain characteristics.

- **Trustworthiness and Reliability**

Using blockchain technology in transactions guarantees trustworthiness (Armonk & Tokyo, 2017). Most features of blockchain technology are related to the provision of transparent and secure applications. Such technology helps to protect the data from possible tampering, beside providing many features that solve numerous systematic problems (Rahmadika & Rhee, 2018). Trust plays a major role in guaranteeing the quality of users' interactions in any network. In order to adopt an innovative technology, guaranteeing trust relies on impressive architecture.

In blockchain technology, the distributed nature and delegation of control of this innovation plays a huge role in guaranteeing users' trust in blockchain in various contexts (Dini et al., 2018a). Moreover, reliability is considered as one of the main advantages of using blockchain-based technology. Blockchain uses consensus protocols (e.g. the proof-of-work consensus algorithm) to ensure reliable transactions before adding a new block to the chain (Watanabe & Fujimura, 2015). The developers and users' enthusiasm regarding blockchain technology comes from the fact that databases' integrity do not need any cryptographic guarantees (Halpin & Piekarska, 2017).

- **Anonymity**

Anonymity in blockchain means hiding the user's identity inside the network. In the blockchain transactions, each participant is given a unique address to interact with the other users without knowing the user's real identity (Zheng et al., 2017). Therefore, users are anonymous when they interact in the public ledger and could be identified by a digital ID. Anonymity plays an important role in the encouragement of business beneficiaries and other domains participants to use blockchain technology.

- **Accessibility**

The nature of blockchain technology-based applications provides a clear picture about all the completed transactions in blockchain. These transactions are shared and accessible for all the network nodes which exemplify the meaning of accessibility as advantage of using blockchain technology. Moreover, such feature distinguish the transparency of decentralized systems over the centralized ones (Yli-Huumo et al., 2016).

- **Security and Integrity**

Blockchain has the advantage that data stored in the public ledger cannot be replaced, deleted or altered once the nodes have authorized the data; and because of this blockchain is also identified as an innovation that has security and data integrity (Yli-Huumo et al., 2016).

- **Cost and efficiency**

By utilizing blockchain technology, any transaction can be efficiently completed in the decentralized environment. Moreover, using blockchain reduces overall cost and enhances transaction efficiency, by decreasing transaction fees and the time required to execute the transaction (Zheng et al., 2017). Blockchain technology, which functions as a decentralized ledger for transactions, has the potential to dramatically reduce transaction costs by doing away with the necessity for the third party that traditional transactions required. This is how it qualifies as a more efficient technology from this matter.

2.1.6 Blockchain Challenges and Obstacles

Despite the benefits provided by blockchain-based systems, there are some challenges and barriers which need to be addressed, that could influence the adoption of blockchain technology in any domains. Yli-Huumo et al., (2016) stated some of these obstacles which can be summarized as the tremendous need for very high integrity and secure transactions, as well as the privacy of participating nodes in order to prevent network attacks that target transaction distribution in blockchain. Some blockchain obstacles and challenges that are identified in recent literature the field are described as follows:

- **Scalability**

The first challenge in using blockchain is transaction scalability. According to Reyna et al., (2018), scalability has been considered as a big concern in using blockchain, where the data and transactions are growing very fast. For example, transactions in Bitcoin are increasing by 1MB per block every 10 min (Reyna et al., 2018). As noted, in blockchain architecture, all the data and transactions are stored as copies in each participant node in the network, which demonstrates the need for huge storage capacity in this technology.

In Bitcoin blockchain, two issues affect the transaction processing. First, the block size is small, and this could affect the preferences of miners to choose high fee transactions over small ones and cause delays for small transactions. Second, the potential throughput of bitcoin, which is the number of processed transactions, is less than 10 (tps) transactions per second (Zheng et al., 2017; Dini et al., 2018a; Yli-Huumo et al., 2016). It is known that blockchain-based technology throughput should be improved to maintain the same level of network transactions frequency. These two issues pose a huge challenge if the increasing number of transactions in the blockchain is to be maintained.

- **Security and Privacy**

Various studies have argued that the main reason for embracing blockchain technology is for its security characteristic; however, multiple studies have also demonstrated that security is one of the disadvantages of adopting blockchain technology (Yli-Huumo et al., 2016). According to Halpin and Piekarska, (2017), blockchain's privacy and security are two important emerging fields that are crucial elements in any research. Furthermore, as found by Yli-Huumo et al., (2016), 14 papers out of a total of 41 papers (34%) on blockchain technology, investigated the disadvantages and challenges of bitcoin and blockchain security. Currently, the blockchain network faces the percentage of 51% possible attacks. In these attacks, a single entity has complete control over the whole of the network mining hash-rate, and it can manipulate the chain and defraud the transactions (Yli-Huumo et al., 2016).

Privacy can be maintained in blockchain by adopting the private key and public key mechanism, which allows users to make transactions without exposing their real identities. On the other hand, as shown in Kondor et al., (2014) and KSI Blockchain (2018), blockchain cannot assure the transaction privacy as balances and values included in the transactions are clearly demonstrated to the public in every public key. As per the views of Yli-Huumo et al., (2016) a large and growing body of literature has investigated improving blockchain and solving the security and privacy challenges. The participating nodes in blockchain are anonymous, which helps to make this technology more secure for all other nodes that are present, so that transaction can be confirmed (Yli-Huumo et al., 2016).

Previous studies have indicated that security is considered as the main challenge that may affect the adoption of blockchain technology (Yli-Huumo et al., 2016). Despite the gradual improvement in blockchain security, reports of various security-related issues are still received

(J. Park & Park, 2017). The challenge of implementing securely blockchain impacts the data structure and the whole Distributed Ledger System (DLS). If DLS is going to be widely adopted in the industry field, then it is crucial that the code and design that help in implementing such systems are developed with a guarantee of the highest level of security (Leon et al., 2017).

2.2 Blockchain Technical Infrastructure

2.2.1 Peer-to-peer Network

In blockchain-based systems, there are two types of class system of the network layer, which are called anonymity providing networks and unstructured peer-to-peer (P2P) networks (Neudecker & Hartenstein, 2018). A peer-to-peer network is defined as a distributed network architecture that is also known as the P-to-P or P2P network. The network's users share their hardware resources that are related to network link capacity, processing power, storage capacity and printers. Networks which provide the offer of content and service such as the sharing of files, and cooperation at the workplace, are known as the shared resources. There is no need for mediators to pass on the resources, because these are available directly through the peers. All the resources needed, either services or content, are provided by the participants of these networks themselves (Schollmeier, 2001).

2.2.2 Public Ledger

The concept of a blockchain-distributed public ledger is about having an identical ledger among all the network peers. The information that is stored in blocks, is likely to be considered as valuable data e.g., currencies. With various sorts of data in the blockchain, it is very important to maintain the privacy and security of the ledger in the network (Halpin & Piekarska, 2017).

2.2.3 Distributed Consensus Algorithms (Protocols)

It is necessary for the network's participants to accept the process of storing the data in the blocks, besides accepting the specific condition of the ledger content for the systematic process of the blockchain network. In blockchain technology, this agreement can be applied by using a distributed consensus protocol, that guarantees the data validations and arrangements before posting the data to the chain. The concept of distributed consensus relates to the method of agreeing to add a new block to the shared chain. (Turkanović et al., 2017). As stated by Jun (2018), a consensus mechanism is considered as an essential method for blockchain, and it makes this technology different among other innovations. According to the traditional approach, deals are something purely transacted between people. Nevertheless, blockchain functions by an agreement on rules in which there is human participation. When the stored data of blockchain is determined as authentic data, the consensus algorithm works effectively in the layer of the network (Jun, 2018).

Distributed consensus can be achieved by using different kinds of protocols (algorithms) such as, Proof-of-Work (PoW), Proof-of-Stake (PoS), Proof-of-Authority (PoA), Delegated-Proof-of-Stack (DPoS), etc. According to Turkanović et al. (2017), PoW and PoS are currently the most used consensus algorithms The concept behind all these algorithms is that there is a need to select the appropriate node to contribute their efforts towards the achievement of rewards and may lead to the competition; and hence, decrease the possibility of chances of attack (Zheng et al., 2017). Then, the consensus protocols make the decision regarding which nodes have the authority to add the newest block to the chain (Lahiri et al., 2018). The following section addresses the main consensus algorithms in detail.

Proof-of-Work (PoW)

Proof-of-Work (PoW) is the type of consensus algorithm that shows all participants' computers that they can perform a specific amount of computational work. In the case of a decentralized network an appropriate user is selected to record the transaction. This selection is done in a random way most of the time. Nevertheless, the random selection is exposed to the possibility of attack. In a blockchain network, once the node decides to add transactions to the chain, a huge amount of work is done to show the eligibility of this node, and decrease the chance of a possibility of attack. In general, the meaning of 'work' refers to the amount of computer calculations.

To describe the mining procedure in PoW, all the network participants have to calculate the hash value of the block header that includes the nonce. The miners here have to change the value of nonce regularly to reach different values of the hash. In the consensus agreement, there is a requirement for the calculation of the value to be equal to the given value, or it may also be smaller than the definite value. Once the node of the network gets to the desired value, then the block will be transmitted to the other nodes, and all the nodes of the network have to agree and validate the correctness of the value of the hash. Once the block has been validated, all other miners can immediately add the new block of transactions to their copy of the ledger. In systems using PoW, the high hash computer power the nodes have, means they have a greater chance of finding the match value of the hash (Zheng et al., 2017). One of the disadvantage of using PoW is regarding its efficiency; as PoW procedures waste several computer-based resources to find out the desired value (Rahmadika & Rhee, 2018).

The PoW is broadly used as the most popular consensus algorithm for the public blockchain (permissionless); and is used to prevent Sybil attacks, especially with the presence of anonymous nodes such as those in the Bitcoin network (Lahiri et al., 2018).

Proof–of–Authority (PoA)

Proof-of-Authority (PoA) is a type of consensus algorithm that is designed as a substitute for PoW for permissioned consortium networks. In permissioned blockchain, all users' identities are real and cannot be faked, since they are related to off-chain identities. As mentioned in the section on blockchain types, consortium (private) blockchains are unlike public blockchains, as the network's new members are added by running a selection of appropriate candidates having a known identity. In PoA, the mining process includes sharing responsibility and authority among the network's members to validate the block of transactions and add them to the chain (Lahiri et al., 2018).

Proof–of-Stake (PoS)

Proof-of-Stake (PoS) is a type of consensus algorithm, used as a substitute for PoW in energy saving terms, wherein all of the participants' computers (miners) have to show a specific amount of currency ownership or reputation before agreeing to add a new block to the chain (Turkanović et al., 2017; Zheng et al., 2017). It has been observed that the probability of candidates attacking networks is much less among those who have the highest amount of currency. The selection process, which is based on the account balance, is known as an unfair practice because one wealthy person can become the dominating personality in the network. Consequently, many solutions have been proposed to be considered as well as the stake size in order to determine who is in charge of validating and appending the next block to the chain (Zheng et al., 2017).

Delegated-Proof-of-Stake (DPoS)

Delegated- proof- of- stake (DPoS) is another type of consensus algorithm similar to the PoS algorithm. According to Zheng et al., (2017), the main difference between DPoS and PoS is that DPOS is defined as being a representative democracy, whereas PoS is a direct democracy. Network members choose their representatives, called 'delegates', who are responsible for validating and appending new blocks to the chain. As a result of this selection, fewer delegates control the validation process of new blocks, which means quick confirmation of the block of transactions.

There are many other consensus protocols such as, Proof-of-Importance (PoI), Proof-of-Activity (PoA), Proof-of-Burn (PoB) and Proof-of-Deposit (PoD).

Comparison between Distributed Consensus Algorithms

Despite the existence of various distributed consensus algorithms, PoW and PoS are the most commonly used algorithms for fulfilling agreements between network nodes in the blockchain (Turkanović et al., 2017).

2.2.4 The Public – Private Encryption Key mechanism

Distributed ledger technology, as blockchain, relies on the public key encryption mechanism that is chosen to maintain security, and thus consistency, irreversibility and non-reputability of the DLT content (e.g., bitcoin) (Zheng et al., 2017). The encryption key protects the data blocks, and a cryptographic hash function is applied to ensure the anonymity, compactness and immutability of the block (Turkanović et al., 2017). In the case of Bitcoin, the peer has the onset of the key, which is related to public and private. The private key is used for the authentication of the user; whereas, the public key is used to address the user. In this scenario, the transaction contains the information regarding the sender's public key, several public keys that are for the receiver and the amount of transferred value. The deal is written in a block within ten minutes, and then the new block is connected with the blocks written earlier (Yli-Huumo et al., 2016).

2.3 Smart contracts: concept and architecture

The smart contracts concept is defined as a computer code that posts and activates blockchain technology transactions, where certain constraints and conditions have been applied (Sharples

& Domingue, 2016). In 1994, Nick Szabo established the term 'smart contract' when he discovered the usefulness of using a decentralised ledger in smart contracts. However, the concept was not totally new, as the idea of smart contracts had been applied for transactions in vending machines, where the offer is placed by the machine providing the products and prices. The user pays the amount of money needed for a specific product and through this payment, the user accepts the offer, and a contract is generated. Then, the machine responds to that action by dropping off the product in the collection place: this represents transferring the ownership of the product to the user. The vending machine performs and enforces the smart contract concept (Jani, 2020).

From the programming point of view, smart contracts are like classes that can be called up by client applications outside the blockchain technology. If we follow the analogy that BCTs are like databases, then smart contracts are like stored procedures, since they execute procedural programming in the blockchain data (IFLR Correspondent, 2018). Ethereum, as a blockchain technology platform, presents the smart contract as one of its fundamental building blocks which has been incorporated with the latest edition of the blockchain technology, and it has been contracting in many areas other than cryptocurrencies. It is possible to perform self-enforcing and shared calculations in a smart contract enabled system of the distributed ledger, which is also based on the user, machine and input of data (Dini et al., 2018a). As stated by Lahiri et al., (2018) smart contracts are an essential motivation for expanding the usage of BCT, apart from the cryptocurrencies domain (Rocha & Ducasse, 2018).

According to Boudguiga et al., (2017) the Ethereum platform is one of the blockchain technologies that embrace smart contract implementation in its applications. This adoption can emphasise the benefits of using blockchain technology for sharing resources and distributing the computational work (Lahiri et al., 2018). Figure 2.2 (see next section) demonstrates the different architectures of blockchain technology platforms mainly Bitcoin and Ethereum, wherein the 2nd generation of the blockchain technology adopted the concept of using distributed applications as a layer between the users and the ledger of blocks in the chain. Smart contracts provide a high level of transparency since there is no third party involved; and, because encrypted records of transactions are shared across participants, there is no need to question whether information has been altered for personal benefit.

2.4 Distributed Ledger Technology Platforms

Since the blockchain is rapidly improving, there are numerous platforms to be chosen from and this study compares them in order to find a suitable framework. This process is being reported at this early stage of the project, in order to be able to achieve a proof-of-concept implementation. Here are some examples of the current well-known DLT blockchain-based frameworks and technologies:

2.4.1 Bitcoin

Bitcoin is considered as the first and most powerful blockchain platform. The process of posting a block in the platform of Bitcoin mainly depends on the acceptance from each node in the network. This happens in sequence order where the first peer has to solve the PoW problem (see section 2.2.3). This depends on the computational power of that peer, then the transaction proceeds to the next peer to complete execution. Once the validation is completed by all the network participants, then the transactions (blocks) are posted in the chain (Dini et al., 2018).

2.4.2 Ethereum

As stated by Ethereum, (2018) and Dini et al., (2018), Ethereum is defined as a decentralized application platform that allows developers to build applications with no control from a third party and free from any risk of manipulation. Ethereum permits the users (developers) to build blockchain-based applications out of the scope of cash transaction systems, where they can design the nature of the transactions according to the desired fields (Yli-Huumo et al., 2016). There are two options for consensus protocols followed by the Ethereum blockchain platform: Proof-of-Work (PoW) and Proof-of-Authority (PoA) (Lahiri et al., 2018). Currently, the Ethereum platform still faces a huge development plan for different aspects of the platform, including the basic components along with advanced layers including payment channels or collective funding. One interesting fact about Ethereum as platform, is that it is open to an unspecified number of network participants (Dini et al., 2018a).

Ethereum is a public blockchain platform that means this platform is available to any participant node without any need for permission or exposure of identity. However, to participate in such platform, any network node has to show the ability to work under the restrictions of the protocol's rules and provide the necessary resources. Despite the public nature of this platform, a developed version called Quorum has been introduced as private consortium mode of Ethereum. As stated by Dini et al., (2018a), Ethereum is widely adopted by blockchain developers, despite the original public version of Ethereum being described as a very slow platform to maintain the heavy amount of transactions needed by various systems (Dini et al., 2018).

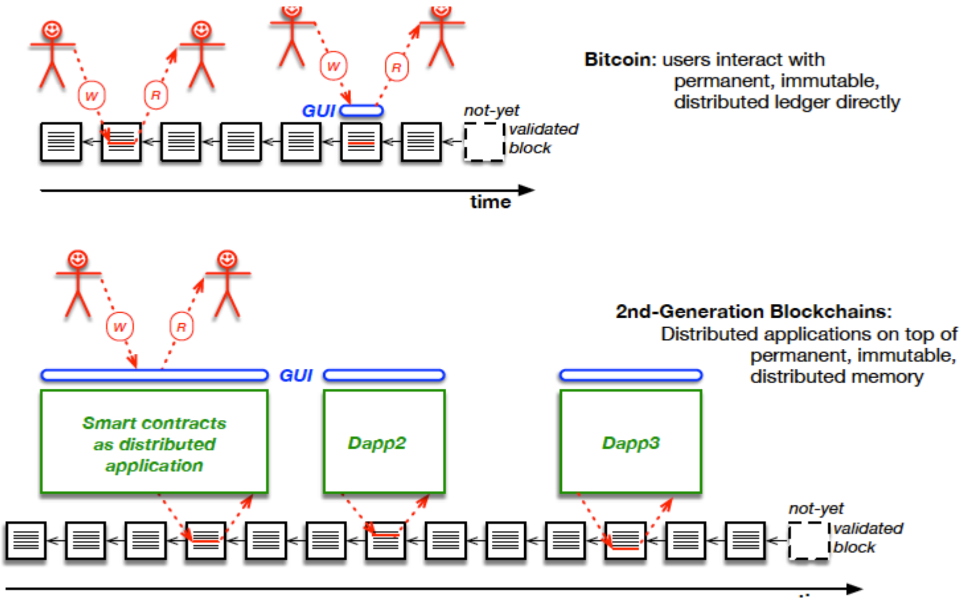

Figure 2.2 Blockchain 2nd Generation – Ethereum (Dini et al., 2018)

As previously mentioned, Ethereum's implementation of smart contracts means that it offers the benefit of sharing resources and distributing any computational work (Boudguiga et al., 2017). The different architecture used in 2nd generation blockchain is shown in Figure 2.2.

2.4.3 Hyperledger

In December 2015, a Hyperledger Fabric platform was established to provide open source blockchain-based projects and related resources (Hyperledger, 2018). Unlike the Ethereum and Bitcoin platforms, the Hyperledger Fabric platform is categorized as hybrid (consortium) blockchain that requires permission to be accessed and be part of the network. Moreover, it relies on a P2P network structure to hide the participants' identities and to protect the comments and records of their transactions with the immutable feature of blockchain. According to Mao, Wang, Hao and Li, (2018), such infrastructure allows the peers in the network to effectively interact with authentic data and obtain reliable information for various industry and financial fields. Since the Hyperledger Fabric platform is a permissioned blockchain, it provides multiple participants (nodes) with different authorizations and permissions generated by the authorized institute (Mao et al., 2018).

As stated by Dini et al., (2018) the Hyperledger Fabric platform is known as the first platform of blockchain system to develop and implement distributed applications that are written without systemically relying on cryptocurrency standards. Applications are written by using multipurpose programming languages. Meanwhile, many current blockchain platforms depend on cryptocurrency or implement smart contracts in specified programming languages related to the application's domain (Dini et al., 2018). According to Apurv, (2018), the Hyperledger Fabric platform provides developers with the right environment to develop their applications with smart contracts, public ledger, privacy and consensus protocols.

There are three basic components of any Hyperledger Fabric-based application namely: model file, script file and the access control list (ACL) file. All the information regarding events, transactions, shared resources, class of assets and network participants are stored in the model file. The second file is the script file, which includes JavaScript codes to run the transactions previously specified in the model file. This file is also called the transaction processor function file. Thirdly, the ACL file is considered as optional, and contains files that specifically define assets along with the participants responsible for performing operations or transactions affecting the defined assets.

There are several advantages of using the Hyperledger Fabric platform in developing applications for the education field. First, Hyperledger is a permissioned blockchain that provides protection to the students' records as basic data in any educational system. Thus, the access to the data and transactions, either for reading or writing, will be controlled by customized permissions as per requirements. So, accessing students' sensitive data, such as certificates and accreditations. will be only allowed to the authorized participants. Secondly, the Hyperledger Fabric platform doesn't rely on cryptocurrency standards, as it is not known as a coin (token)-based blockchain, meaning that no bitcoins or similar cryptocurrencies need to be transferred in order to post the transactions on the chain. This feature makes it a less complicated platform for implementing educational applications. Lastly, Hyperledger blockchain can obtain details of students' certificates and accreditations for the prospective employers or other higher education institutes by querying authorized access to that information (Apurv, 2018).

As noted by Mao et al., the two popular platforms Hyperledger Fabric and Ethereum are both developing distributed ledger applications based on blockchain. While both platforms share some features, they have varying domains and fields of application, as well as different authority for the network participants' permissions (Mao et al., 2018). Figure 2.3 shows the differences between the Hyperledger Fabric and Ethereum platforms in five categories, namely: type, description, governance, authority and use of smart contracts.

Characteristic	Hyperledger Fabric	Ethereum
Category	Consortium blockchain	Public blockchain
Description	Modular platform	Generic platform
Governance	Linux Foundation	Ethereum developers
Authority	Permissioned, private	Permissionless, public or private
Smart contracts	Chaincode (e.g., Go, Java)	Smart contract code (e.g., Solidity)

Figure 2.3 Comparison of Hyperledger Fabric and Ethereum blockchain platforms (Mao et al., 2018).

2.4.4 Holochain

Holochain is one of the blockchain platforms that offer the decentralized blockchain environment with give more attention data centric assumptions (Harris-braun, Luck & Brock, 2018). As mentioned by Dini et al. (2018), the Holochain platform was the only blockchain platform that they tested which was agent-centric. Holochain maintains the idea of reliable data by tracking the participants' history of transactions and updates the public ledger without the need of agreement from all the participants. Holochain consists of two main components: Holochain proper and Holo; whereby the Holochain proper is the fundamental technology that is used to run the Holo that represents the chain governance, transactions and financial framework (Dini et al., 2018a).

2.4.5 Stellar

Stellar is known as an open source blockchain platform that is designed to develop financial applications by using the Stellar consensus protocol. It allows transferring money, connecting banks and interacting users regardless of the users' locations (overseas). The main benefit of using Stellar, is to transfer money in a fast, authentic and economic way (Stellar.org, 2019).

2.4.6 Quorum (permissioned Ethereum)

Quorum is considered as an industrial version of Ethereum, and is a private blockchain platform which was established by J.P. Morgan to serve industrial field demands (Dini et al., 2018). The purpose of using Quorum is to ideally provide any institute or group with well-known peers to privately conduct their transactions speedily and with a high rate of throughput. Moreover, Quorum was not developed only for the financial industry, as it shows powerful influence in other fields to overcome challenges and facilitate blockchain adoption (J.P. Morgan, 2019).

2.4.7 IOTA

IOTA as defined by IOTA, (2019), is a permissionless distributed ledger technology platform. IOTA embraces the emerging Internet of Things with an open source DLT; and is considered as the first platform in this field. The goal of this union is to obtain information integrity and enhance transactions amounts in IoT devices. Moreover, IOTA relies on tangle structure in structuring data in its application. Also, IOTA uses the Directed Acyclic Graph (DAG) as a replacement for a blockchain technology structure. The main purpose of using such topology is to motivate the network scalability, since scalability is a major problem with blockchain networks (IOTA, 2019).

2.4.8 Comparison of DLT Platforms

Table 2.1 contains some criteria to compare between the DLT platforms mentioned in the above section.

Table 2.1 Comparison between DLT platforms

Criteria / Platform	Blockchain Type	Public / Private	Standards
1. Bitcoin	Permissionless	Public	Cryptocurrency
2. Ethereum	Permissionless	Public	Smart contracts- Domain-specific programming languages
3. Hyperledger	Permissioned	Private	General purpose programming languages
4. Holochain	Permissionless	Private	
5. Steller	Permissioned	Public	Cryptocurrency, Financial (banks, payments)
6. Quorum	Permissioned	Private	
7. IOTA	Permissionless	Public	Open-source DL, IoT

2.5 Blockchain in the Higher Education Field

Blockchain has shown a powerful presence in various fields, including the financial industry, education and supply chain management. This is because it provides a high level of transparency for conducting transactions and interactions among network participants. Consequently, different higher education institutions in different countries have adopted blockchain technology so that it can help in designing different approaches and solutions for higher education. Several of these systems adopted blockchain technology by using Bitcoin blockchain (Turkanović et al., 2017).

Blockchain technology has been adopted in various domains and fields as it has several advantages of accessibility, audibility and distributed storage (Turkanović et al., 2017). In the education sector, most challenges are caused by the fact that students' academic records are very sensitive, and the regulation of their management is also very complex (Turkanović et al., 2017). All the data needs to be recorded and shared with the network of need-to-know parties, including school administrators and prospective employers. Using blockchain technology could help modernize the traditional academic transcripts in higher education institutions (HEIs) (Jirgensons & Kapenieks, 2018),. As noted by Sharma et al., (2018) the use of blockchain in Indian education systems has reduced the amount of public spending, enriched and increased opportunities for the employment of graduates and enlarged the collaboration between the public and private sector in the hiring process. In fact, the benefits of blockchain have enabled new and innovative applications across many fields and environments.

2.5.1 MOOCs

In the last decade, Massive Open Online Courses (MOOCs), have become known as one of the most salient methods which facilitates learning on a large scale and as the part educational landscape (Joksimović, Mills, Dawson, Graesser & Brooks, 2018). Therefore, MOOCs is considered to be a well-known movement in the adoption of technologies in learning systems. According to a report there are 7,000 massive open online courses that are offered to students in more than 700 universities, and 58 million students are registered for these courses (Joksimović et al., 2018). MOOCs is depending on the third-party storage which can effect the user trust as towards such systems which is not guaranteed the security and privacy aspects (Li et al., 2022).

2.5.2 Credentialing System (Digital Certificates)

Credentialing systems are the part of an institute's systems that generates and manages students' and alumni's certificates, degrees and achievement awards. These types of documents are necessary for alumni to get jobs that match their degrees. With the many issues that the current universities' credentialing systems are facing, it is a good idea to move toward digitizing this process in order to solve the issues and seize some great opportunities. The current credentialing systems are often analogue operations to generate and manage certificates that are slow and unreliable in some cases; and which may entail other cultural and social issues, depending on the context of the education systems.

Meanwhile, creating a digital infrastructure for certification systems will provide an important opportunity to take advantages of many promising technologies e.g., blockchain. Nevertheless, such systems are dealing with highly sensitive data and represent the institute's professional reputation, both of which need to be **safeguarded**. Any decision about choosing a suitable technology that enables such features, should rely on full awareness of the technology's design and characteristics that are guaranteed trustworthy enough to run such an important system.

According to Apurv (2018), in recent months, there has been an increasing interest in using blockchain-based digital certificates among many higher education institutes. Adoption of blockchain technology helps to build a certification infrastructure that enables students to have control of the complete record of their achievements. Through this, students can also share their credentials with other universities and prospective employers and offer the beneficiary assurance and trust that the degree in question has only been issued to the named individual (Apurv, 2018). However, blockchain technology is not a straightforward process that will instantly overcome the challenges of today's credentials; yet adopting this technology will enable various improvements to the systems currently being used.

2.5.3 Similar Work

This section covers the discussion regarding similar work in the field of adopting blockchain technology for higher education, in particular for the certification process.

MIT Media Lab (Blockcerts)

Forward-thinking organisations across every industry are looking to blockchain technology to combat fraud, mitigate risk and relieve administrative burdens associated with exchanging information and content. When used to issue official records as part of a holistic content and process management strategy, the power of blockchain technology has become increasingly evident (Hyland, n.d.). Blockcerts, which was developed for creating, publishing, viewing and validating a blockchain-based certificate, is known as an 'open standard'. There are many digital records registered on the blockchain that are cryptographically signed, tamper-proof and shareable. The goal behind this innovation is to show the capacity of the individual and to share official records (Blockcerts, 2019).

According to Jirgensons and Kapenieks (2018), in the United States, MIT's Media Lab is the only institute that has established and developed a complete education credentialing system based on blockchain technology. The MIT team depends on the Bitcoin framework for developing the credentialing system instead of Ethereum. Their view of Bitcoin as the stronger technology for holding transactions was the reason for its selection (Jirgensons & Kapenieks, 2018).

MIT introduced Blockcerts as an open standard for academic credentials on the blockchain, and it can be freely used for verifying academic credentials. However, according to Rasool et al. (2020), there are three limitations to Blockcerts in order to compare to DASC:

1. It changes the existing workflow of degree issuance and is difficult for degree-awarding institutes to adopt. Blockcerts requires a student to create an account and share it with the degree-awarding institute; only then can the degree be issued through Blockcerts. This limits the university to issuing a single degree per transaction, as against their existing workflow of printing degree documents in bulk. The Decentralised Application for Smart Certificates (DASC) exposes application programme interfaces (APIs) through which universities can perform data submission in bulk. The DASC also requires that there be no student intervention during the degree issuance process; thus, it can be easily incorporated within the academic institute's existing degree-issuance workflow.
2. Blockcerts only operates with degrees and certificates that are individually issued in digital form; and only with digital data available through Blockcerts. This limits students to applying for a job or higher education through Blockcerts' credentials.

3. It does not offer any solution for degrees that have already been issued to previously graduated students. The process of degree issuance needs to be initiated by degree-awarding institutes by sending invitations to students. The invitations are then accepted by students who are willing to join Blockcerts. However, it is particularly difficult to reach out to students who have already graduated and invite them to participate in degree issuance through Blockcerts. Therefore, participating institutes can easily list the data of all degree documents that have been awarded to date, which further simplifies the adoption of a blockchain-based certificates verification solution by academic institutions.

EduCTX

The European Credit Transfer and Accumulation System (ECTS) is a concept which is based on the global blockchain and has been developed within the higher education credit platform named EduCTX. EduCTX utilises the advantages of blockchain, namely the decentralized architecture and anonymity which offer security, longevity, transparency, immutability and global simplification. For this reason, EduCTX is considered as an internationally trusted credentialing system for higher education institutes (Turkanović et al., 2017).

Knowledge Media Institute, Open University (Badges)

The Open University of Knowledge Media Institute (KMI) is a British university known as one of the most innovative universities to employ blockchain. An Ethereum-based blockchain platform called OpenBlockChain has been created by KMI for academic applications in partnership with British Telecommunications (BT). KMI targets students at UK universities, and has developed 'badges' called Microcredentials that are designed for the courses offered on the UK's MOOCs and open learning websites. The smart contract controls the registrations of the earned Microcredentials, and provides details about the badge, such as the receiver, a security assertion, the issuer, evidence of accomplishment and the criteria applied (Jirgensons & Kapenieks, 2018).

KAUST (Saudi Arabia)

On November 2018, it was announced by the King Abdula University of Science and Technology (KAUST) and Learning Machine Technology (LMT) that the university would start issuing blockchain-anchored credentials and blockers. These changes are adopted by the

KAUST in line with adoptions by innovative institutions at all over the world such as MIT, Stanford University and the University of Melbourne (KAUST, n.d.).

2.6 Saudi Arabia: Higher Education Background

The educational system in Saudi Arabia has been improved enormously by a variety of strategies, including the adoption of new education programmes and research and development initiatives. One of the main goals of the Ministry of Education (MOE) in Saudi Arabia is to develop an integrated services system which supports the education process by raising the efficiency of performance and adopting modern support technologies (MOE, 2017). The number of Saudi universities has gradually increased, from ten universities in 1999 to twenty-six public universities in 2017. The number of universities is expected to grow in anticipation of a drastic increase in population to 35.9 million by 2020 in comparison to 29.2 million in 2012 with current population 36.9 million (Statista, 2018). The number of university-aged students in Saudi Arabia grew to reach about 1.7 million students in 2016, whereas in 2009, the number of students was 850,000 and less than 650,000 in 2006. These facts reflect that there are a variety of important changes occurring in Saudi higher education, in terms of its capacity, research impacts, international links and graduate outcomes (ICEF, 2018).

2.6.1 The Current Situation of Managing Students' Certificates in Saudi Arabia

In Saudi Arabia, most of the higher education institutions (HEIs) maintain a complete course record and transcripts for students in the customary formats that display all the records belonging to each institute. The structure of these HEI's databases is designed so that it can only be accessed by designated members of staff of the educational institution through a security- maintained online system, with little or no interoperability. Furthermore, all major educational institutions adopt a specialized system for maintaining students' complete course records, which preserves the security of the data in that database. In cases where students apply for positions in foreign countries, they sometimes have to show their degrees and other academic achievements in a different language and with different accreditation standards. These foreign organisations (prospective employers or academic institutions) then face the challenge of accessing the applicant's complete course records, as well as the lack of standardisation of achievements and other issues.

As mentioned before, the current systems in Saudi HEIs use central database technology that is hosted and controlled locally by IT professionals, which entails a number of unresolved issues and latent opportunities:

- **Centralisation:** The central database is hosted locally by IT professionals in institutes.
- **Sharable Qualifications:** HEI's systems do not allow sharing of any of the students' records with any party.
- **Lack of Standardization:** The onus is on the student to translate the academic transcript to the language and standards of other schools or HEIs (authorized organizations).
- **Hard copies:** The current situation in HEIs is to still use hard copies instead of digital ones; and it takes time, cost and effort for the certificate to be generated Also, these copies omit any description of the learner's skills and achievements.
- **Dishonesty:** Many universities do not guarantee the authenticity of student transcripts; and several cases have indicated that it is possible to change alumni records. This forces prospective employers to make sure the certificates provided by the job candidates are validated by the universities issuing them (Hamdan et al., 2018).

The above-mentioned issues with the higher education system's present educational system can be resolved with blockchain technology. A blockchain-based educational tool will incorporate all the advantages of this technology. With the help of such a platform, students would be able to keep transparent and accountable digital records of their academic accomplishments and share them with the network of suitable parties, such as school officials, other educational institutions, and potential employers. The school that produced the record will confirm all of the learner's credible records and accomplishments. Additionally, a blockchain platform enables users to publish their thoughts and notes on the network, giving them the option to copyright their ideas while also keeping them timestamped and stored.

2.7 Blockchain Technology in Other Fields

Bitcoin is known worldwide as the most common application of blockchain technology (Yli-Huumo et al., 2016). Nevertheless, these days, blockchain has shown tremendous impact on various domains apart from cryptocurrency applications. While presently blockchains are dominating in the financial domain, it has been noticed that blockchain also has various applications in other fields (Zheng et al., 2017). Given the growing awareness of the blockchain revolution , various traditional industries could consider blockchain as solution, and the huge opportunity to bring enhanced and revolutionized systems into their sectors (Zheng et al., 2017).

2.7.1 Health Care

In the health care sector, there are various methods that have been presented in the industry for electronic health records (EHR). There are various areas where blockchain technology can be implemented in healthcare, such as permissions management, data accessing and clinical trials. Recent studies have shown that interoperability is very similar to the EHRs, where blockchain technology can be adopted and provide a great enhancement to healthcare (Turkanović et al., 2017). In the pharmaceutical industry, the adoption of the blockchain technology can benefit patients by reducing the sale of counterfeit drugs; and in the implementation of public and smart healthcare management (Turkanović et al., 2017).

2.7.2 EuroCat (EU regional Computer Assisted Theragnostic project)

The intention of this project is to help physicians, patients and researchers by the enhancement of cancer treatment with an advanced computer network for clinical research and decision-supporting software. This software mines both data and treatments in a new international patient database and helps to predict treatment outcomes for each new patient. As stated by EuroCAT (n.d. n.p.), "This international advanced computer network will rapidly identify patients for clinical trials and automate many of the standard processes". This project exemplifies how machine learning from patients' data can be used.

2.8 E-government Blockchain systems (Smart Government)

This section presents the usage of blockchain technology in the government systems of several countries.

2.8.1 Estonia

In 2015, Estonia has become one of the world's first countries to adopt and deploy blockchain technology (Srivastava, Dhar, Dwivedi & Crichigno, 2019). "KSI is a blockchain technology designed in Estonia and used globally to make sure networks, systems and data are free of compromise, all the while retaining 100% data privacy" (KSI Blockchain, 2018). Estonia's government understood the benefits of distributed ledger technology (DLT) so they set the protocols to add new blocks to the chain. Another advantage of blockchain technology is that data cannot be changed once it is posted. “With KSI Blockchain deployed in Estonian government networks, history cannot be rewritten by anybody and the authenticity of the electronic data can be mathematically proven” (KSI Blockchain, 2018) Areas developed with blockchain technology include law, policing and justice:

e-Law: Is an online database for the Estonian Ministry of Justice where the citizen can read every law submitted since 2003 and check who submitted this law. The system uses blockchain called the ‘electronic coordination system for draft legislation’, which works alongside another system used in Tallinn City Council which publishes all the council sessions and all the city’s legislative documents (KSI Blockchain, 2018).

e-Justice: The system called e-files was designed to follow up all the court procedures. “e-File enables the simultaneous exchange of information between different parties’ information systems: police, prosecution offices, courts, prisons, probation supervision, bailiffs, legal aid system, tax and customs board, state share service centre, lawyers and citizens” (KSI Blockchain, 2018 [P.16]). It holds information classified according to the court’s needs such as types of cases, categories of cases and subcategories (KSI Blockchain, 2018).

e-Police: The system allows officers to access all information about drivers immediately. Also, police officers can get to reach the massive information in various databases. “The system is integrated with the information system of the Schengen Zone, allowing them to see if the vehicle is stolen or if the driver is wanted in another country” (KSI Blockchain, 2018). Handling queries which help to provide effective services, the cross-border database allows access to Estonia’s database from other nearby countries (KSI Blockchain, 2018).

2.8.2 China

According to Manganiello, (2019), China has constructed what is called a ‘blockchain wall’ that is an ecosystem contains of three main levels or layers. These levels or layers differ in who are the participants and targeted beneficiaries of the services. It is a widely held view that in Chain, the adoption of blockchain technology involved the majority of powerful parties in the country. China has been able to reserve a significant location in the world economy for adopting technology and innovations. China’s political rules allow for quicker and easier application of cutting-edge technologies (Manganiello, 2019).

2.9 Business Field

As stated by Leon et al. (2017), on some occasions, a decentralized and distributed technology may enhance a business situation and suit it better. With the help of this approach, DLT can perhaps noticeably bring obvious changes in the application of business-to-business all over the world (Leon et al., 2017).

2.9.1 Supply Chain Management

According to the recent research, blockchain technology can be used to ensure food safety in the food supply chain, which is a complicated network of various shareholders like farmers, distributors, retailers and consumers (Mao et al, 2018). There are various articles in the media discussing food safety issues and public health as a major concern, such problems and related illnesses have also attracted the attention of governments around the world (ibid). With such issues, it is obvious that the existing food safety management systems have suffered from several problems which need to be resolved (ibid). In this field, where regulation and supervision are hard missions, questions have been raised about how to collect reliable and authentic information; and to minimise the unreliable data that could be present in the current supply chain system (Mao et al., 2018).

From this perspective, various huge and powerful companies around the world have started to operate their supply chain systems based on blockchain technology. Walmart, IBM and Nestle are examples of companies conducting studies on blockchain technology to improve their supply chain efficiency and ensure food safety (Leon et al., 2017; Mao et al., 2018). According to Gartner (2018), in supply chain management systems the benefits of using applications based on blockchain could possibly take place in operations such as goods traceability, tracking items counterfeits or efficient paperwork handling (Panetta, 2018). Moreover, all the transactions done by traders will be able to be maintained and open to all the network parties, which will give an opportunity for sufficient credit evaluation; meanwhile, authentic data and reliable information can be collected about traders by specified regulators (Queiroz, Telles, & Bonilla, 2019). Blockchain has enabled the creation of a network that reduces complexity across all supply chain stakeholders thus providing an opportunity to improve the entire chain (Mao et al., 2018).

There are different benefits provided by blockchain as a new revolution in supply chain management (SCM), such as transparency, increased efficiency and accessibility and the reduction of fake products (Apte & Petrovsky, 2016). Blockchain technology enables companies to track a product starting from its initial production until its delivery. Consequently, this environment makes it difficult for fraud or counterfeit products, and only legitimate products are allowed to pass, as any illegal or black-market goods are easier to trace. Consumers now have the option to track their product and verify its origins, like place and date of manufacture, and its authenticity. Hence the traffic in illegal and counterfeit products can be reduced to a great extent (Apte & Petrovsky, 2016).

In conclusion, in supply chain management, designing systems with blockchain-based technology comes with various advantages, as opposed to the traditional SCM system, mainly for regarding distribution, immutability, security, auditability and traceability.

2.9.2 Saudi Customs' Shipment Tracking System based on Blockchain

As stated by Gartner (2018), major logistics businesses, as well as large technology businesses, introduced a combined global trade digitization platform built on blockchain technology. Eventually, using such technology helps in establishing an immutable and shared record of complete transactions, and it also gives access to the information to all the different partners anytime (Panetta, 2018). The vision of the Saudi customs is to provide support to the Kingdom, so that it can build a prosperous economy that can fully employ its strategic geographic position, improve the volume of international trade with various countries across continents and increase profits from trade (Saudi Customs, 2019). Moreover, the aim is to become one of the first countries in the whole region to provide exceptional customs services that can help to develop a global logistics hub (Saudi Customs, 2019).

As stated by RTT News in 2019, Saudi Customs combined its custom tracking platform called Fasah with the TradeLens solution in a pilot project that provided blockchain technology to enable shipping (Rick, 2019). Fasah is Saudi Arabia's national shipment tracking platform that combines all the private and government entities included in cross-border trade (FASAH, n.d.). Saudi Customs has also combined with Tabadul that is its IT partner, that has also overseen the combination of TradeLens and Fasah (RTTNews, 2019). According to TradeLens (n.d.), the combined platform is an unbiased and open platform which is underpinned by blockchain technology and supported by big industry players which have expertise in the digitizing of the international supply chain. The platform of TradeLens has been combined by IBM and Maersk including professional teams from both companies to develop the innovation, and direct its adoption by different industries (TradeLens, n.d.).

The objective of the pilot project is to combine Fasah with the TradeLens for specific tasks and to take advantage of features such traceability, immutability, auditability, compliance and to minimise fraud. This pilot project is one step in a long process by Saudi Customs towards satisfying the objectives listed in Saudi Arabia's Vision 2030 (Saudi Customs, 2019). Meanwhile, the pilot project integrates the blockchain technology, the ability of Saudi Customs combined with Maersk's shipping ability to achieve a crucial milestone in the era of blockchain technology adoption. By utilizing blockchain, the main objective of Saudi Customs is to be a premier provider of customs services in the whole region, that will lead to Saudi Arabia becoming an international logistics hub (RTTNews, 2019).

2.9.3 The Internet of Things (IoT)

As stated by Zheng et al., (2017), the Internet of Things (IoT) is considered as one of the leading fields in adopting blockchain technology. According to AlHogail et al., 2018 an IoT system can be explained as a combination of various interconnected smart devices that can cooperate to accomplish combined goals and tasks. Moreover, the IoT can be seen as a technology that enables various techniques, standards and services; and recent attention has focused on the provision of IoT in both industry and academia (AlHogail & AlShahrani, 2018). The IoT is committed to creating a world where different objects are entirely connected to the internet and interact with each other with the minimal human intervention (AlHogail & AlShahrani, 2018).

The amount of the connected devices is assumed to be in between 20 and 50 billion till the year 2020 because a huge number of devices can be supported by the IoT (Alam, 2018). The exceptional growth in IoT systems has created new opportunities by which methods allow information to be shared and accessed easily. Reyna et al., (2018) highlights the cause of such initiatives is mainly the existence of the open data paradigm. However, these creative systems and methods face some significant vulnerabilities, for example the shortage of confidence that has been shown in many scenarios (Reyna et al., 2018). Blockchain can increase the efficiency of the IOT by giving a sharing service that is trusted, where there is the advantage of a decentralized environment, in which information is easily traceable and reliable (see Figure 2.4). Using blockchain technology integrated with the IoT will increase security, as at any point in time, the data's sources can be recognized with a guarantee of the data's immutability. As result of this integration, the IoT will provide a secure environment where information can be safely shared between several participants (Reyna et al., 2018).

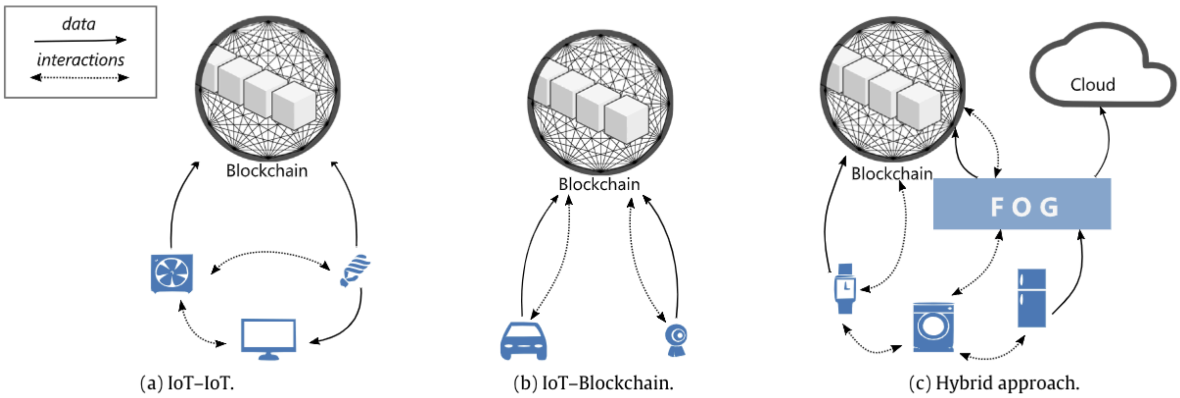

Figure 2.4 Blockchain and IoT interactions (Reyna et al., 2018)

2.10 Technology Acceptance Models and Theories

To fulfil the aim of studying the existing literature that covers the research context, we need to understand the most widely used technology acceptance theories and the influential factors they propose. This investigation addresses three important models namely, the Technology Acceptance Model (TAM), the Diffusion of Innovation (DOI) and the Unified Theory of Acceptance and Use of Technology (UTAUT).

2.10.1 Technology Acceptance Model (TAM)

The Technology Acceptance Model (TAM) was devised by Davis in 1986. It considered as an information system model that provides insights on the mechanisms behind technology acceptance in order to anticipate or predict the behaviour of the individuals working in the organisation and give a theoretical framework for effective technology deployment (Marangunić & Granić, 2015). The TAM's functional goal was to tell professionals about actions they may need to take before system adoption (ibid). Moreover, Mortenson and Vidgen (2016) stated that the TAM developed a theory of technology adoption by outlining the mechanisms that mediated the link amongst the IS features (external variables) and effective system utilisation (See Figure 2.5). The TAM's approach was founded on the Theory of

Reasoned Action, that offered a psychological viewpoint on individual behaviour that had been lacking in the IS study at the current time (Mortenson & Vidgen, 2016). As per the viewpoint of Granić and Marangunić (2019), external elements (system design characteristics) elicit cognitive reactions (perceived ease of use and perceived usefulness), that in consequence elicit an emotive reaction (attitude towards utilising technology/intention), impacting usage behaviour.

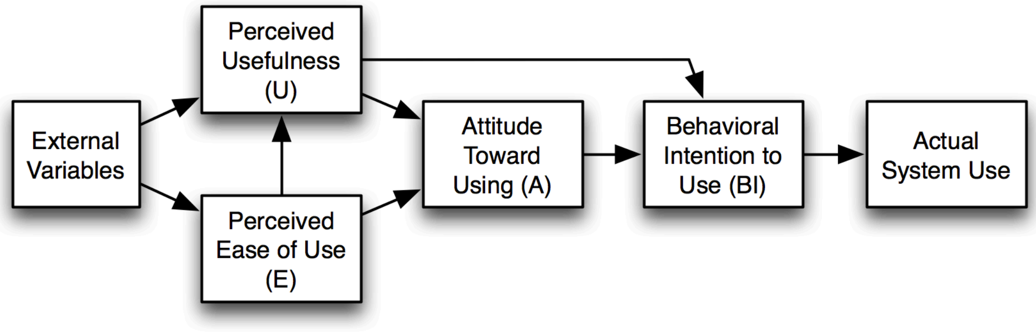

Figure 2.5 TAM model (Davis, 1989)

The TAM therefore describes technology acceptance behaviour as a result of perceived ease of usage, perceived usefulness and behavioural intention. Anticipation of favourable behavioural consequences and the idea that behaviour would not be labour-intensive are captured by perceived ease of usage and perceived usefulness (Granić & Marangunić, 2019). In addition to this, Martinez (2020) identified that the attitudes towards behaviour, that is an emotive judgement of the prospective effects of the behaviour, might be used in place of behavioural intention; and the greater the emotive reaction, the more likely that the action would occur. The influence of perceived utility on actual usage might be direct, emphasising the variable's relevance in predicting and explaining (Fuentes-Martínez, 2020). According to Alshamsi, Al-Emran & Shaalan, (2022), the TAM is considered as the one of the most common models in investigating blockchain adoption. It was used to determine the critical factors affecting the blockchain adoption. The emphasis of two main factors, ease of use and usefulness as perceived by the end users is to illustrate, the ability to adapt identifies relevant factors from the viewpoint of users as well as organisations, such as awareness and trust. Thus, this research perspective is to study the blockchain by relying on the perceived ease of use variable from this model that is driven by external variables in the context of blockchain certification system.

2.10.2 Diffusion of Innovation (DOI)

According to Kaminski (2011), E.M. Rogers' Diffusion of Innovation (DOI) Theory, published in 1962, is among the earliest ideas regarding technology acceptance. It was developed to describe how a concept or commodity develops traction and diffuses (or distributes) within a certain demographic or social structure over a period. As a consequence of this spread, individuals embrace a new concept, habit or commodity as an element of a social structure. Moreover, adoption of any new concept, activity or commodity does not occur immediately in a social structure; rather, this is a procedure in which certain individuals are much more likely than other individuals to embrace the innovation. It was discovered that those who accept an invention early have distinct traits from those who acquire it later.

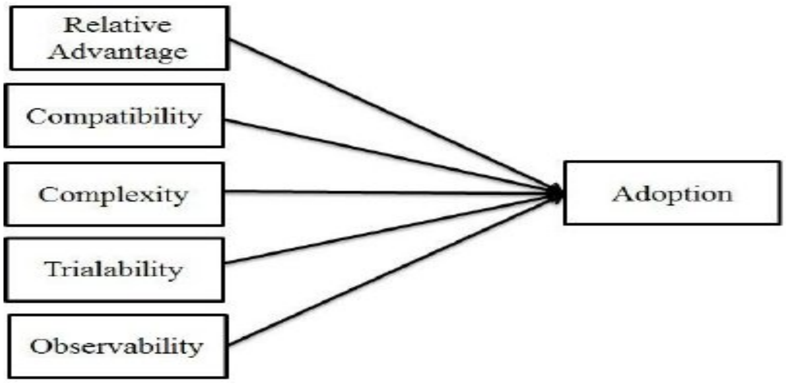

Figure 2.6 Diffusion of Innovation (Rogers, 2003)

While promoting an invention to a specific demographic, it is critical to identify the features of that demographic that will aid or impede acceptance of a breakthrough (Kaminski, 2011). The factors in the DOI according to Rogers 1983 (See Figure 2.6). The DOI theory has gained considerable attention in the current research literature. DOI framework indicates that individual adoption of innovation is divided into five categories as follows: Relative advantage, Compatibility, Complexity, Trialability and Observability (Turan et al., 2015). Among the factors of the DOI framework, it is discovered that the factors of trialability and observability can be measured by the adoption of blockchain technology from the perspective of the user or organisation. Consequently, studying and investigating these factors will be valuable to achieve the research objectives of this research.

2.10.3 The Unified Theory of Acceptance and Use of Technology (UTAUT)

According to Wahdain and Ahmad (2014), the unified theory of acceptance and use of technology (UTAUT) is an acceptance and use of technology paradigm proposed by . the purpose of which was to describe user intention to utilise an information system as well as subsequent use behaviour. According to the idea, four major components exist: 1) performance expectancy, 2) effort expectancy, 3) social influence, and 4) enabling conditions (Wahdain & Ahmad, 2014).

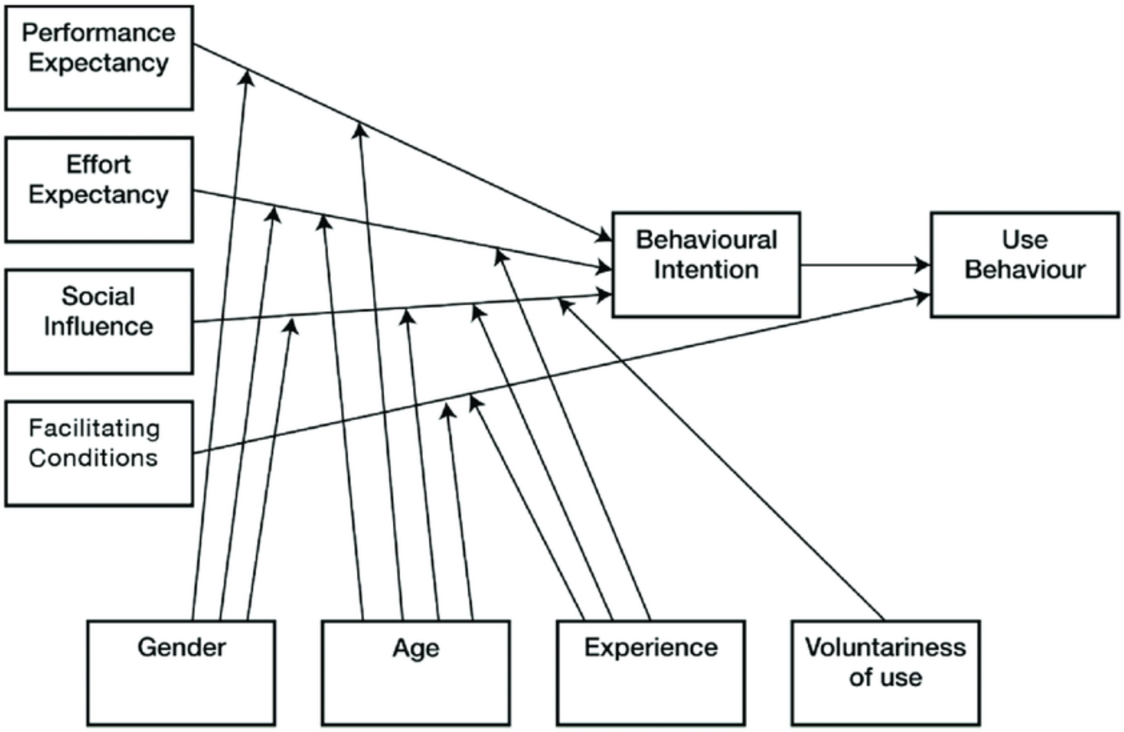

Figure 2.7 UTAUT Model (Turan et al., 2015)

Moreover, as per the viewpoint of Venkatesh et al., (2003), the first three are direct predictors of usage intention and behaviour, whereas the fourth is a predictor of user behaviour. Gender, age, experience and voluntariness of use are thought to limit the influence of the four major factors on usage intention and behaviour. The theory was created by reviewing and consolidating the constructs of eight previous models used to explain information system usage behaviour (theory of reasoned action, technology acceptance model, motivational model, theory of planned behaviour, a merged theory of planned behaviour/technology acceptance and usage, model of computer chip use, dispersion of innovation and technology theory, as well as social cognitive theory). Subsequent validation of the UTAUT in longitudinal research by

Venkatesh et al. (2003) revealed it to explain 70% of the variation in Behavioural Intention to Usage (BI) and around 50% of the variance in actual use (Venkatesh, Morris, Davis & Davis, 2003).

2.11 Summary

This chapter has addressed the latest research about blockchain technology that includes its history, infrastructure, types, domains, consensus algorithms, advantages and challenges. Moreover, this chapter has reviewed the existing blockchain frameworks that would suit the domain of developing educational systems based on blockchain. Addressing the current cases of utilizing blockchain to solve the issues in higher education systems was one of the main topics covered in this chapter. This topic answers the first and second sub-questions in this research that is about focusing on topics that have been studied in current research on higher education systems based on blockchain technology. The literature review has led to an understanding of each component of blockchain technology in more detail and how these features have encouraged the expanding adoption of blockchain among various fields beyond cryptocurrencies. It can also enhance knowledge and experiences that enable developers to innovate a novel technique by combining each technique altogether or improve an existing technique. Lastly, three widely-used theories and models that explain the acceptance of the new innovations and technologies are discussed in order to help build the conceptual model for this research.

Chapter III

3 Research Methodology, Model, and Hypotheses

The goal of this study, which used a variety of methods, was to investigate and truly comprehend several prospective users' understanding of distributed ledger technology (DLT) specifically in blockchain, at various institutions of higher education. This chapter provides information regarding the method used to conduct the research and a brief discussion of the research phases. It covers the techniques used to gather information, the data collection instruments, and the validation and assessment process. It additionally contains data concerning how the information was examined and involves the ethical considerations followed to conduct the study. This chapter explains the research methodology in depth, as well as all its core aspects, which clearly explain how the research is approached. In addition, this chapter intends to distinguish and discuss in detail the methods used to address the research questions and hypotheses specified in section 3.2.2.

3.1 Research Design and Method

This section focuses on the research methodology, which includes the research design, the research stages and the methods used at each stage. It explains, how these methods and strategies were chosen based on the nature of the conceptual framework, objectives and participants. Before delving into the specifics of this section, the researcher must first define the research methodology. A research methodology can be defined as a structured approach to problem-solving. Consequently, a research methodology endeavours to plan all the work involved in a study. As stated in (Goddard & Melville, 2005), the research methodology clearly shows the entire design of data collection, analysis, and overall procedure for assessing the proposed solution as well all measured influencing factors.

3.1.1 Research Design

An appropriate research methodology and design should be developed on a thorough review of the literature and the proposed theoretical framework. As a result, this section is intended to address the strategies and stages of this research while considering the nature of the research problem, its aims, and the required analysis. The first section includes the three main research strategies that were used as the foundation of this research, namely, the case study, survey and experiment strategies. The second section presents the overall stages of this research, which form the structure of this thesis.

Research Approach

This study is based on three strategies: case study, survey, and experiment, and this section identifies the reasons for these choices. The research questions, objectives, and context are the primary motivators for selecting combined strategies. This section also identifies the study approach in terms of inductive and deductive approaches.

This research employs a **case study** strategy to describe, compare, analyse and comprehend various elements of the stated research problem. One of the goals of this study is to provide more detailed results from various perspectives. Three case studies can be viewed as exploring and investigating the influential factors from, as the three cases are: students in higher education, prospective employers and high-level academic institution representatives. The researcher chose multiple case studies in this study because she wanted to validate, investigate and analyse the impact of the proposed factors on the adoption of blockchain-based systems from various user groups' perspectives.

As stated in Chapter 1, the primary goal of this research is to improve the certification process in the higher education sectors by utilizing blockchain technology and fully comprehending all its features. As a result, selecting the **survey strategy** was critical to achieving the research objectives and goals. As clarified by Glasow in (Glasow, n.d.), there are three main advantages to deploying a survey strategy which applied to the current study. The first advantage is that survey research is utilised in a quantitative study in order to describe specific characteristics of a specified population. Therefore, the researcher can use these characteristics to find the relationships among studied factors or variables. Also, the nature of the research following the survey strategy is mainly subjective, where the primary data source of research in such studies is the people. Lastly, survey research can be at pains to select a representative sample, then the study's findings can be generalised among a specific population.

The **experimental strategy** is distinguished by its focus on evaluating and studying cause and effect relationships (Goddard & Melville, 2005). This method is used in the present research to achieve the goal of investigating the validity of the proposed hypotheses. As the authors in (Dennis & Valacich, 2001) argued, the primary strength of an experimental study is the level of precision and control achieved; the main purpose is to test and extend the theory. Moreover, in designing a piece of experimental research, the researcher should consider realism and generalizability, and they should also concentrate on precision as an essential aspect. Thus, the study can analyze the relationships between and among variables, and in this way, ensure that the analysis is as objective as possible (Bell, 2009). The researcher aims to minimize ambiguity and eliminate confusion regarding the hypothesised relationships using the experimental research design. This design results in investigating users' intention to adopt blockchain technology in the certification process in Saudi HEIs.

In addition, the **Deductive research approach** is used in this study. People typically relate scientific study with a deductive approach to study. The researcher studies what others have done read existing theories of whatever phenomenon the researcher is studying, and then assesses hypotheses that emerge from those theories (Sheppard, 2020).

3.1.2 Research Methods

In a research study, a method can be defined as a fundamental technique which is applied in the research for collecting data with the help of different types of instruments such as interview and questionnaire (Bryman, 2008). In qualitative and quantitative research, different data collection and data analysis methods are used: such as thematic analysis for analysing qualitative data and statistical techniques for quantitative data. Methods also cover the other processes also such as sampling and the research approach and underlying philosophy. In other words, it can be stated that methods in a research study is the collection of different kinds of tools and techniques that are used for the purpose of collecting data, analysing data and interpreting data. Research methods come in three categories: qualitative methods, quantitative methods and mixed methods (Bryman, 2008), (Sheppard, 2020).

In quantitative research, the data is mainly collected in numeric form. The use of quantitative data in a research study is done for different purposes such as examining the data patterns, calculating average data, testing the relationship between variables, and generalizing results to a particular population. (Steckler et al., n.d.) and (Kamolson, 2007), have noted that in the quantitative approach the methods used are taken from the field of physical science where mainly statistical techniques are used for the purpose examining any real social phenomenon or analysing the human behaviour and perceptions of a particular sample to determine causal relationships between the variables.

In contrast, qualitative data is found in a textual form which is non-numerical, and it mainly emphasizes the identification and analysis of particular data patterns (Kilani & Kobziev, 2016). For the qualitative data collection, open-ended questions are mainly used and the content analysis method applied in qualitative research studies usually identifies particular themes and patterns in the form of textual data (Kilani & Kobziev, 2016). In qualitative research a very small sample is used to get responses using open-ended interview questions, however, the thematic analysis method fosters a strong base with which to analyse that data (Palinkas et al., 2015). To sum up, as stated by (Kamolson, 2007), qualitative data is in non-numerical form and hence statistical methods cannot be used for its analysis.

The third category of method is mixed methods. Tashakkori & Creswell (Tashakkori & Creswell, n.d.) have defined this mixed method research as being where the researcher uses both qualitative and quantitative data for the purpose of collecting, analysing and interpreting the final results on a particular research topic. In the research studies, the use of mixed methods is an advanced approach that can be effective for addressing a research problem as it comprises the advantages of both approaches (Sheppard, 2020). In order to have a more effective understanding of the research problem in a verified manner, the use of qualitative data facilitates the researchers to get descriptive data and examining the consistency of this data with that of the quantitative data collected through survey questionnaire, so that both data results can be compared and analysed together. With the use of the mixed method in the research study, the final research results can be strengthened by the use of more than one form of evidence in relation to the factors that are explored in the research and that influence the adoption and use of blockchain technology. Along the same lines, (Tashakkori & Creswell, 2007) has suggested that the selection of the mixed method for a study is not only based on the consideration of research objectives and questions, because the sampling and analysis of the data is also done from different perspectives. Hence, the consideration of all the above points determines the use and implications of using mixed methods in the current study in order to address the selected research problem. The methods selected for the current study were complementary and involved using surveys, experiment, and semi-structured interviews.

3.2 Research Stages

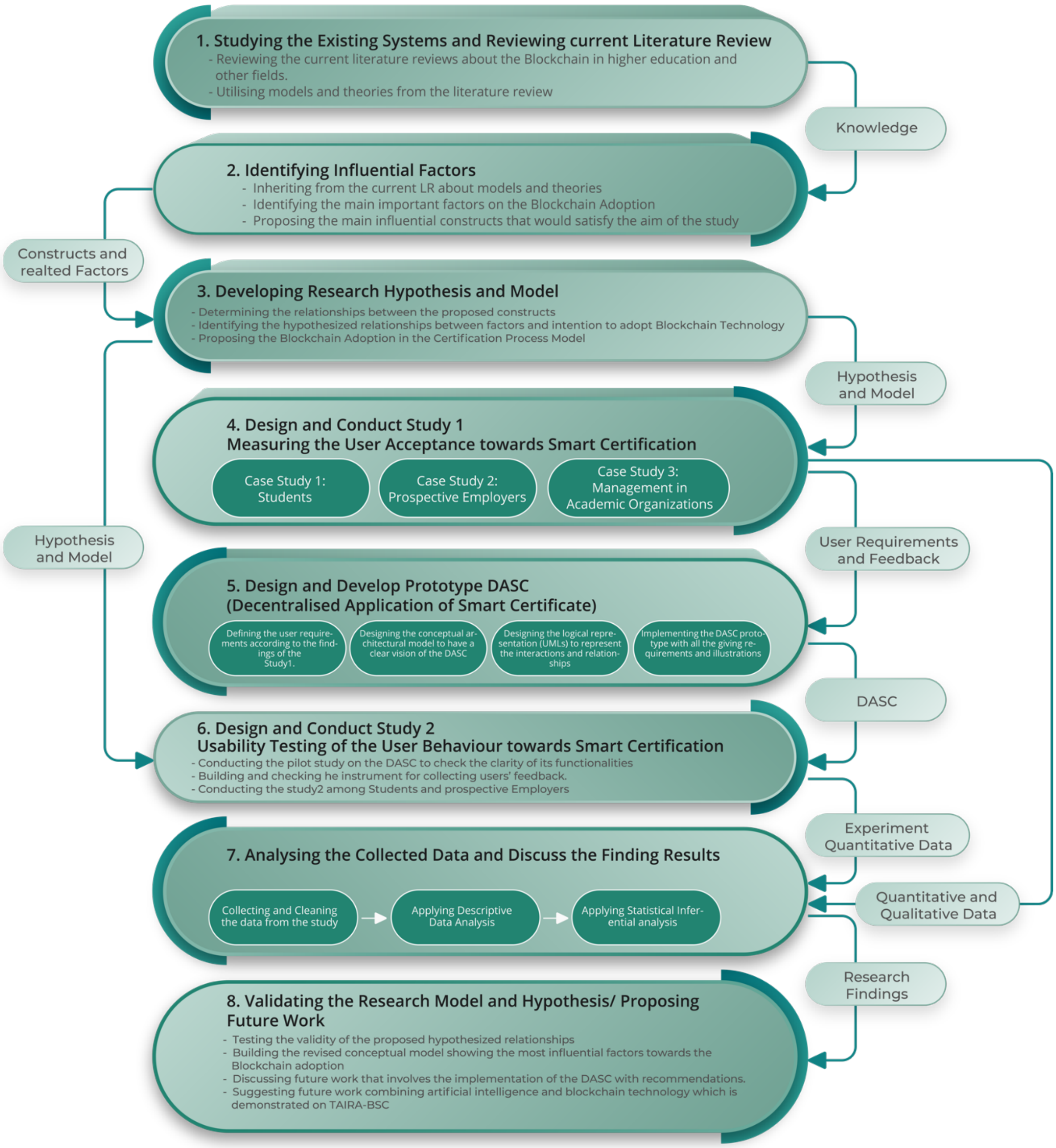

Figure 3.1Research Methodology

This section briefly describes each stage of this research along with the aim of the stage, the main outcome and how it was conducted. The purpose of this section is to show the organization of the whole research and how each stage outcome is significantly used as information for the following stage. Figure 3.1 graphically represents these stages with some of the main tasks conducted during each stage; and, as a whole, it shows how the researcher performed the research life cycle. Sections of Figure 3.1 are used to illustrate subsequent sections of the chapter but are not given separate figure numbers.

3.2.1 Explore and investigate the existing research literature

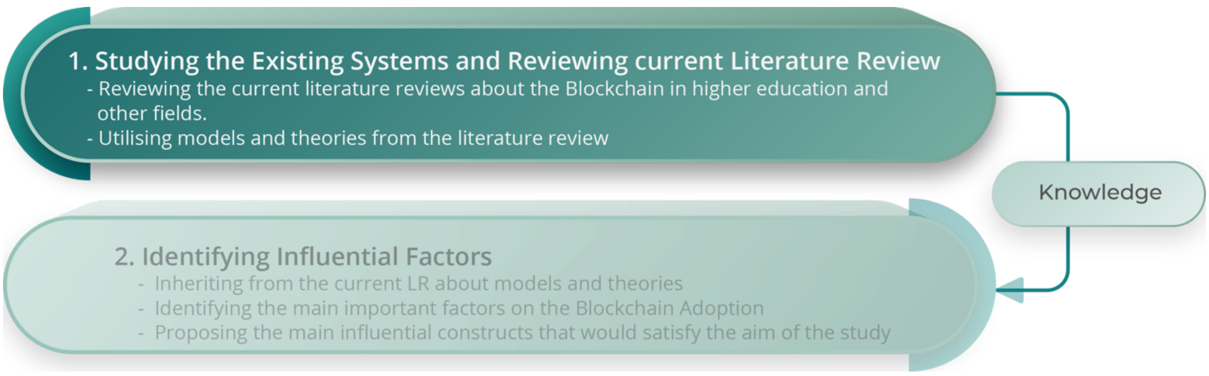

Figure 3.2 Stage1: Explore and investigate the existing research literature

Nearly every academic research starts with reviewing the existing literature relevant to the research topic and domains. The literature review section aims to show how the researcher understands the overall structure of the proposed topic through a deep investigation of previous work and related concepts (see Figure 3.2). Moreover, it allows the reader to see where this research contributes to the current knowledge and enriches future studies with more research opportunities. This step includes literature review, investigating blockchain-based platforms and protocols, and learning from very promising implemented systems (e.g., those used in China, Dubai and Estonia). A good literature review can provide the researcher with an overview of what is known about their chosen topic. Moreover, the literature review answers one of the sub-questions of this research that is about the research topics have been addressed and studied in blockchain-based technologies utilised in higher education including the benefits brought by blockchain technology to resolve the current problems in the higher education sector.

3.2.2 Identify the Influential Factors of Blockchain Adoption

In order to build a conceptual model containing influential factors affecting the adoption of blockchain in the higher education sector, an extensive analysis of the literature of technology acceptance in conjunction with insights gained from investigating several models and theories was outlined in Chapter 2 (section 2.12). This section (as in Figure 3.3) summarized the commonly used theories in analysing the acceptance of technologies, including: the Technology Acceptance Model (TAM), the Diffusion of Innovation (DOI) and the Unified Theory of Acceptance and Use of Technology (UTAUT). These preceding models (TAM, DOI and UTAUT) helped the researcher comprehend the factors involved in technology acceptance from different perspectives. However, these models have some limitations when applied to a specific field, perhaps due to their having too broad a context. Hence, this research aims to develop a more comprehensive framework appropriate for examining the adoption of innovations such as blockchain in the compassionate context of Saudi Higher Education.

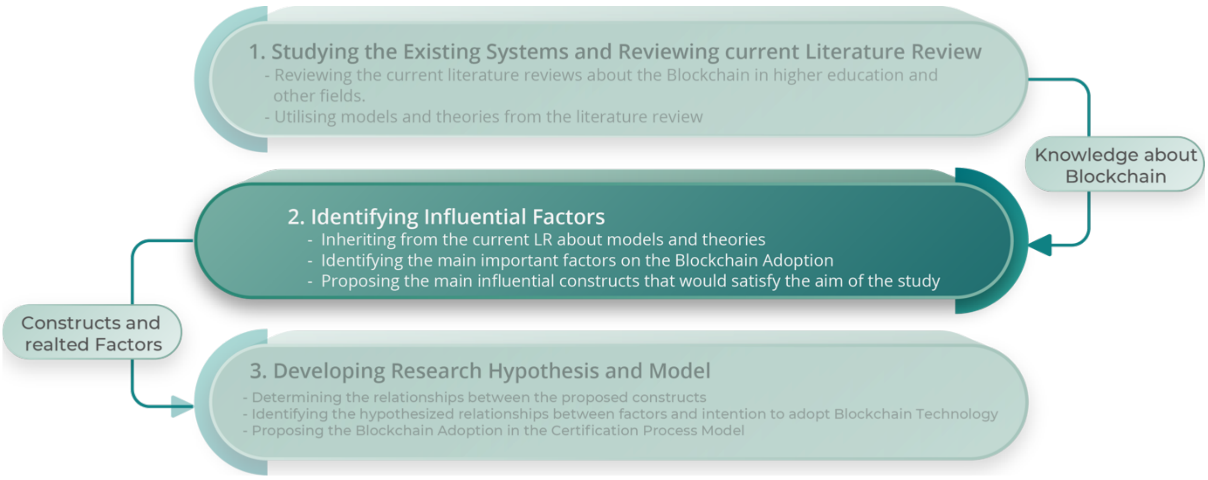

Figure 3.3 Stage2: Identifying influential factors

Consequently, the researcher decided to use certain constructs that had already been tried and tested by other scholars and shown to be significant in explaining technology acceptance. Therefore, some of the constructs used in the proposed model are inherited from the discussed models. From TAM, as mentioned before that it was used to determine the critical factors affecting the blockchain adoption. The emphasis of two main factors, ease of use and usefulness as perceived by the end users is to illustrate, the ability to adapt identifies relevant factors from the viewpoint of users as well as organisations, such as awareness and trust. Thus, this research perspective is to study the blockchain by relying on the perceived ease of use variable from this model that is driven by external variables in the context of blockchain certification system. Also, among the factors of the DOI framework, it is discovered that the factors of trialability and observability can be measured by the adoption of blockchain technology from the perspective of the user or organisation. Finally, from UTAUT model, social influence and effort expectancy are the most relevant factors to fulfil the aim of this study and investigate the users and organisation intention to adopt the Blockchain technology as promising innovation in the education field.

Moreover, the researcher also identified and incorporated vital constructs that were shown to have significance for technology acceptance in the context of blockchain technology. Additionally, the developed model was inherited from existing research in the field of adopting blockchain technology (Sander et al., 2018). The motive behind developing such a model was to understand more precisely any obstacles that would affect the acceptance of leveraging the certification process by adopting blockchain in the higher education sector in Saudi Arabia. Besides, developing a conceptual model that fits the Saudi context is essential for this research, as it would help in understanding the influential factors affecting the adoption of Smart Certificates, and could be generalised to the context of other developing countries.

In this section, the researcher illustrated the main influential factors towards adopting blockchain technology in the higher education sector that would be tested at a later stage of this research. Mainly, this is about evaluating the certificate-issuing system (i.e., DASC). There are five main categories of factors that reflect the essential requirements for the system to be adopted.

Trust (T)

Understanding the meaning of trust involves complications as this factor is influenced by several quantifiable and non-quantifiable properties. Some studies have investigating the impact of trust on the users' intention to adopt the new technology which resulted in a significant positive relationship (Han et al., 2014). In the process of accepting and using new technology, trust plays a very important part, as it has a significant role in guaranteeing users' interactions in any network. As stated by (ARMONK & TOKYO, 2017), using blockchain technology in transactions guarantees trustworthiness in transaction-based applications.

Most features associated with blockchain technology are related to the concept of providing transparent and secure applications. Such technology helps protect blockchain-based applications from any tampering with transaction data while also providing many other features and solving numerous system problems (Rahmadika & Rhee, 2018). The distributed nature of blockchain technology and the delegation of control in these innovations play a massive role in guaranteeing users' trust toward blockchain technology in various contexts (Dini, Hirsch, & Carboni, 2018b). In order to adopt innovative technology, ensure the trust relies on impressive architecture. In (Jun, 2018), the author stated that blockchain technology is considered the third trust machine. Moreover, trust has been investigated in studies on the adoption of technologies that involve handling, storing or processing sensitive information (Venkatesh, Thong, & Xu, 2016). Deploying a blockchain system helps to ensure trust in a network of unknown participants. As stated by (Casino et al., 2019), the real peer-to-peer society was created after the blockchain technology revolution.

Security and Privacy (SP)

Various studies in the literature have argued that the main reason for embracing blockchain technology is for its security characteristic; however, multiple studies have also demonstrated that security is one of the disadvantages of adopting blockchain technology. (Halpin & Piekarska, 2017) state that the privacy and security of blockchain are the rich emerging fields that have critical requirements for further research. (Garcia-Font, 2020) noted that identity management is a fundamental part of ongoing blockchain research. At present, almost all major authentication systems depend on the use of usernames and passwords, which is associated with several critical disadvantages and risks. The use of blockchain technology can mitigate many of these disadvantages, promote privacy and security, decentralize the storage of identifiers, and – perhaps most importantly – enable effective identity management to be achieved without the need for conventional username and password-based authentication systems (Garcia-Font, 2020).

Moreover, one of the main advantages associated with the use of blockchain technology is tamper resistance and, in particular, the technology's ability to provide secure data. With this feature, it is almost impossible to alter data due to the simultaneous control of all the devices that contain the distributed data. In education, preserving the privacy of students' sensitive information plays an important role, especially when sharing personal and confidential data with others (Chowdhury et al., 2018).

Social Influence (SI)

In the blockchain field, the concept of social influence refers to users' perceptions of the services provided by that technology that is highly influenced by the perceptions of others about its adoption. In (Venkatesh et al., 2016), the unified theory of acceptance and use of technology states that social influence is one of the main four factors that affect the user's decision towards technology adoption.

Awareness (AW)

The awareness can be referred to the user's actual experiences and knowledge about a specific technology in which the user will not only perceive the emergence of a new technology, but also will evaluate the possible outcomes and costs of adopting that technology (Han et al., 2014). This research aims to examine awareness level among the prospective users. The goal is to determine how awareness would affect the adoption intention concerning towards blockchain technology in the certification process.

Efficiency (EF)

By utilising blockchain technology, any transaction can be efficiently completed in the decentralised environment; therefore, it reduces overall cost and enhances transactions efficiency (Zheng et al., 2017). As stated by (Garcia-Font, 2020), reducing paper-based work, lowering the process's associated administrative costs, and increasing the efficiency in routine processes involving multiple parties are considered as the main purposes in several blockchain projects among various fields. Thus, the researcher considers including efficiency as a factor in the process of adopting blockchain in higher education. Finally, these factors are this research considerations to examine the acceptance of new technology in the sensitive field such as higher education, all the items to measure each factor are represented in table 3.1.

Table 3.1 Items to measure each factor in the survey

Factor	Measured Items
Trust (T)	- Functionality and Transparency - Knowledge and Familiarity - Easy to Access and Share - Applicants' Credentials Authenticity

Social Influence (SI)	-	Social Influence
User Awareness (AW)	-	User Awareness
Privacy and Security (PS)	- - -	Privacy, Immutability, Security and Reliability Perceived Risk Fraud and Dishonesty
Efficiency (EF)	- -	Efficient Smart Certificate Cost Reduction

3.2.3 Develop the Research Hypotheses and Model

To evaluate the system and obtain user feedback, the research hypotheses were distributed across five main factors. The framework shown in Figure 3.5 illustrates these factors and their influence on the adoption of blockchain technology in the higher education sector as the main aim of this stage (See Figure 3.4). The main object of concern is the evaluation of the proposed certificate issuing systems the Decentralised Application for Smart Certificates (DASC). This was also to be designed with the main research question:

> **How can the certification systems in Saudi's HEIs be enhanced by leveraging the decentralised ledger technology embodied by blockchain technology to generate more immutable and transparent Smart certificates?**

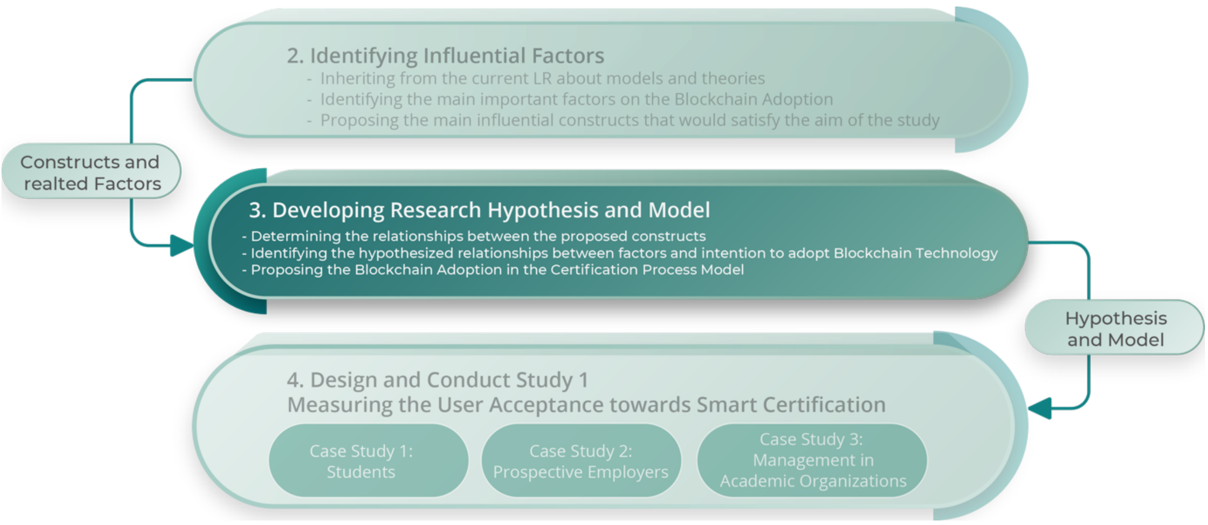

Figure 3.4 Stage 3: Developing research hypothesis and model

Trust is a major factor that has been investigated in studies of the adoption of technologies that involve handling, storing or processing sensitive information (Venkatesh et al., 2016), (Alshamsi et al., 2022). Besides, according to (Dini et al., 2018a), the distributed nature of blockchain and delegation of control of these innovations play a massive role in guaranteeing users' trust toward blockchain in various contexts. Enabling employers and students to have a trustworthy and transparent system, as in a blockchain-based system, would drive the adoption process among higher education institutions. Therefore, the researcher proposed the hypotheses, which are presented below:

H1: *In the certification process in the higher education sector, an increase in the level of* ***trust*** *toward blockchain technology will increase users'* ***intention to adopt blockchain technology****, given that trust is considered a major determinant of user acceptance.*

> **H1a:** *Blockchain technology* ***functionality and transparency*** *positively influence user* ***trust*** *toward blockchain adoption for the certification process.*
>
> **H1b:** *User* ***knowledge and familiarity*** *about blockchain positively influence user* ***trust*** *toward blockchain adoption for the certification process.*
>
> **H1c:** *Easy* ***access and convenient sharing*** *of student credentials positively influence user* ***trust*** *toward blockchain adoption for the certification process.*
>
> **H1d:** ***Trust in applicants' accreditations*** *positively influences employers'* ***decisions*** *toward blockchain adoption for the certification process.*

In education, preserving the privacy of students' sensitive information plays an important role, especially when sharing personal and confidential data with others (Chowdhury et al., 2018). Due to the definition and features of blockchain technology mentioned above, it is possible to ensure security and privacy. The following hypotheses are proposed:

H2: *In the certification process in the higher education sector, an increase in understanding the level of* ***security and privacy*** *provided by blockchain technology will increase users'* ***intention to adopt blockchain technology****, given that this allows for better maintenance of student certificates.*

> **H2a:** *Perceiving security features of blockchain technology* ***(privacy, immutability, security and reliability)*** *positively influences users' understanding of the level of* ***security and privacy*** *provided by blockchain technology for the certification process.*

H2b: *The possibility of eliminating certificate* ***fraud and dishonesty*** *positively influences users' understanding of the level of* ***security and privacy*** *provided by blockchain technology for the certification process.*

H2c: *The* ***perception of low risk*** *associated with the use of blockchain technology positively influences users' understanding of the level of* ***security and privacy*** *provided by blockchain technology for the certification process.*

According to Venkatesh et al. (Venkatesh et al., 2016), researchers who have studied theoretical models consider social influence to be one of the major extrinsic motivators for technology acceptance and use in different contexts. Hence, studying aspects of the impact of social influence and user awareness is essential to an examination of the adoption of innovative technology, especially when it relates to critical processes such as generating student certificates in higher education. According to (Raman & Don, 2013), several conducted studies found that social influence was significant in determining an individual's intention to adopt innovative technology. Hence the following hypothesis will be tested:

H3: *In the certification process in the higher education sector, level of positive* ***social influence*** *is positively associated with users'* ***intention to adopt blockchain technology****.*

As stated by (Schipper, 2014), the computer science field is one of the leading domains investigating the formalised conceptions of awareness. In the awareness domain, technology awareness is another important stream to study an individual's adoption of innovative technologies. In higher education, the level of the user's awareness plays a very important role among many studies (Alshamsi et al., 2022),(Han et al., 2014). Studying the impact of user's awareness in very important, especially as the researcher takes into account the research objectives, sample and context. The following hypothesis is proposed:

H4: User awareness *positively influences the users'* ***intention to adopt blockchain technology*** *in the certification process.*

The most academic certification systems are still paper-based as reported by (Garcia-Font, 2020), which means that verifying their authenticity is typically inefficient. Moreover, other considerations, including time and cost, are significant in the current process of verifying paper-based certificates to prevent manipulation and dishonesty. Providing higher education institutions with a system that functionally validates the authorized holder's certificates with less cost and time could eradicate doubts about certificates. These hypotheses are proposed:

H5*: *In the certification process in the higher education sector, an increase in the level of* ***efficiency *and reduction in the associated cost of blockchain technology will increase users'* ***intention to adopt the blockchain technology*** *for the certification process.*

> **H5a:** *The* ***efficient smart certificates*** *enabled by blockchain technology positively influences the* ***efficiency*** *of the certification process.*
>
> **H5b:** *The* ***cost reduction*** *provided by blockchain technology positively influences the* ***efficiency*** *of the certification process.*

H6: *After the users test the proposed system DASC, their intention to adopt the blockchain technology for the certification process in HE will be significantly higher.*

Finally, this study concentrated on an investigation of the effect of the above-mentioned factors, the research questions and the research hypotheses. The focal point was to examine the utility of the proposed framework for adopting blockchain in the certification process and to examine its applicability to a variety of other processes in the higher education sector. Therefore, testing the research hypotheses is necessary to determine whether a satisfactory level of blockchain technology has been achieved and maintained in accordance with the relevant standards in terms of trust, acceptance and security. These hypotheses were examined twice by conducting two studies, the 1st study to measure the user's acceptance and the 2nd study to test the users' behaviour in terms of the same factors after testing the DASC prototype. These two studies follow the same approaches and procedures and use same sample.

Develop the Research Conceptual Model

This section describes the research model and provides details about the influencing factors that will be examined throughout this study. To examine the importance of the aforementioned factors on the adoption of blockchain technology, a research model has been proposed that draws from diverse research on adoption and is empirically tested by the current study.

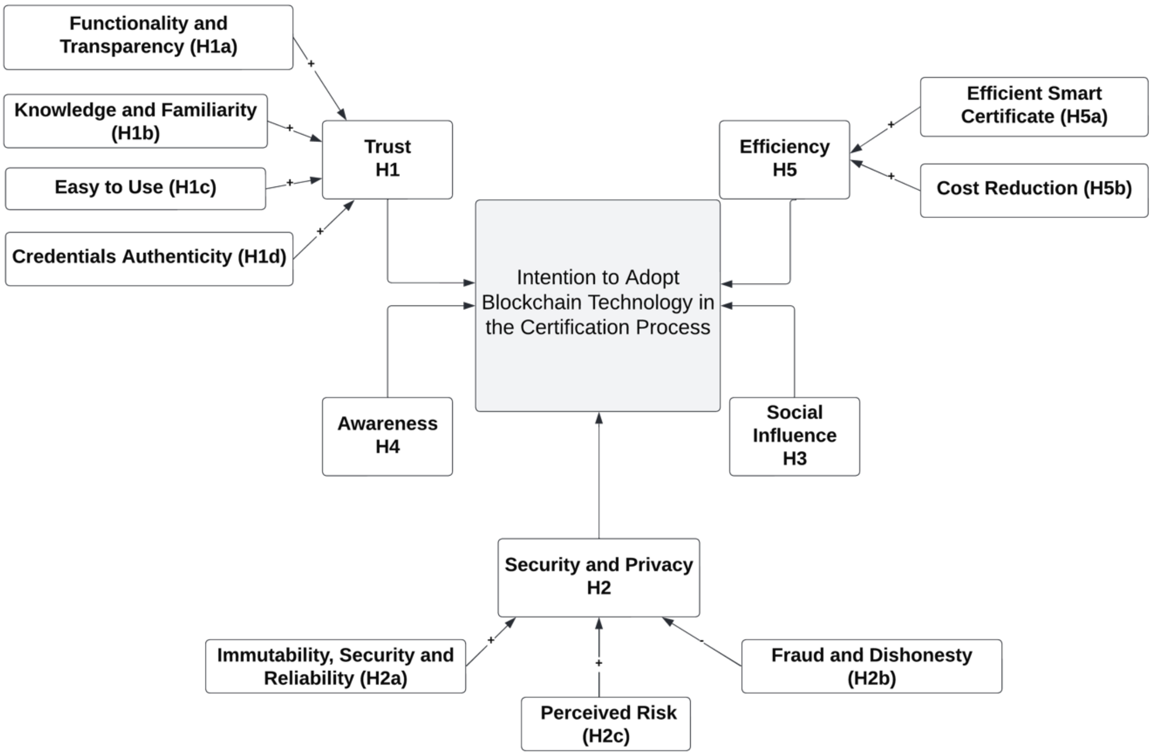

Figure 3.5. Research Conceptual Model including Factors and Hypotheses

The model is illustrated in Figure 3.5 and shows all the suggested factors with related research hypotheses that are described in the following section. One of the main contributions of this thesis is the model which is used to examine and evaluate the measured factors that have a crucial influence on different groups of participant users' adoption and use level of blockchain. Consequently, the development of this model helps in the process of analysing blockchain technology adoption for the certification process.

In this model the researcher attempts to merge the influential factors obtained from reviewing the existing literature about blockchain technology acceptance in several domains. This model embraces one dependent variable which is the intention to adopt the blockchain technology. also contains five main independent variables which are personal factors, trust factors, social influence factors, security and privacy factors and efficiency factors. This helped to fill the knowledge gaps and to overcome limitations, which were identified in the previous studies presented in the literature review (Chapter 2), while developing this research.

As stated previously, the current situation of generating and validating students' certificates on higher education is still a manual process that depends on hard copy certificates. The main aim of this study is to evaluate the adoption of blockchain technology in the certification process of the higher education sector. In the manner of technology adoption, we describe the process that starts with the user's awareness of the technology and ends with the user embracing the technology and taking advantage of it. The researcher then articulate the factors affecting the adoption of the decentralised technology, namely blockchain, in the process of generating and validating students' certificates. The next step of this study is to collect the user feedback and test the prototype.

3.2.4 Design the 1st Study

This section discusses how the hypothesis of this study and the proposed research model shown in Figure 3.5 were to be empirically tested. This empirical study has been developed with the influential factors of the framework for Saudi Arabia as developing country in mind. The goal of this study was to evaluate the acceptance of DLT in the certification process in higher education among students and prospective employers (See Figure 3.6). The participating students, top-management in academic institutes and employers were asked about their views on blockchain technology in terms of the factors of trust, social influence, user awareness, privacy and security and efficiency, along with detailed items associated with each factor. The researcher regarded prospective employers as the prime drivers of the research due to the benefits that stand to be attained if blockchain technology were to be adopted in the certification process in higher education.

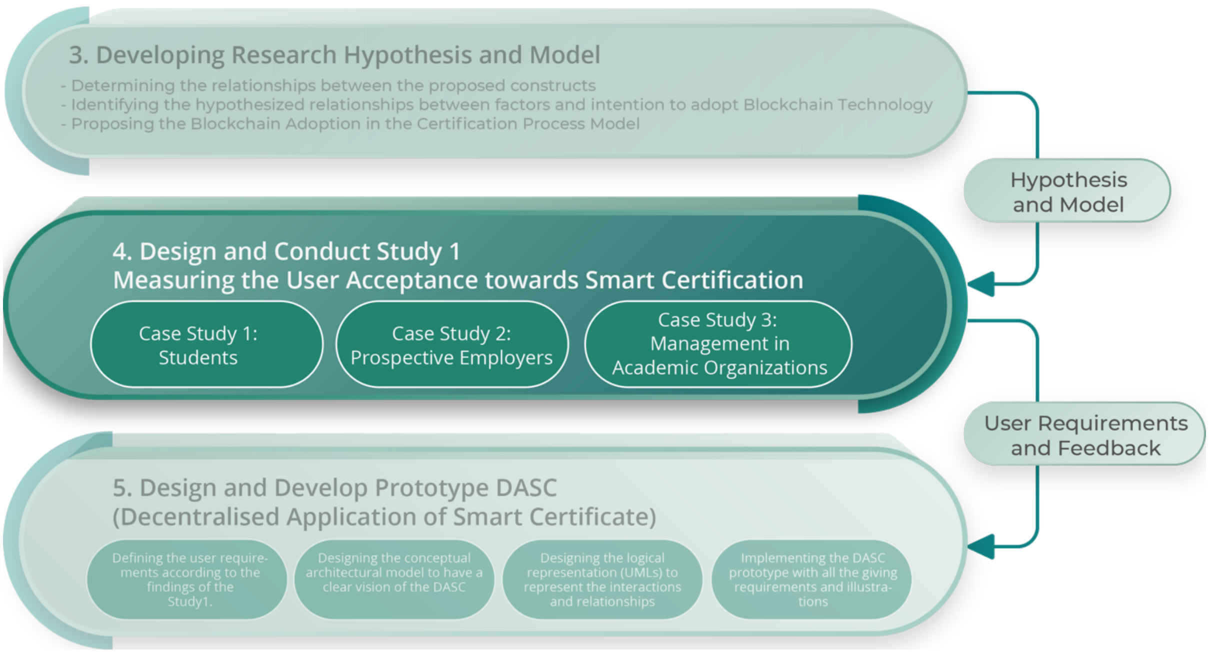

Figure 3.6 Stage 4: Design the 1st study

An online questionnaire was distributed to higher education students and prospective employers. The student questionnaire was designed to be answered by students in Saudi universities, specifically in the universities in Riyadh, the capital city of the country. the survey questions It was self-conducted constructed based on my research hypothesis and framework developed. Although, I explored some similar research as in these studies (Sander et al., 2018), (Chivu et al., 2022). This survey covered different aspects such as demographic information, technology awareness, current process situation and factors affected the adoption of blockchain in the certification process in Saudi Arabia.

The study contained three main categories namely, prospective employers in Saudi marketplace, top management in academic institutes and higher education students. The prospective employers were included because they provide the primary drive for this study due to the pressures, they can impose to encourage higher education institutes to adopt blockchain technology to facilitate their process of validating candidates' credentials. Nevertheless, the results of the 1st study have already been published (Alshahrani, Beloff, & White, 2022) and these are considered as a preliminary stage in analysing the study's findings. A deeper analysis is presented in Chapter 4 of this thesis. For the students' sample, the data were collected from higher education students in various schools such as Science, Technology and Engineering, Business and Economics and Humanities and Art.

The study focuses on senior students in their last year (fourth and fifth year) of their study, when the issuance of their certificates and recording details of their achievements and their qualifications are main concerns. For the prospective employers' sample, the data were collected among randomly selected employers from a list of companies working in Saudi Arabia in many fields such as telecommunications, construction and manufacturing, and IT. The employers who participated on the study, were selected by the researcher from a well-known website (maroof.sa), which is in collaboration with the Saudi Ministry of Commerce.

The survey consisted of a five-section questionnaire consisted of a series of structured items. Socio-demographic data were obtained using the items in the first section of the questionnaire, focusing on each participant's gender, age, educational background and area of specialization. The focus of the second section was each participant's awareness of blockchain technology and the process of generating certificates for educational purposes. The final part of the questionnaire, which encompassed four sections in total, focused on an evaluation of current systems for generating certificates, as well as the factors influencing blockchain adoption in the context of higher education.

Data collection to figure out the main user requirements were mainly accomplished by using qualitative methods. During this research stage, the researcher conducted semi-structured interviews to support the research objectives, context and survey findings. The target participants were individuals in the upper echelons of the selected academic institutions. The interview questions were based on the proposed model's influential factors also derived from the survey elements. The goal was to collect the respondents' opinions about current certification systems, how they anticipated blockchain-based smart certificates would evolve in the future and their insights into a DLT-based solution. The interviews helped complete a holistic picture by including the top management in HE in selected academic institutions and enriched the discussion regarding the level of users' acceptance of the adoption of blockchain technology.

Sampling method

This section describes all the involved process on both survey and experiment prototype studies which are prior to the stage of analysing the collected data to conclude the main findings. It includes the description of the pilot studies, the methodology of participants' sampling, and the criteria involved on the user responses about the studies.

As defined by (Singh et.al., 2014) sampling refers to the procedure of selecting the study's group of participants, which are individuals within a population, in order to evaluate or predict the characteristics of the whole population. Sampling benefits studies by facilitating the data collection with the least expense and time (Singh et al., 2014). At this stage of the research, the target population for the study's sample consisted of students in higher education and potential prospective employers. The aim of the research was to measure specific criteria within these two contrasting sample groups.

As in a similar study undertaken by (Alghamdi, 2017), a mixture of two sampling methods were used: i.e., purposeful and convenience sampling were used to maximise the number of respondents, which helped to achieve the research objectives. Purposeful sampling is the most commonly used technique in qualitative research to identify and determine particular participants for the most effective use of limited resources (Patton, 2014).

Convenience sampling is an approach when the researcher approaches the participants based on his or her own convenience and the convenience of the participants. Convenience sampling is also an efficient technique, which was compatible with the available resources, time, location, and research setting. This sampling strategy is viable in comparison to other approaches due to its more efficient time/cost ratio. Thus, choosing convenience sampling suits the nature of this research under all the circumstances of the researcher being faraway for the country of the conducted research and the light of Covid-19 and its complications.

During both studies, the survey sample contains two participants categories: students and the prospective employers. For the student category, the researcher planned to collect the data from higher education students in various schools such Science, Technology and Engineering, Business and Economics and Humanities and art. The study focuses on senior students in their last year (fourth and fifth year) of their study, where issuing their certificate and maintaining their qualifications are main concerns.

For the prospective employers, the list of chosen employers will be selected randomly from a list of companies working in Saudi Arabia in many fields such as telecommunications, industrials, and IT. The list is advertised on a well-known website (maroof.sa) which is collaborating with the Saudi Ministry of Commerce. In order to encourage their motivation both categories for participation the researcher emphasized the importance of this study and the great contribution they are making. Chapters 4 and 6 contains more details about how big each sample was and how the size of the sample was determined.

Pilot Study

The aim of the pilot study in this research was fourfold: to develop the research instrument items while improving the instruments, to validate the instruments, to calculate the average completion time for the questionnaire and interview, and to evaluate the participants' understanding of the items (Saunders et.al., 2009). The researcher ensured a valid and understandable prototype and survey questions during this stage and then obtained feedback on the research instruments and tools. Moreover, running a pilot study allowed the researcher to evaluate the time needed to fill out the questionnaire and whether respondents from the different target groups in the study understood the questions and were unlikely to have objections to answering them. The researcher then made the necessary improvements to the survey questions in the light of the feedback collected from pilot participants. This pilot study revealed that all items in the survey instrument were reliable and valid within the range of acceptable academic research and suitable for use in the main study.

During the pilot study for the 1st study survey, a total of 15 participants: 10 students and 5 prospective employers, participated in the pilot study and evaluated the questions. The pilot study was conducted in a Covid-19 secure manner which meant no face-to-face interactions happened. The questionnaire was sent by email to the pilot participants of students and prospective employers. Moreover, the pilot study for the interview questions took place in this stage, one of former academic management representative have tested the interview questions and gave few comments about the questions that I updated and amended.

3.2.5 Design the DASC Prototype

A major component of this research was building and developing a proof-of-concept blockchain-based prototype system for the higher education institutions in Saudi Arabia. This stage discussed in detailed the process of designing this prototype which consists of several tasks as shown in Figure 3.7.

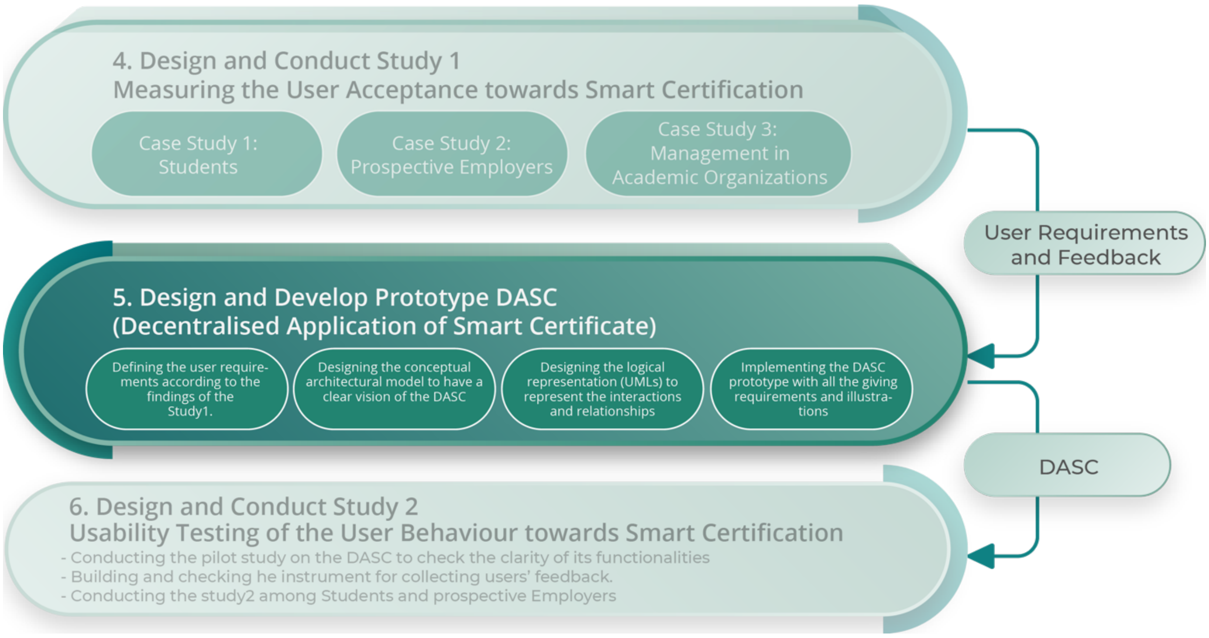

Figure 3.7 Stage 5: Design the DASC

Since blockchain is rapidly evolving the author could not choose a suitable framework at this stage of the research; rather, the researcher took time and effort to understand the process of generating and verifying academic certificates besides understanding the underpinnings of the architecture and implementation of blockchain details (Hebert & Di Cerbo, 2019). This was because blockchain adoption requires an intensive effort to fully comprehend how it might function in a specific domain. This was the motivation toward producing a visual proof-of-concept, which was intended to illustrate the idea of a smart certification system.

3.2.6 Design the 2nd Study

The questionnaire that was designed for the 2nd Study was similar to the one used in the 1st Study with one additional section about the user feedback about the DASC's GUI. The participants were familiar with its format as they were from the same sample used in the 1st Study. The difference was that this questionnaire also focused on how being presented with the prototype DASC had affected participants' attitudes and intention to adopt. This section offers a detailed discussion of the study's results and maps the results to the research hypotheses (See Figure 3.7). After obtaining questionnaire data, the data collected through the primary case study questionnaire were checked and pre-processed for statistical tests.

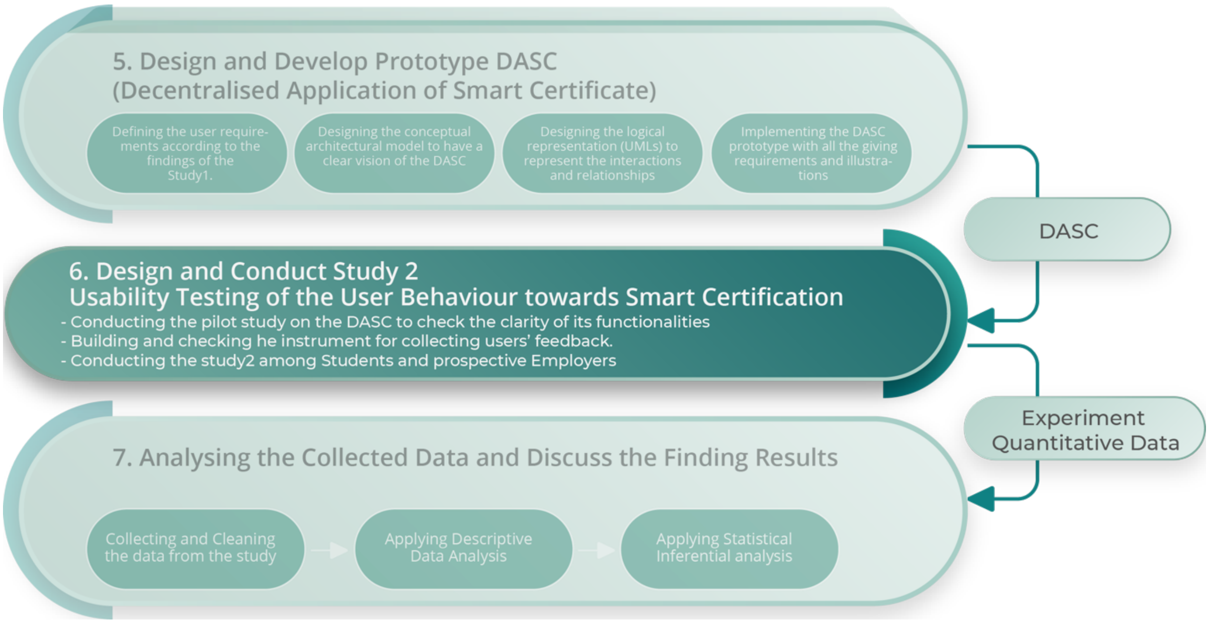

Figure 3.8 Stage 6: Design the 2nd study

The report containing all the survey data was generated using the online service Qualtrics[1], and to visualize the results, charts were used. The data were imported into Excel,

[1] www.qualtrics.com

after which their quality was evaluated. The Statistical Package for the Social Sciences (SPSS) was used for quantitative analysis after completing the data cleaning and pre-processing stages.

For the pilot study for the 2nd study, where the prototype was tested, 5 participants: 4 students and 1 employer, completed the questions. The aim was to select the students and employers from the sample used in Study 1, using as intensive means as those discussed in Chapter 5, to promote consistency between Studies 1 and 2, where all the prototyped DASC GUIs have been in discussed, see Chapter 5 for more details. Therefore, it is possible to conclude that the sample size for this pilot was suitable (Whitehead, Julious, Cooper, & Campbell, 2016). The participants provided comments and suggestions during the pilot, which included categorising the questions into several sections, rephrasing questions, and removing irrelevant questions. For example, in the pilot study of 2nd study, the participants indicated that the task of sharing the credential is not clear in the sharing screen, thus the researcher change the button label to be clearer. The majority of the suggestions were taken into consideration and resolved when reviewing the questionnaires.

3.2.7 Analyse the Collected Data and Discuss the Findings

The main purpose of this step is to analyse the collected data from the users, especially the learners and academics, to determine their intention to adopt blockchain-based certification system as shown in Figure 3.9. This will be done through interviews, questionnaire, and testing of the proposed prototype DASC. One of the challenges in the data analysis process for quantitative data is the variety of statistical methods to correctly test the data collected and ensure the validity of the findings.

There are two fundamental steps to analysing the data in quantitative research as noted by (Hair et al., 2010). Firstly, descriptive statistics from the sample data describe the essential features. Secondly, using data collected from a sample to identify inferential statistics in order to examine hypothesised relationships between the variables. Consequently, these two steps would make inferences about the larger population when the findings of these statistical analyses have been generalised beyond the research sample to understand the data collected. The purpose of this step was to capture participants' perspectives about adoption of blockchain technology in Saudi higher education institutions (universities and colleges). The sample includes decision-makers, IT managers, faculty and students from selected universities in Saudi Arabia.

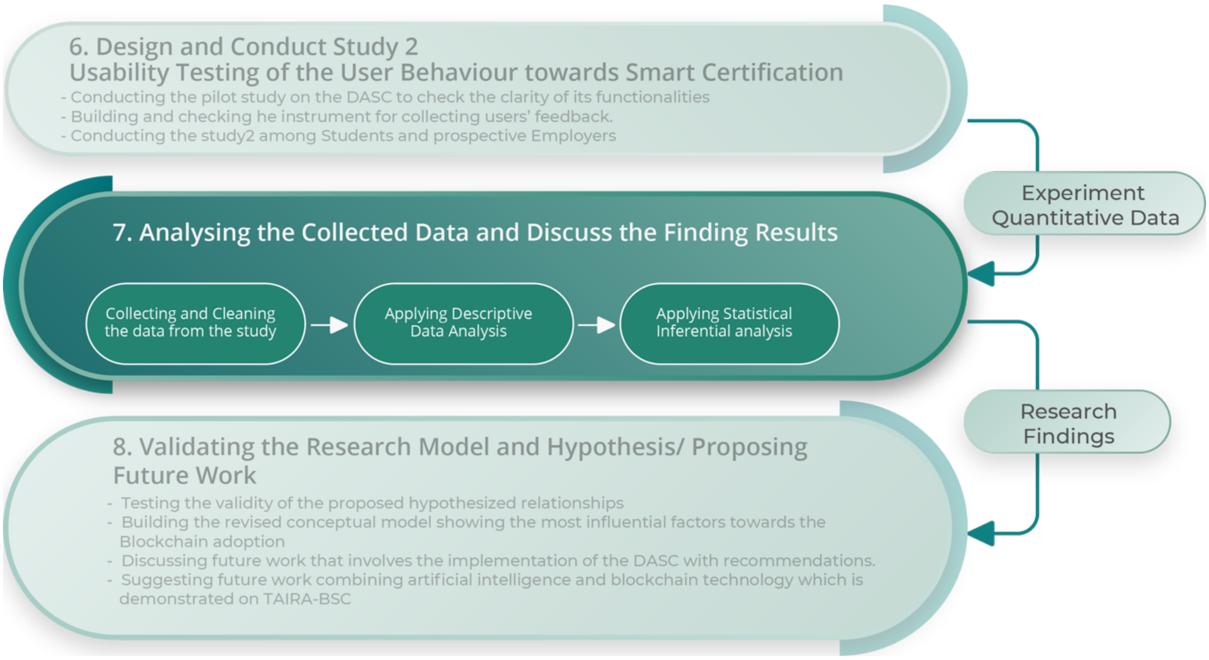

Figure 3.9 Stage 7: Analysing the collected data

The survey is designed to collect data regarding many factors to evaluate the users' acceptance and intention to adopt blockchain technology. To conduct the analysis phase of this research the data went through two main steps. Firstly, the researcher used descriptive statistics such as frequency tables, percentages and bar charts to present the analysed data including all the measured factors. This allowed a meaningful description, of participants and their intention to adopt blockchain technology by showing the distribution of the scores, or measures, of the impact of those factors. This addressed the main goal of this research, which was to examine the leveraging of blockchain in the certification process. Secondly, the data collected from different groups in the sample allowed the researcher to identify inferential statistics in order to test the research hypotheses and validate the relationships between the research constructs.

This section offers a detailed discussion of the survey results and maps the results onto the research hypotheses. After obtaining questionnaire data, the data collected through the primary case study questionnaire were checked and pre-processed for statistical tests. The report containing all the survey data was generated using the online service Qualtrics, and to visualize the results, charts were used. The data were imported into Excel, after which their quality was evaluated. The Statistical Package for the Social Sciences (SPSS) was used for quantitative analysis after completing the data cleaning and pre-processing.

Likert Scales and Likert-Type Scales

Each of the last four sections of the questionnaire consisted of a series of statements (ranging from three to six) representing each factor, for which the participants were asked to indicate their level of disagreement or agreement using a 5-point Likert scale. Likert scales, whether they include two points (e.g., only 'Agree' or 'Disagree') or more, are frequently applied in research in education and the social sciences (Joshi, Kale, Chandel, & Pal, 2015). Table 3.2 shows the scale used in the data collection instrument for the purpose of measuring the participants' responses in both studies related to this research. As stated by (Tullis & Albert, 2013) the majority of scales used in the current research instruments were Likert Scales and this allows descriptive analysis to incorporate mean and standard deviations.

Weighted Mean

As mentioned above, this research used the Likert scale to measure the participants' views regarding the survey questions. Hence, for analysing the Likert scales, the authors calculated the weighted averages of the provided data with the scale from Strongly Agree=1 to Strongly Disagree=5 (see Table 5), so that the tendency of the combined scores could be ascertained by using an interval length of 0.79. The numbers entered into SPSS represent 'weight' and the weighted average for the scale needs to be calculated to understand the achieved means values. The results can be interpreted to show the level of acceptance or rejection of each factor in the study's suggested framework.

Table 3.2 Weighted Mean and Result Interpretation

Likert Scale Equivalent	Description	Mean Weighted Average	Interpretation
1	Strongly Agree	1.00 – 1.79	Highly Influential
2	Agree	1.80 – 2.59	Influential
3	Fair	2.60 – 3.39	Moderately Influential
4	Disagree	3.40 – 4.19	Not Very Influential
5	Strongly Disagree	4.20 – 5.00	Not Influential

Data Cleaning

In terms of the pre-processing phases that were applied to clean the data prior to statistical analysis, its aim was to ensure data completeness and, alongside this, to guarantee that the data were not distorted in any way by the various opinions of specific groups. Since the data were small in size and ordinal, parametric (Pearson Correlation, Welch's *t*-test) and non-parametric (Spearman Correlation) tests were applied when suitable (Harris et al., 2008). The statistical analysis given as follows offers a description of the results.

Reliability of the study (Internal Consistency)

This section offers a description of the approach used to evaluate the reliability of the data collection instrument. When evaluating the measurement instrument, both reliability and validity are crucial to consider. In the case of reliability, it defines as the degree to which a measure is consistent, and three types of consistency are considered in psychological research: internal consistency (i.e., consistency across items), inter-rater reliability (i.e., consistency across researchers), and test-retest reliability (i.e., consistency over time) (Paul C. Price et al., 2017). A data collection instrument is regarded as reliable if it generates comparable results after being applied across similar situations and if it is free from errors to a satisfactory degree.

Cronbach's alpha was used as a measure of internal consistency in this research (where the value ranges from 0 to 1), which is one of the most common techniques applied in the literature (Tavakol & Dennick, 2011). Opinions differ about how to interpret Cronbach's alpha values, but a commonly used schema views acceptable alpha values typically range from 0.70 to 0.95. For the **1st study**, tables 3.3 and 3.4 indicate the alpha values (α) for each factor and their related items in the framework that were analysed to establish each factor's reliability based on the theoretical framework for both students and employers' samples.

Table 3.3 1st Study Cronbach's alpha test (Internal Consistency) and Analysis for Student Survey

Factor	**Items**	**Student**	
		α	**Analysis**
Trust (T)	**13**	**0.957**	Excellent
Social Influence (SI)	**4**	**0.936**	Excellent
User Awareness (AW)	**4**	**0.879**	Very Good
Security and Privacy (SP)	**10**	**0.937**	Excellent
Efficiency (EF)	**9**	**0.969**	Excellent

In this research, Cronbach's alpha values in the 'Student' category ranged from 0.879 to 0.969, whereas they ranged from 0.835 to 0.951 in the 'Employer' category. Since these values exceed the threshold, they are indicative of good internal consistency and reliability. Hence, it is reasonable to conclude that the data collection instrument was comprised of a group of consistent variables that captured the meaning of the framework.

Table 3.4 1st Study Cronbach's alpha test (Internal Consistency) Values and Analysis for Employer Survey

Factor	Items	Employer	
		α	Analysis
Trust (T)	**14**	**0.951**	Excellent
Social Influence (SI)	**5**	**0.835**	Very Good
Security and Privacy (SP)	**14**	**0.919**	Excellent
Efficiency (E)	**8**	**0.873**	Very Good

For the **2nd study**, tables 3.5 and 3.6 indicate the alpha values (α) for each factor and their related items in the framework that were analysed to establish each factor's reliability based on the theoretical framework for both students and employers' samples.

Table 3.5 2nd Study Cronbach's alpha test (Internal Consistency) and Analysis for Students data

Factor	Items	Student	
		α	Analysis
Trust (T)	**16**	**.892**	Very Good
Social Influence (SI)	**4**	**.728**	Good
User Awareness (AW)	**4**	**.842**	Very Good
Security and Privacy (SP)	**9**	**.667**	Moderate
Efficiency (E)	**10**	**.958**	Excellent

Cronbach's alpha values in the "Student" category ranged from 0.728 to 0.958 except for the SP factor, whereas they ranged from 0.822 to 0.978 in the "Employer" category. Since these values exceed the threshold, they are indicative of good internal consistency and reliability. Hence, it is reasonable to conclude that the data collection instrument was comprised of a group of consistent variables that captured the meaning of the framework.

Table 3.6 2nd Study Cronbach's alpha test (Internal Consistency) and Analysis for Employers' data

Factor	Items	Employer	
		α	Analysis
Trust (TU)	**16**	**.969**	Excellent
Social Influence (SI)	**4**	**.911**	Excellent
User Awareness (AW)	**4**	**.830**	Very Good
Security and Privacy (SP)	**9**	**.822**	Very Good
Efficiency (EF)	**10**	**.978**	Excellent

Content Validity

In a quantitative method, a pilot test is conducted in advance for ensuring the validity of the content and the results of pilot study are reviewed by the board as stated in section 3.2.8 'Pilot Study'. On the basis of this review, the questionnaire was altered, and the content is made simpler.

Validity of the study (Convergent Validity)

In the case of validity, this refers to the question of whether the scores associated with a measure actually reflect the variable that is targeted for measurement. In evaluating validity, one of the crucial factors that researchers consider – namely, reliability – has been discussed already. In the event that a measure has acceptable internal consistency and test-retest reliability, it is reasonable for researchers to be confident that the scores represent the intended object of measurement (Paul C. Price et al., 2017).

To measure the validity of the study's data, Average Variance Extracted (AVE) was chosen as the most appropriate approach for this kind of research to validate the framework in order to measure the convergent validity. In AVE analysis, factor loadings greater than 0.5 show an acceptable level of convergent validity (Hair et al., 2010). In table 3.7, the AVE values are greater than the 0.5 threshold, except the trust factor, which indicate the acceptable convergent validity. Thus, the result indicates the model is valid and the model's factors are related.

Table 3.7. Average Variance Extracted (AVE)

Factors	AVE			
	1st Study		2nd Study	
	Students	Employers	Students	Employers
Trust (T)	.554	.509	.563	.556
Social Influence (SI)	.723	.737	.611	.794
User Awareness (AW)	.734	.693	.698	.632
Privacy and Security (PS)	.549	.454	.520	.638
Efficiency (EF)	.804	.545	.609	.682

Descriptive Statistics

Frequency measure is the most frequent used method of statistical analysis with the help of which the characteristics of sample can be compared in the form of rates, ratios and proportions. With the use of descriptive statistics, the presentation of the larger data is done in a very simplistic manner. The main indicators that are used in the descriptive statistics include central tendency, frequency distribution, dispersion measurers. The frequency distribution determines the responses of individuals. As identified by (Hair et al., 2010), central tendency can facilitate a good understanding of the different variables and characteristics of the population. With the help of descriptive statistics, the simple description can be done of the larger set of data. The assessment of the dispersion measures can be done in the descriptive statistics by the use of the variance and standard deviation. These descriptive statistical results for both studies have been intensively discussed and presented in Chapters 4 and 6.

Inferential Statistics

To test the proposed hypothesis of this research, three steps were followed in this part of the study. First, the composite score for each factor on this study was measured and interpreted to evaluate the influence on the adoption of blockchain technology for the certification process. Then, the researcher used the Shapiro-Wilk test and calculated skewness and kurtosis statistics for the purpose of checking the normality distribution of the data. Accordingly, the correlation coefficient test was chosen in regard of results from the normality distribution test and the two-test followed in this research were the Pearson and Spearman correlation tests. These inferential statistical results for both studies are presented and intensively discussed in Chapters 4 and 6.

Test of Distributed Normality

This refers to checking the normal distribution of the study data to evaluate if it is equally and normally distributed. Normality is defined by (Hair et al., 2010) as the extent of distribution among the sample data with the regard to maintaining the normal distribution. For checking the normal distribution, first the Shapiro-Wilk test has been used (Shapiro & Wilk, 1965). To interpret its value, the researcher followed the rule that if the chosen alpha level p was equal or less than 0.05, then the null hypothesis that the data are normally distributed was rejected. If the p-value was greater than 0.05, then the null hypothesis was not rejected, and the data were considered to be normally distributed. Moreover, the researcher calculated the Standard Deviation SD values which denote the normality of the variable data where the value of (SD <1) indicated a satisfactory normality. By using the Shapiro-Wilk test, the researcher calculated the values of skewness and kurtosis which are used to measure the data normality with an acceptable value range between - 2.58 to + 2.58. These tests and statistics were employed to allow the research to detect whether the collected data was normally distributed or not. This research used the SPSS version 27 program to present the results of descriptive statistics which are outlined in Chapters 4 and 6 from the different perspectives of participant students and prospective employers.

Table 3.8. Normality distribution and the Correlation assessment tests

Normally Distributed Data (Parametric Method)	**Not Normally Distributed Data** (Non-Parametric Method)
Pearson Correlation	Spearman Correlation

In order to evaluate the correlation between the proposed factors two correlation tests: the Pearson and Spearman correlation coefficient tests were utilised. As illustrated above in Table 3.8 the choice between these two tests is mainly according to the results of the data normality distribution. If both factors are normally distributed or when samples are very large, then Pearson's correlation coefficient is the most suitable test to examine the relationship. For interpreting Pearson correlation results (noted by r); widely used procedures specified by Cohen regard a correlation of $r=.1$ as small, $r=.3$ as moderate, and $r=.5$ as strong. On the other hand, Spearman rank correlation is the appropriate test to be followed when the sample data is not normally distributed, and the sample is small (less than 100). Additionally, Spearman correlation performs in similar way to the Pearson coefficient, but the difference is worked on a ranked data.

Two independent samples measures t-test

As stated before, one of the strategies utilised in this research was the experimental strategy. The two studies conducted in this research were designed to investigate user perceptions about smart certificates as a blockchain-based certification system. Therefore, the T-test was employed as it indicates if the scores of the proposed factors from two studies for the same participants significantly differ ($p < 0.05$). This test enabled the researcher to answer whether students' and employers' intention to adopt blockchain scores were different before and after the DASC prototype testing questionnaire. In addition, this test indicates the t-value and the significance level of the difference between the two studies; by checking the results of this test along with the results from the statistical analysis (descriptive and inferential), the researcher will be able to specify if the proposed hypotheses can be accepted or rejected. In this study the research used Welch's t-test in particular to compare the user's intention to adopt blockchain between the two studies that is in details described in section 6.6.

3.2.8 Validate and Evaluate the Research Model

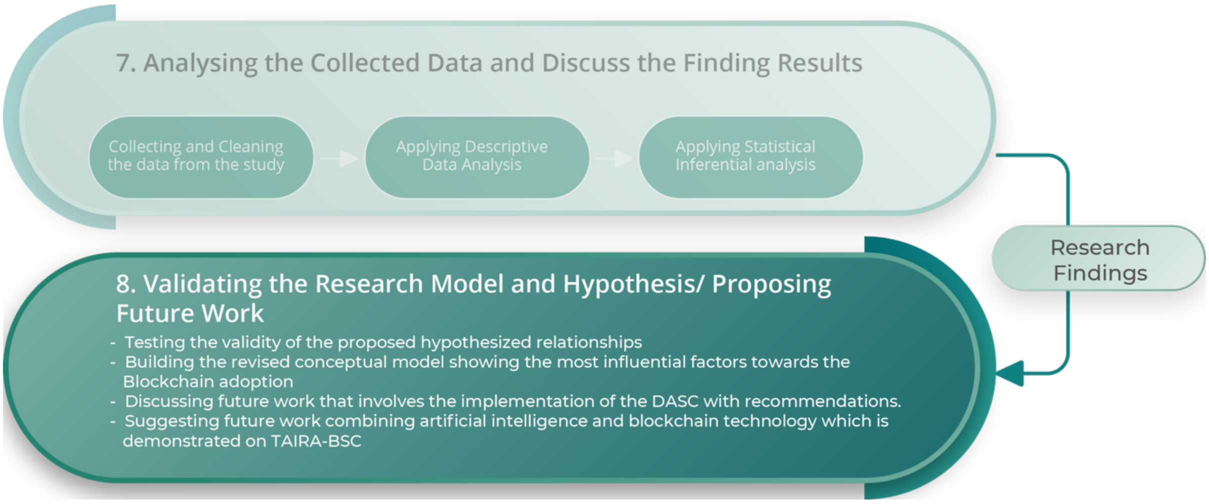

Figure 3.10 Stage 8: Validating the research model

As shown in Figure 3.10 this stage involved many steps that connected the proposed research questions with the hypotheses and the hypothesized relationships between factors and the research findings to formulate the main contributions to knowledge. Firstly, the validity of the proposed hypothesized relationships was tested (as described in Section 3.2.8). Then, the revised conceptual models were built and showed the most influential factors towards the blockchain adoption with a discussion about the most influential factors and how the findings would raise several questions for future research. Moreover, in the last stage of this research the aim was to discuss the future work that involved the implementation of the DASC along with recommendations based on insights from this study. Finally, the last stage of this research presented possibilities for future work in combining artificial intelligence and blockchain which is demonstrated on TAIRA-BSC as discussed in Chapter 7.

3.3 Ethical Considerations

This study was conducted at the University of Sussex, and hence its ethical guidelines were followed in this research. Firstly, the anonymity of the participants was ensured to remove any fear of facing any negative comments or repercussions. Secondly, a full guarantee of confidentiality was given by not disclosing the data shared by any individual respondent. A copy of the data was also saved as backup, and this and the original dataset were under password protection to avoid unauthorized access. In the second study, considering Covid-19 situations, online services were used. Firstly, virtual observations were conducted, and questionnaire got filled by the participants through video calls to two universities in Saudi Arabia (IMSIU and KSU). Informed consent was obtained from all participants and all were above the age of 18. Participants were given the freedom to withdraw from the survey and to refuse observation. In the Science and Technology Cross-Schools Research Ethics Committee (C-REC) at the University of Sussex, 2 applications were made, and approvals received for the research (with application nos. **ER/MA2026/1** and **ER/MA2026/2** as shown in **Appendix A)**. Moreover, the research applied for **Researcher Facilitation Letter** from local university (see **Appendix A**). The two studies' information sheets and consent forms, details of the experiment, recruitment email and questionnaires, interviews list of questions (see **Appendices B and C**) were also subjected to ethical review.

3.4 Summary

This chapter addresses the research methodology and all its related components. It starts by identifying all the concepts about the research methods, strategies and design. Then, a detailed discussion illustrates the steps this research follows which lets the reader know this research has been conducted. These steps include all the major tasks, studies, factors and every detail about this research. Also, this chapter outlines all the procedures and tests following on from the data analysis stage of this research. It explains in detail all the steps obtained in the following chapters to fulfil the research objectives. Also, this chapter presents the conceptual model proposed for this research along with all the proposed influential factors and research hypotheses. Moreover, this chapter also highlights the ethical considerations of this research along with all the obtained procedures to conduct the two studies.

Chapter IV

4 1st Study: User Perceptions Regards Blockchain Technology

This chapter presents findings and discusses the result of data analysis of the 1st conducted study to investigate the users' perceptions about adopting blockchain technology in the certification process. It starts with a description of the sample and provides demographical information. It continues with the results for each of the hypotheses and the observation for two of the sample groups included in this study, namely, students in higher education and prospective employers. This chapter contains the following sections: firstly, an overview about the study is covered in Section 4.1. Then, the details about the interviews with top management in academic institutions are provided in Section 4.2. Sections 4.3 and 4.4 discuss the results; and the statistical analysis of both the descriptive and the inferential statistics collected from the students' sample are given in some depth. Sections 4.5 and 4.6 cover details of the employers' survey, and also discuss the results and the analysis of descriptive and inferential statistics. The revised models for students and employers are discussed in last section of this chapter, as is the contribution made by the current research to Women's Studies.

4.1 Overview

The goal of this empirical study (Study One) was to evaluate the acceptance of distributed ledger technology (DLT) in the certification process in higher education among students and prospective employers. All students and employers were asked about their views on blockchain technology in terms of the factors of trust, social influence, privacy and security and efficiency, with detailed items associated with each factor that are represented in the conceptual model proposed in the Chapter 3 that is illustrated in Figure 3.5. For the student category of the study, there was a total of 426 responses to the survey, and 405 of those respondents agreed to proceed with completing the survey. The authors extracted the 21 responses where participants had not given their signed consent. The employer sample consisted of an initial 34 responses to the survey, where 8 participants did not provide signed consent, and 4 participants did not complete the whole questionnaire. Thus, the final total sample size for employer participants was 22 responses. In the final sample of the study participants in the student category, the gender distribution was as follows: female participants constituted 70%, while there were 30% male participants. The largest age group was participants between 18-25 years old (60.2% of the sample).

Table 4.1 Demographic Characteristics of the Student Survey for the 1st study

Characteristics		**Student**		**Employer**	
		Frequency (n= 405)	Percentage %	Frequency (n= 22)	Percentage %
Age					
	18 – 25	244	60.24	0	0
	26 – 35	88	21.72	11	50.0
	36 – 45	49	12.09	9	40.9
	46 – 60	21	5.18	2	9.1
	+ 60	3	0.7	0	0
Total		405	100	22	100
Gender	Female	285	70.4	6	27.3
	Male	119	29.4	16	72.7
	Prefer not to say	1	0.2	0	0
Total		405	100	22	100
Education Level	High school or equivalent	25	6.17	1	4.5
	Undergrad	220	54.32	0	0
	Bachelor's degree	88	21.72	8	36.4
	Postgraduate or higher	72	17.77	13	59.1
Total		405	100%	22	100
Field Domain					
	Science, Technology and Engineering	208	51.35	12	54.6
	Business and Economics	47	11.60	5	22.7
	Humanities and Art	49	12.20	4	18.2
	Other	101	24.94	1	4.5
Total		405	100%	22	100

On the other hand, the largest age group of the participants in the employers' sample were aged between 26 and 35 years (50%). In contrast with the student sample, most of the employers were male participants, and these represented 72.7% of the sample. Regarding the educational level of prospective employers, 59% of the participants were postgraduates or higher level. The employers' sample was mostly derived from the Science, Technology and Engineering domains followed by Business and Economics and Humanities and Art in terms of what they had studied. Moreover, a third of the participants indicated that they had a moderate level of awareness of blockchain technology. The employers mostly came from public sector organisations (54% of the sample) while the rest were working in the private sector.

4.2 Interviews with Top Management in Academic Institutions

Interviews present the opportunity to fill in gaps in the researcher's knowledge. Through this process, it is possible to get to know the interviewees better, and tailor questions to each subject's specific requirements (Kilani & Kobziev, 2016). In this study, interviews served to analyze academic management perspective on the present certification systems, as well as to investigate the suitability of the two universities' technical infrastructure based on five factors: social influence, security and privacy, trust, efficiency and user awareness. The interviews also helped to engage the participants in discussions regarding the system's principal functions, which supported the research goal of end-user participation. In conclusion, this section allowed the researcher to gain insight into HE senior management's outlook regarding how certification processes can be enhanced by blockchain technology.

4.2.1 Interviewee Selection Process

Five professors from varying levels of HEI management in Saudi Arabian universities were interviewed for this study. The interviews were conducted in a semi-structured manner. Several important factors emerged from this process, while also expanding the researcher's knowledge of both the challenges that existing HE certification systems pose and the difficulties in successfully implementing blockchain technologies. Previous qualitative research suggests that between five and fifty participants represents an acceptable number (Dworkin, 2012). Consent was obtained from all subjects in advance of their interviews.

Due to limitations imposed by COVID-19, each interview was conducted online, with the answers anonymized. Before each interview, a brief description of the research goals and methods of analysis was presented to each subject (see **Appendix B**). This had also been presented at the participation proposal stage. The most senior manager to participate in this study was the Vice-Dean for Electronic Transactions and Communications. A second participant was in charge of the university's IT infrastructure, services and support. A third interviewee also described their role as being in IT, with their department supervising and providing technical support to the university's admission and registration system, BANNER

(An online admission and registration system available to all students to perform admission and financial transactions) ("Banner (Student Management system self-service)," n.d.). The other two interviewees were former vice-chairs in two different departments familiar with the graduates' auditing process before the HE students received their certificates. The five participants were chosen due to their technical expertise and experience in the field of IT implementation. All the interviewees possessed substantial knowledge of the university's existing certification systems and were able to provide informed answers to the questions asked.

After initially being designed in English, the interview questions were translated into Arabic to increase the response rate, generate more precise answers and increase efficiency. The questions were translated and reviewed by a translation specialist to ensure the translation's accuracy and effectiveness. Also, the researcher conducted a pilot interview to check the clarity of the questions with one academic faculty resulting in no changes happening to the questions. Qualitative data coding was used to identify patterns and themes within the responses, which complements the statistical analysis of the survey data. For the data generated to be assessed thematically, an analytical approach was required to ensure sound methodological decision-making (Williams & Moser, 2019). The process of reading through the transcripts to uncover the main themes for both the interviewee and the interviewees was conducted manually in this study, with keywords or phrases identified and matched against the data model (McLellan, MaCqueen, & Neidig, 2016). As shown in sections 4.4 and 4.6, the results were then compared with the statistical analysis to verify the hypotheses.

4.3 Student Survey Descriptive Analysis and Interpretation

A questionnaire was disseminated online to students enrolled in higher education and also to prospective employers. The target population of students consisted of all students enrolled in Saudi Arabian universities, particularly Riyadh's universities (i.e., universities in the country's capital). To maximize the response rate, the questionnaires were disseminated in Arabic and English. The types of data obtained via the questionnaire were as follows: demographic information, technology awareness, current process situation and factors influencing the adoption of blockchain in the certificating process in Saudi Arabia.

4.3.1 Part1: Demographic Information

The influence of demographic information and characteristics was analysed to find out any external influences upon the level of the aforementioned factors that would affect the adoption of the blockchain in the higher education field. The following section describes the details results of the student sample's demographic information.

Age

As shown in Figure 4.1 the result shows 60% of the participants were aged between 18 to 25 years. This indicates some degree of representativeness in the sample as most Saudi undergraduate students are aged between 18 and 25 (UniPage, 2022). The second large percentage of participants' age were between 26 to 35 years which represents 22% of the whole sample. Then, 12% of participants were between 36 to 45 years old. The last two percentages were 5% and 1% for participants between 46 and 60 and above 60 respectively.

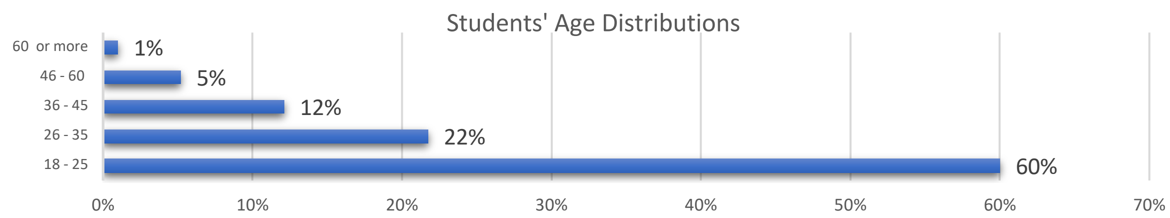

Figure 4.1. Study 1: Students' Age Distribution

This study aimed to examine the students' perceptions about adopting blockchain technology in the field of maintaining and verifying their academic accreditations. Given this age distribution, the researcher is highly confident about satisfying the aims of this study and answering the research questions with data from a representative sample.

Gender

The survey result shows the gender of the most participants were female, with women representing 70% of the whole sample (see Figure 4.2). The large number of female participants arguably enriches the study especially in a community such as Saudi Arabia; and further investigation regarding the need to know more about women in this context is in section 4.5 in this chapter.

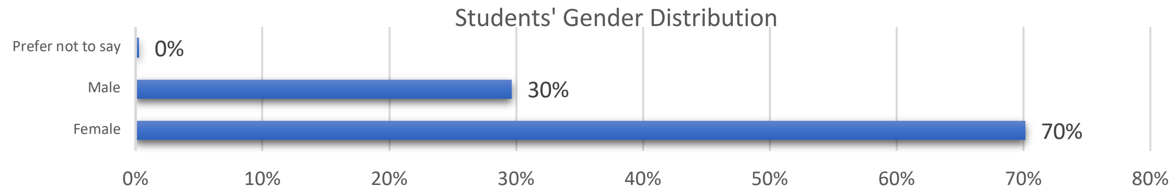

Figure 4.2, Study 1: Students' Gender Distribution

Educational Level

Regarding educational level, most of the participants was in the undergraduate category with 54% percentage which is the target sample of the study as the researcher aimed to investigate the undergraduate level (see Figure 4.3). Moreover, 22% of the participants held bachelor degrees while 18 percent were postgraduates or higher levels. Lastly, only 6% of the sample were as high school graduates or equivalent; this was because some of the undergraduates considered themselves as yet only as high school certificate holders.

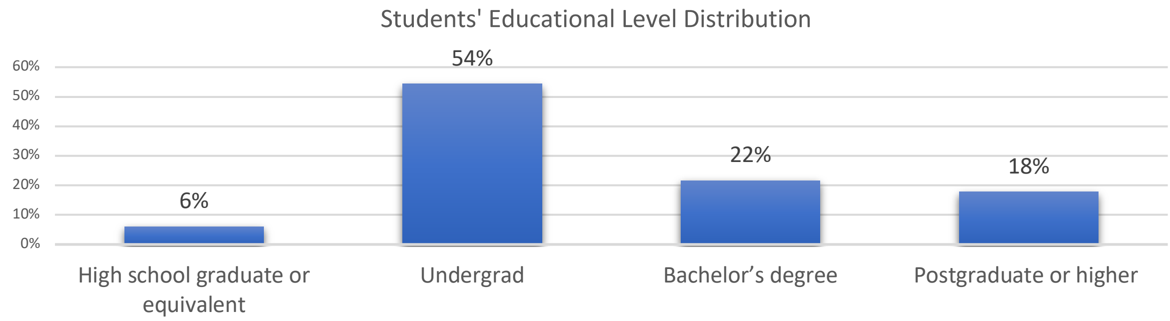

Figure 4.3, Study 1: Students' Educational Level Distribution

Field and Domain

When students were asked about their domains and fields the results (see Figure 4.4) reflect that most of the participants (51%) were studying science, technology, and engineering majors. On the other hand, as shown in Figure 10, an equivalent percentage of the sample i.e., 12% of the participants, were from two fields humanities and business majors. However, a quarter of the participants chose ‘Other’ as their choice which could be because the higher education students in Saudi Arabia have to finish their preparatory year in the university before they can be directed to the appropriate departments according to their grade point average Grade Point Average (GPA).

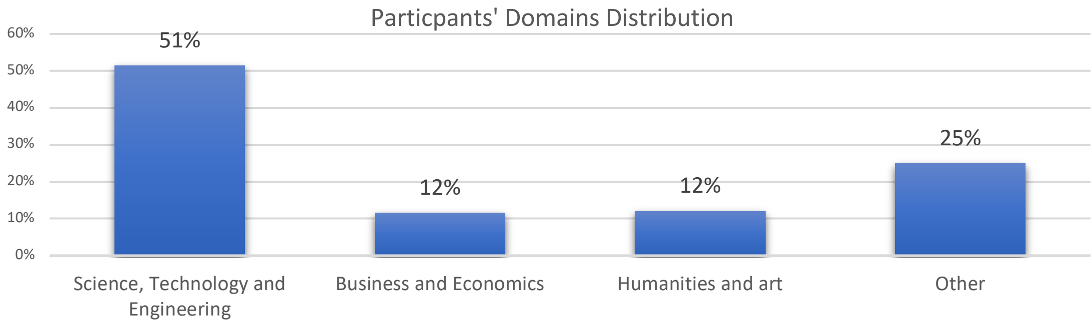

Figure 4.4, Study 1: Students' Domains Distribution

4.3.2 Part 2: Level of Knowledge and Previous Experience about Blockchain technology

In this section, the purpose was to investigate the participants' backgrounds and level of their prior knowledge and possible experience about blockchain technology. Moreover, this section of the questionnaire was designed to estimate the user's level of the participants to measure how this could affect adoption intention. This section consists of four aspects about the student's understanding and perception about Blockchain which are their knowledge, experiences, skills and training, and their views about the main factors influencing adoption.

Knowledge: First, the participants were asked to indicate their level of awareness about blockchain technology. The results, as shown in Figure 4.5, reflected that more than half of the participants (55%) didn't have any level of knowledge about the blockchain and only 32% of the sample revealed they had a moderate level of knowledge about blockchain. This is an unsurprising result given the sample's youth and status as students, which would affect their level of knowledge about a recent innovation such as blockchain technology.

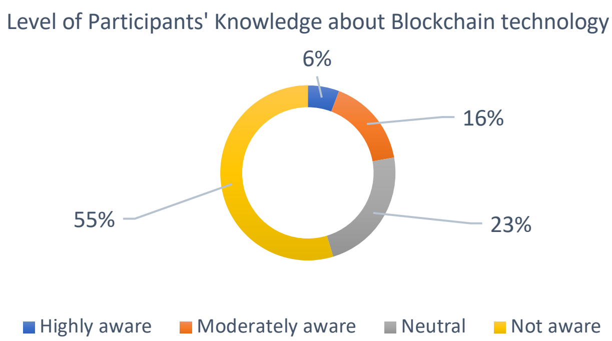

Figure 4.5. Study 1: Level of Students' knowledge about blockchain

Experience: The second aspect to be investigated in this part of the questionnaire was about the level of blockchain technology usage among this study's participants and aimed to measure the participants' experience of blockchain technology. As shown in Figure 4.6, the results showed that the majority of the participants had not used blockchain for any reason (90%). This lack of experience could be as result of the young age and student status of the participants as mentioned above.

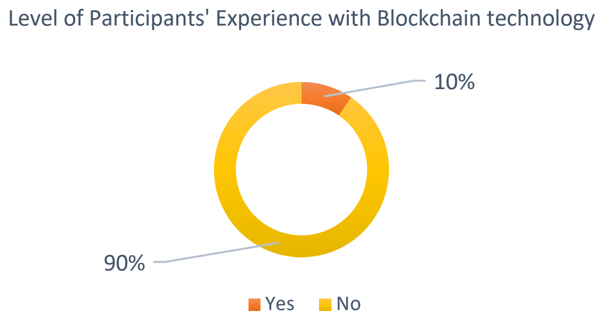

Figure 4.6. Study 1: Students' experience with blockchain technology

Skills and Training: The participants were asked about their opinion regarding any skills and training provided to them to use any aspect of blockchain technology. The skills and training refers to any type of workshops or not curriculum trainings the users may practice during their study. As presented in Figure 4.7, the results show that a total of 43% of students said they didn't have or rarely had adequate skills and training to use any aspect of blockchain technology. Furthermore, more than 50% of the responses indicated that participants were getting some training and skills to deal with such systems and 6% indicated they were having a regular program to enhance their level of skills and were receiving proper training to handle blockchain-based systems.

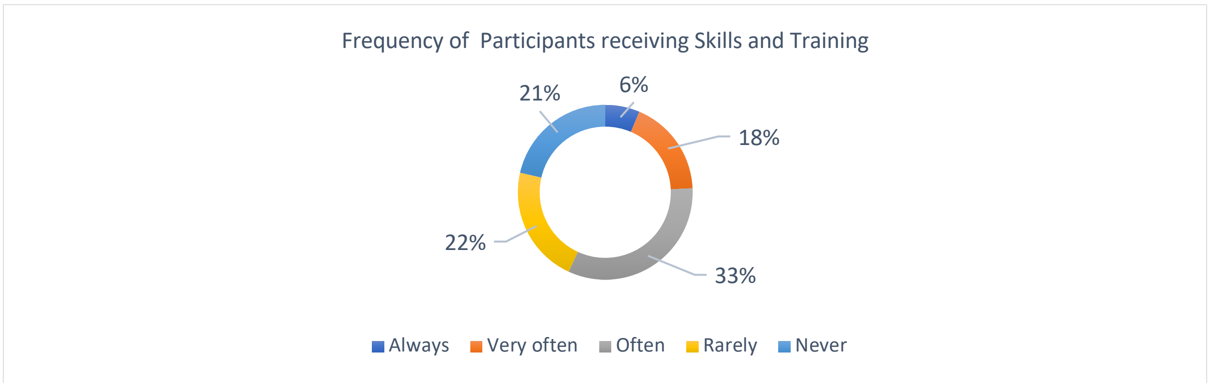

Figure 4.7. Study 1: Frequency of Participants receiving Skills and Training

Influential Factors: this section was designed to address the perceptions of the students regarding the factors affecting the adoption of blockchain technology in the field of higher education. Figure 4.8 shows the options that were given to the participants to choose from, where they could choose more than one factor. The figure also shows the percentages for their chosen options.

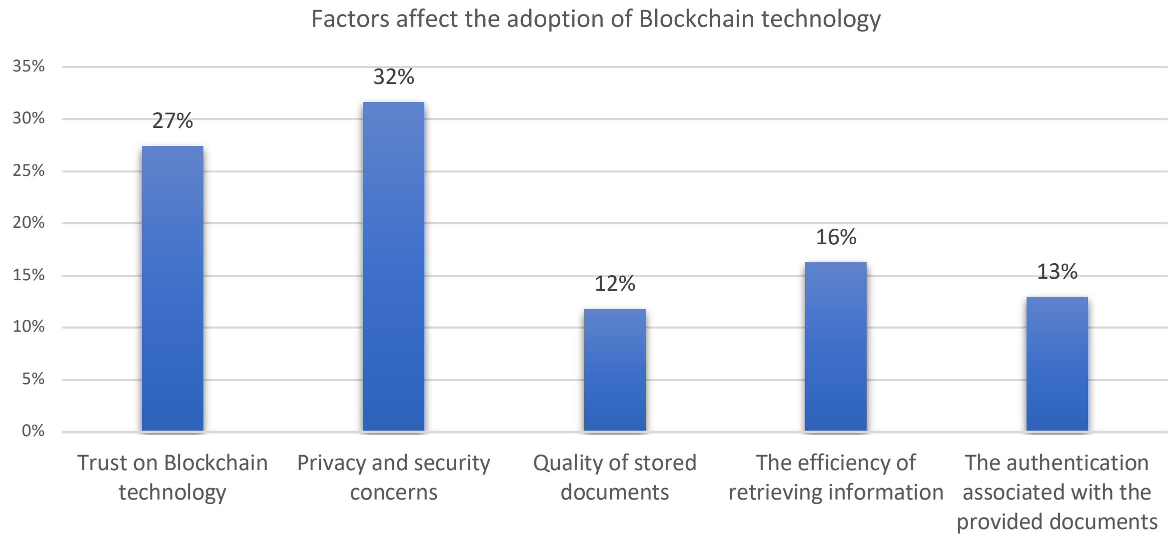

Figure 4.8. Study 1: Students' opinion about factors that affected Blockchain technology

Around 32% of participants considered privacy and security-related concerns as the most important factor would affect the adoption of the blockchain for the certification process. 28% of the respondents reported that their concerns about trust would play a huge role in their adoption of blockchain technology. As expected, trust played a huge role in deciding to adopt a new technology. For this reason, the research focused part of the study towards investigating the impact of trust on the adoption process. A total of 16% of the sample mentioned the efficiency of retrieving information; and 13% mentioned the authentication associated with the provided documents. Lastly, the quality of the documents in the blockchain was chosen by only 12% of the participants. These results indicate that the students have an acceptable level of understanding of the factors influencing blockchain adoption. The largest proportion of the sample agreed that concerns related to the privacy and security were important for adoption, which is a good indication of understanding in the sample since it is a major debate in the field of blockchain adoption.

4.3.3 Part 3: Existing System Issues

This section addresses the issues about the current handling of students' credentials in higher education institutes. It emphasises how this research articulates them as motivations for adopting blockchain technology and overcoming these problems. Figure 4.9 represents the main issues in generating the student's certificates in the higher education institutes that were given as options during the survey.

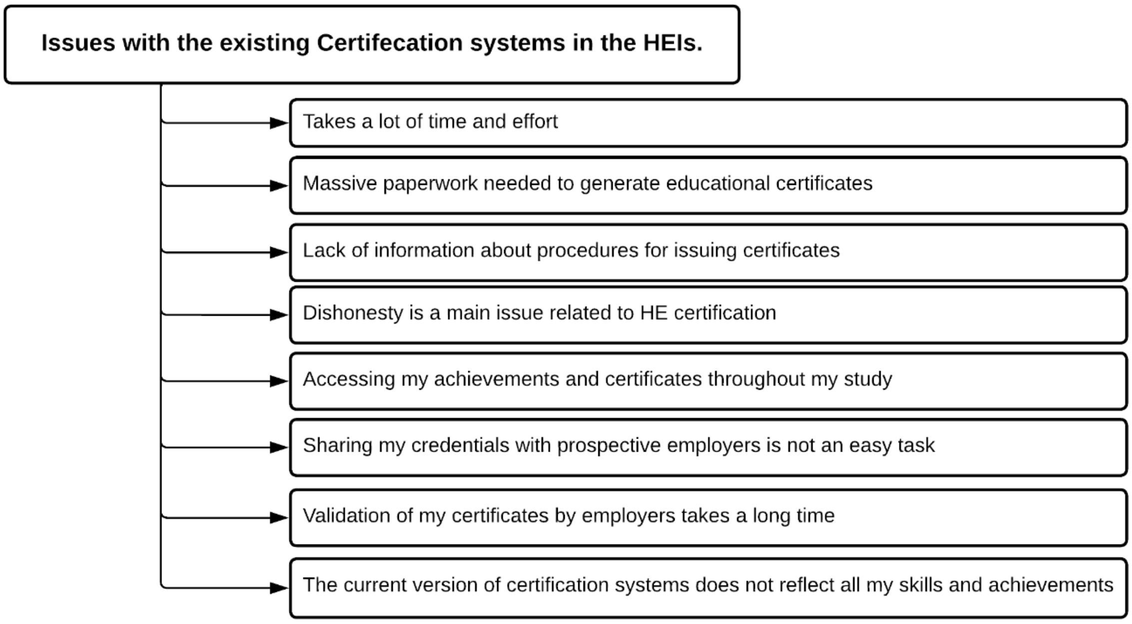

Figure 4.9: Problems and issues in the existing certification process in higher education

Figure 4.10 below details the results. The first statement was whether the current version of certification did not reflect the student's skills and achievements; and 57% of the students agreed with this perception of the current certification process while 36 percent were neutral. On the other hand, only 7% of the respondents disagreed with this statement and did not think the current system under-represented their achievements.

Another statement in this section, was about whether the current process of validating certificates by the employers was a time-consuming procedure. The result shows that the largest percentage (59%) of the sample agreed that this process in the current system takes time. Meanwhile, 30% were neutral and only 11% of the participants disagreed, which could reflect misunderstanding or lack of experience by some students regarding this process. After that, the students were asked about the process of sharing their credentials with a prospective employer; and whether they considered it a complicated process, especially as they have to share their certificates as hard, authenticated copies.

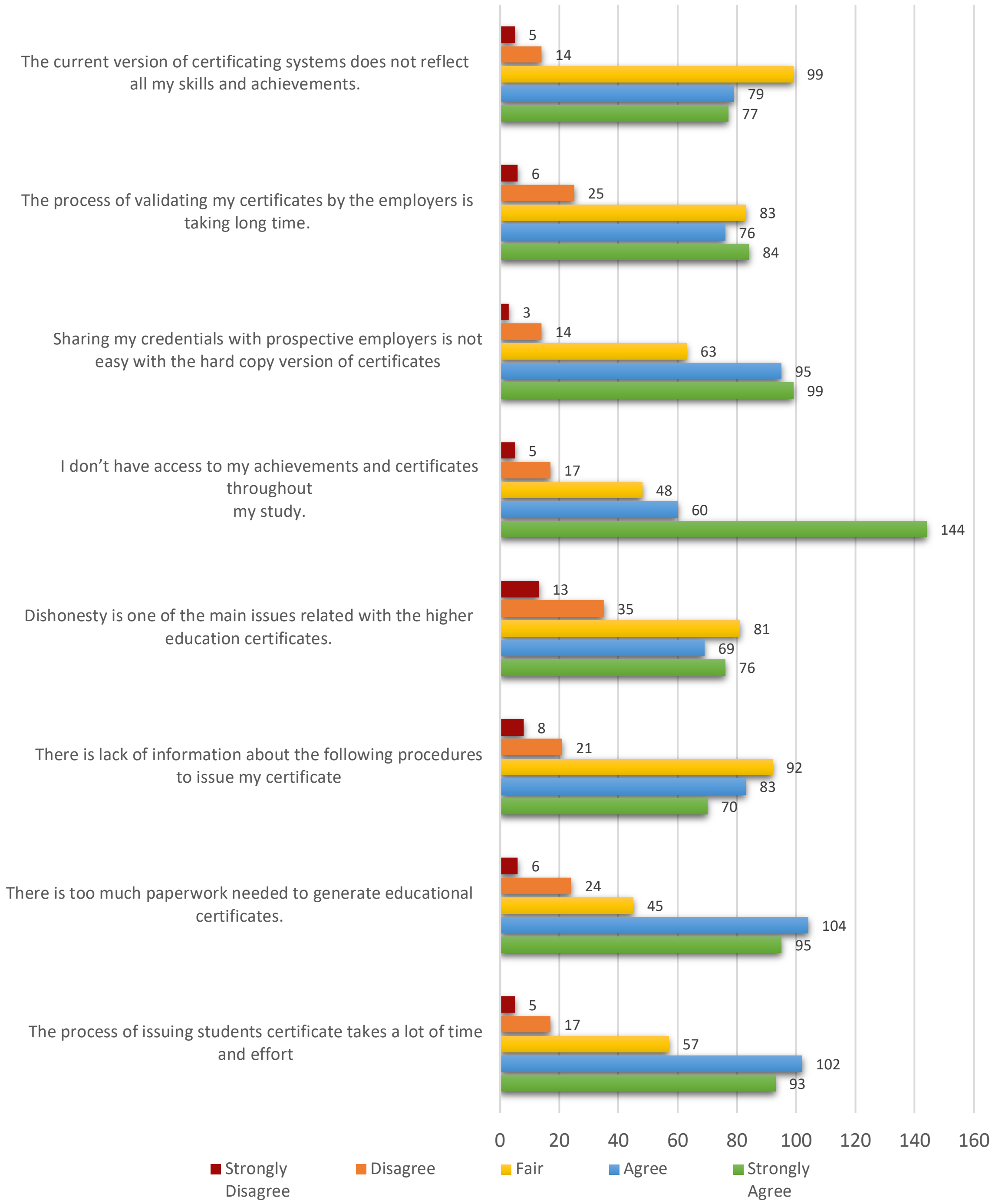

Figure 4.10. Study 1: Analysing the current issues with the existing systems for the student sample

The results showed that 71% of the sample agreed with this statement, and, thus, could have experienced this problem. Meanwhile, 23% of the participants were neutral and only 6%

disagreed with this being an issue in the current system. Regarding participants' opinions about whether the current system does not allow them to access their achievements and certificates during their study majority of the respondents (75%). On the other hand, only 8% disagreed with this statement and around 17% were neutral about this issue.

Dishonesty is considered as one of the primary issues related to higher education certificates and this explains the decision to put it as one of the main issues related to the existing certification systems. As mentioned in Chapter 1, many academic institutes have faced several cases concerning about this matter. The results reflect that around 53% agreed that this issue was one of the challenges affecting the current system. Furthermore, 30% of the participants were neutral; and only 17% of the respondents disagreed that this was an issue.

Another critical issue that the current system faces is the lack of information about the procedures required to issue students' certificates. The result indicates that 56% of the participants agreed this was an issue. Meanwhile, 34% of the students were neutral, and 10% disagreed. These responses might indicate that these participants did not find the procedures problematic or that they had yet to go through this process and understand the way it performs. The participants were also asked about their perceptions about whether there was too much paperwork needed to generate their educational certificates. The majority of the students (73%) agreed that this procedure required too much paperwork. However, 15% of the participants were neutral and around 12% disagreed with this being an issue in the existing system.

Lastly, when the participants were asked about their perceptions about if the current process of issuing students certificates requiring a lot of time and effort, the results show that 72% agreed with this statement. Meanwhile, 20% of the participants were neutral, and only 8% of the participants disagreed with this statement that the current system required a lot of time and effort. This could be because they hadn't gone through this process yet as they were still at the beginning of their higher education journey.

In conclusion, this part of the survey measured the students' perceptions about the existing issues and problems in the current certification systems in the HEIs in Saudi Arabia. The result of this investigation reveals that majority of the students (in excess of 70% of the whole sample) strongly agreed on the following issues: Firstly, that the process of issuing certificate is a time-consuming task and needs effort to be completed. Secondly, the current process needs too much paperwork in order to generate educational certificates. Thirdly, that the current system doesn't allow them to access their achievements and certificates easily during their studies. Finally, that sharing credentials with prospective employers was not an easy task (as it requires a hard copy version of certificates). These problems were those receiving the highest levels of agreement for this part of the study; which highlights those issues which can be solved by proposing the blockchain-based certification system, as addressed in Chapter 5.

4.3.4 Part 4: Factors affecting the adoption of blockchain technology in higher education

In the previous section, the results clearly revealed that students were largely unhappy with the existing certification system, which strongly shaped their perceptions towards adopting the new technology. This section in the questionnaire was designed to measure the impact of each factor on the proposed model for the adoption of blockchain technology in the certification process in the higher education sector from the students' perspectives. As discussed thoroughly in Chapter 3, the proposed model includes five factors that affect the adoption process, and which are listed and mapped in section 3.2.2. These factors, namely, trust, security and privacy, social influence and efficiency, were therefore investigated by survey, after the students had experienced the Decentralised Application of Smart Certificates (DASC) and the results were analysed to measure the student's intention to adopt the blockchain certification system.

Trust Factor (T)

Trust has been investigated in studies on the adoption of blockchain that involve handling, storing or processing sensitive information (Chivu et al., 2022),(Brookbanks & Parry, 2022),(Sander et al., 2018). Blockchain technology ensures data persistence since it is stored in a distributed manner, which means many copies of the same ledger are shared, updated and synced among nodes. Trust has been investigated among three measures, functionality and transparency, knowledge and useability, and ease of access and sharing. The students' participants were asked to rate their agreement with many statements regarding the trust factor and all the other related constructs.

- **Functionality and transparency (FT)**

The first measure of the trust factor was about the student participants' perceptions of the functionality and transparency of the proposed solution. Table 4.2 presents the statements included in the feedback questionnaire to be completed after the participants had experienced the DASC. As shown below, functionality and transparency were measured by six items. In the items (FT1) and (FT6), more than 66% of the students agreed that blockchain's transparency and its immutable features, made it a trustworthy technology for managing educational certificates; while more than 31% of the participants were neutral with very little disagreement. Additionally, as shown in Figure 4.11**,** 67% of the students believed that blockchain could handle all forms of academic credentials, transcripts and certificates (FT2).

Table 4.2: Study 1: The measures related to FT

Factor	Item Code	Statement
FT	FT1	Blockchain technology transparency makes it a suitable option for managing educational certificates.
	FT2	Blockchain technology can handle all forms of academic credentials, transcripts and students' certificates.
	FT3	Blockchain technology provides a high level of trust to students by eliminating the control of third parties.
	FT4	Adopting blockchain technology in higher education enables students to share their official documents directly with anyone requesting them.
	FT5	Blockchain technology embodies the learning outcomes and enhances the attainment of competencies within the educational scope.
	FT6	Blockchain technology's immutable features will give me full trust in the certificates provided.

Furthermore, 67% of the participants indicated that implementing a system that eliminates the control of third parties would increase their level of trust in blockchain technology; while, around 30% were neutral about this aspect of blockchain technology (FT3). Moreover, the data indicated that over 70% of students in the sample believed in the ability of blockchain technology to facilitate the sharing of their official documents directly with external parties; which indicates the need for this feature in the certification process, as only 26% were neutral and there was hardly any disagreement (FT4). Lastly, the results also revealed that 67% of the participants agreed about the ability of blockchain to help HEIs embody the learning outcomes and enhance the attainment of competencies within the educational scope (FT5).

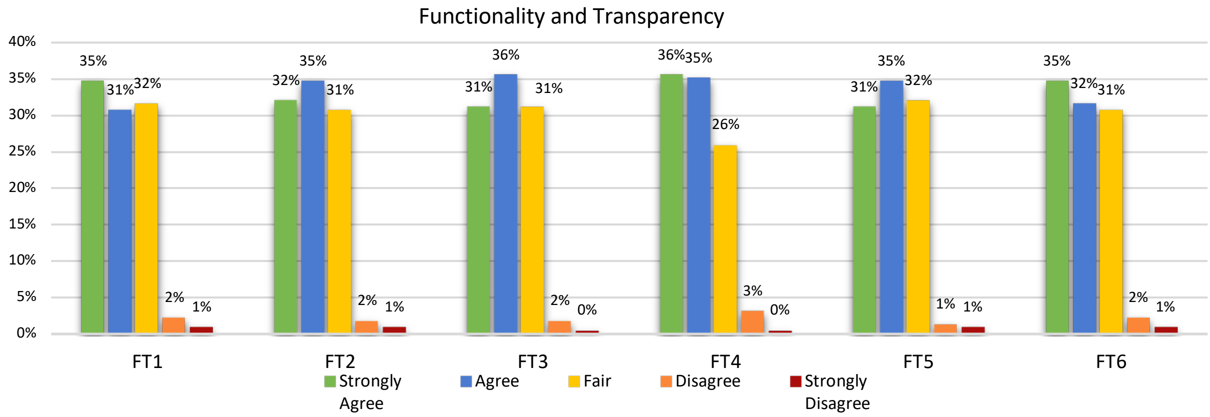

Figure 4.11. 1st Study Functionality and Transparency measures in the student sample

– Knowledge and Familiarity (KF)

The second measure of the trust factor was about the participants' knowledge and their attitudes to blockchain usability. Table 4.3 demonstrates the three measures used to investigate this factor and Figure 4.12 illustrates the collected results. Firstly, participants were asked about their familiarity with the benefits associated with using blockchain technology in the higher education, and the responses show that 41% indicated themselves as familiar with blockchain while 38% were neutral and 21% were unfamiliar (KF1). Thus, as expected, the result generally shows that the sample was not very familiar with the benefits of using blockchain in the higher education sector. Meanwhile, 38% of the respondents agreed with the statement about trusting blockchain even without any knowledge about its functionality. On the other hand, 42 percent were neutral and 20% disagreed thereby implying they wouldn't trust blockchain unless they understood its functionalities (KF2).

Table 4.3: Study 1: The measures related to KF in the student sample

Factor	Item Code	Statement
KF	KF1	I am familiar with the benefits associated with using blockchain technology in higher education.
	KF2	I trust blockchain technology even without any knowledge about its functionality.
	KF3	I am aware about how to get the information needed to understand the concept of blockchain technology.

The participants were asked if they aware of resources available to increase their knowledge about blockchain. The results indicated that 45% of the students agreed that they knew how to educate themselves about this technology. Meanwhile, more than half of the participant didn't know how to get the information to understand the concept and functionalities of blockchain (KF3). This raises a flag about the amount of effort that academic institutes have to do to spread the knowledge about this cutting-edge technology.

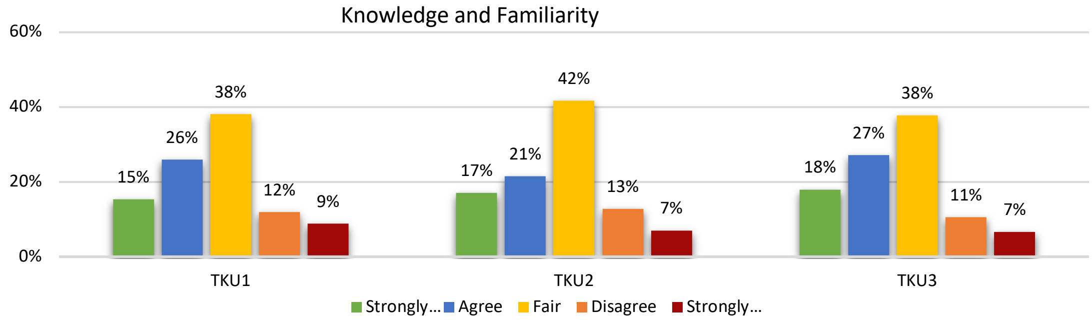

Figure 4.12. 1st Study KF measures in the student sample

- **Ease of Access and Sharing (EAS)**

This was the third measure investigating the factor of trust among participants in the student sample. It concerns the participants' views regarding their trust in blockchain to provide an easy way to access and share their certificates. Table 4.4 shows all the items related to this factor and Figure 4.13 provides all the results obtained for this factor. In terms of their views about easily accessing and sharing credentials via blockchain, most of the students (72%) agreed that blockchain technology offered full access to their certificates, while 25 percent were neutral (EAS1). Over 70% also agreed that blockchain enabled credentials to be shared conveniently with any prospective employers (EAS2). More than (70%) of students agreed blockchain would reduce the time and effort needed to control their credentials. On the other hand, quarter of the respondents were neutral about this statement, and less than 5% disagreed (EAS3).

Table 4.4: Study 1: The measures related to EAS in the student sample

Factor	Item Code	Statement
EAS	EAS1	Using blockchain technology will give me the full access to my certificates at any time.
	EAS2	Using blockchain technology will allow me to share my credentials with any prospective employers.
	EAS3	Using blockchain technology will reduce the time and effort in controlling my credentials.
	EAS4	Blockchain technology is useful, and the universities will be convinced to trust this technology and adopt it.

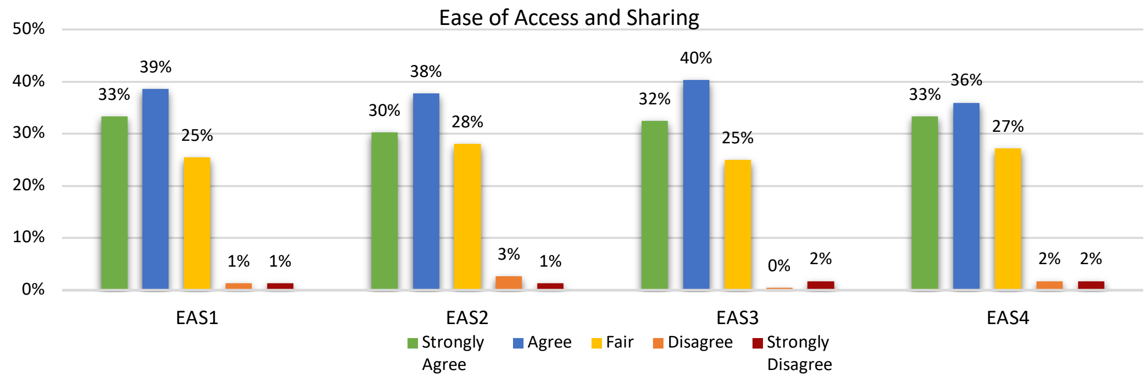

Figure 4.13. 1st Study EAS measures in the student sample

The participants were also asked about whether the usefulness of blockchain would convince HEIs to adopt it, the results indicated that majority of the students agreed and could realise the bright future of higher education certification systems after adopting blockchain technology (EAS4).

Security and Privacy Factor (SP)

This section was designed to measure the students' perceptions about security and privacy issues related to blockchain technology. This factor is considered to have a critical impact on users' intention to adopt blockchain, as discussed previously in Chapter 3 and as presented by this study (Sander et al., 2018). Therefore, the researcher investigated this construct through two factors, the perceived security, privacy, immutability and reliability of blockchain, and the perceived risk associated with this technology from the students' perspective.

- **Perceived security, privacy, immutability and reliability (PSP)**

A large number of participants (78%) agreed that security was an important benefit of integrating blockchain technology into higher education while (20%) were neutral (PSP1). Moreover, data from students indicated high agreement (more than 70%) regarding the ability of blockchain to offer high levels of security and privacy for smart certificates stored on the chain, including interactions between connected nodes, data protection and integrity (PSP2) (PSP3). Meanwhile, less than quarter of the participants were neutral regards this matter and very few disagreed. Figure 4.14 shows the results obtained in this section for all the items shown in Table 4.5. When the students were asked about the effect of blockchain security features on the employers and employment process by providing reliable, authentic, and transparent certificate, 75% of the participants agreed. Meanwhile, the disagreement level among these items was below 5% of the sample, which is considered a very low level (PSP4).

Table 4.5: Study 1: The measures related to PSP

Factor	Item Code	Statement
PSP	PSP1	Security is an important benefit of integrating blockchain technology in higher education.
	PSP2	Knowing that blockchain is maintaining high level of security includes data protection, integrity and privacy could affect my trust toward it.
	PSP3	Blockchain technology helps in attaining high levels of security and privacy for smart certificates stored on the chain that affect decisions about prospective employees' qualifications.
	PSP4	Blockchain technology enhances the prospective employees' certificates' reliability and transparency.
	PSP5	Blockchain technology can establish secure connections between all included parties and ease interactions between them.
	PSP6	Blockchain technology can be very useful in authenticating students' original identities as well as their smart certificates.

The large extent of agreement about the security and privacy-related items reflected the students' belief in the ability of blockchain to provide the certification systems with secure and transparent transactions (PSP5). Likewise, most of the participants believed in the usefulness of blockchain technology in authenticating student identities and smart certificates. The result for this item indicated that 74% of the respondents agreed on this fact about the blockchain while 22% were neutral and only 4% disagreed about this item (PSP6).

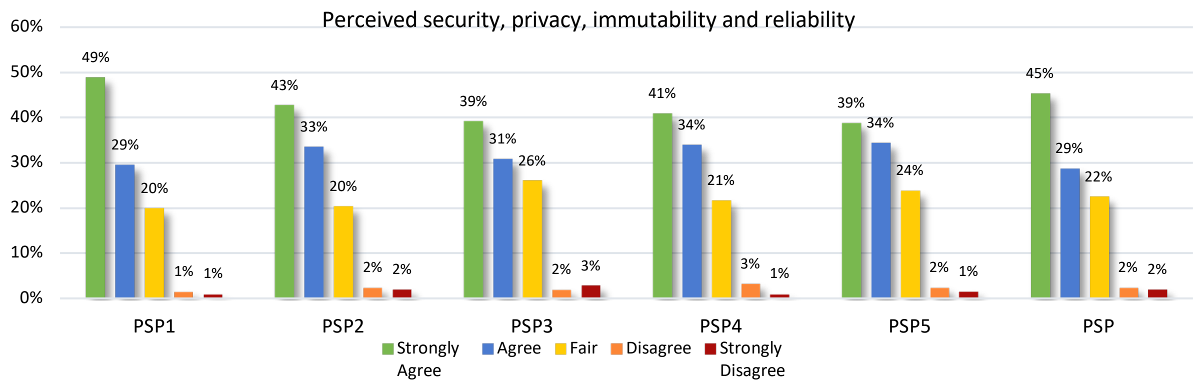

Figure 4.14. 1st Study PSP measures in the student sample

- **Perceived Risk (PR)**

This factor was measured by four items represented in Table 4.6 and the results were visually represented in Figure 4.15. In the matter of perceived risk assessment in this study, most participants were neutral about seeing blockchain as a risk to their privacy or security when adopting smart certificates, while 49% agreed it was no risk (PR1). However, 54% indicated a high level of confidence about sharing their credentials through a blockchain-based system, around 40% were neutral and only 6% disagreed (PR2).

Table 4.6: Study 1: The measures related to PR in the student sample

Factor	Item Code	Statement
PR	PR1	I think using blockchain technology would not risk my privacy or security.
	PR2	I feel very confident while using and sharing my credentials through blockchain technology.
	PR3	I will use my smart certificate in the blockchain even if I have no idea about its security.
	PR4	I feel my information is secured if I can control who is seeing my credentials.

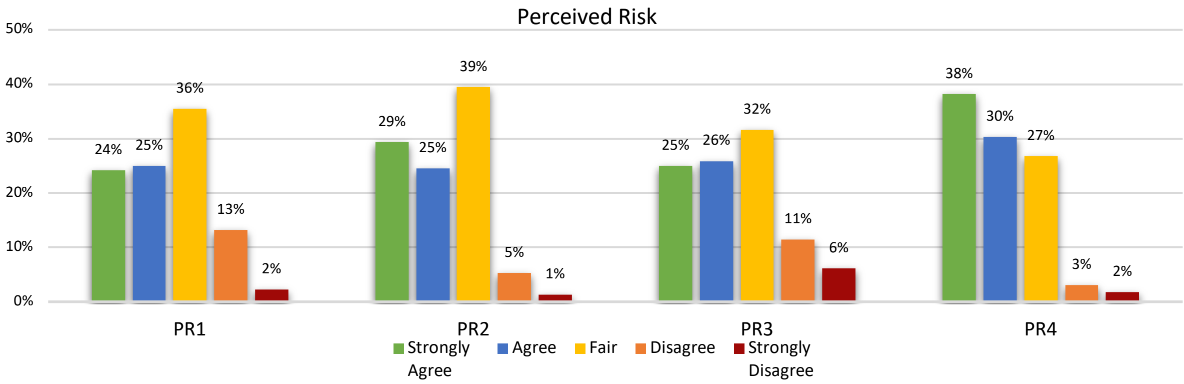

Figure 4.15. 1st Study PR measures in the student sample

Moreover, most of the participating students (51%) agreed with the statement that they could guarantee the security of their certificate if they could control and grant access to authorised parties (PR4). Thus, privacy and security are seen as crucial when handling personal and important data such as students' credentials, especially with regards to blockchain (Halpin & Piekarska, 2017), which possibly accounts for the high number of participants remaining neutral as they may not be sure of what the risks to their security and privacy actually are.

Social Influence Factor (SI)

The social influence factor for this study focuses on the students' perceptions of the social impact of blockchain and how social motivations can encourage the intention to adopt blockchain technology in higher education certification processes. Firstly, the students were asked their opinions about the impact of adopting blockchain in providing the society with promising careers chances (S11). The results show that 64% of the respondents agreed while

30% were neutral, as shown in Table 4.7. Also, most participants (75%) agreed that blockchain adoption in certain higher education institutions would encourage others to seek to attain the same transparency level, thereby having a tremendous effect on adoption decisions (S12). Moreover, a large number of students (67%) agreed that the transparency and immutability of a blockchain-based certification system would encourage students to build a high level of skills and acquire the qualifications that are recorded and help them take advantage of career opportunities (S13).

Additionally, most of the participants (67%) believed that the reputation of blockchain technology in various fields motivates higher education institutions to adopt DLT (S14) [44], argued that social influence is a major factor to investigate when exploring intention to adopt new technology. Hence, as expected, this study's results emphasize that in a higher education context such as that of Saudi Arabia, this factor has a substantial impact in moving the certification process to under the DLT umbrella.

Table 4.7: Study 1: The measures related to SI in the student sample

Factor	Item Code	Statement
SI	SI1	Adopting blockchain technology creates better careers opportunities for me.
	SI2	Adopting blockchain technology encourages other educational institutes to have the same transparency level to their outcomes.
	SI3	Adopting blockchain technology encourages students in building the productive skills needed to support their career decisions.
	SI4	Blockchain technology's reputation in various fields, should encourage higher education to adopt it.

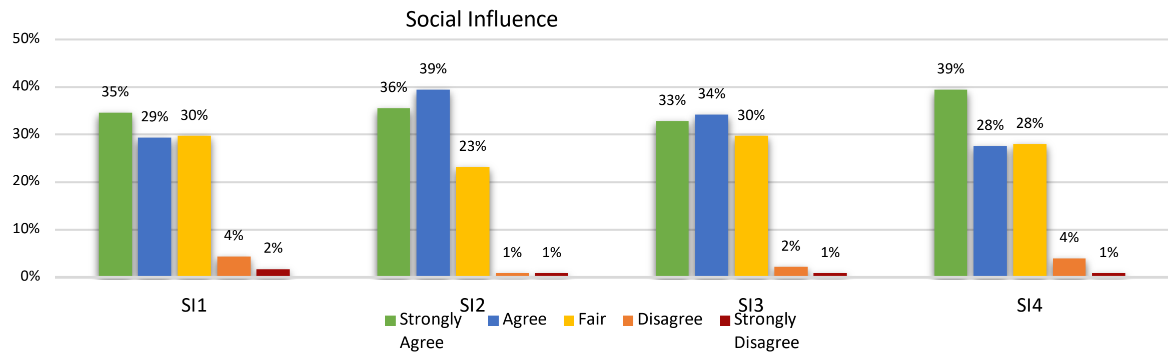

Figure 4.16.1st Study SI measures in the student sample

User Awareness (AW)

The students' perceptions about the impact of user awareness on their intention to adopt blockchain, were measured by four items which are represented in Table 4.8. First, participants were asked if adopting blockchain in the certification process was possible, in order to check their awareness about the different deployments of this technology. The results showed that 75% agreed that using this cutting-edge technology was possible, while only 21% were neutral (AW1). Furthermore, most of the participants (69%) believed that integration of a blockchain-based system with the current systems would not be a barrier facing the adoption process (AW2).

Table 4.8:Study 1: The measures related to AW in the student sample

Factor	Item Code	Statement
AW	AW1	Blockchain technology can be adopted for generating and validating students' certificates.
	AW2	Adoption of blockchain technology will allow the institutes to easily integrate it with existing centralized systems.
	AW3	I have a good perception of the advantages of adopting blockchain in higher education institutes.
	AW4	I am aware about the challenges that prevent adopting blockchain in higher education institutes

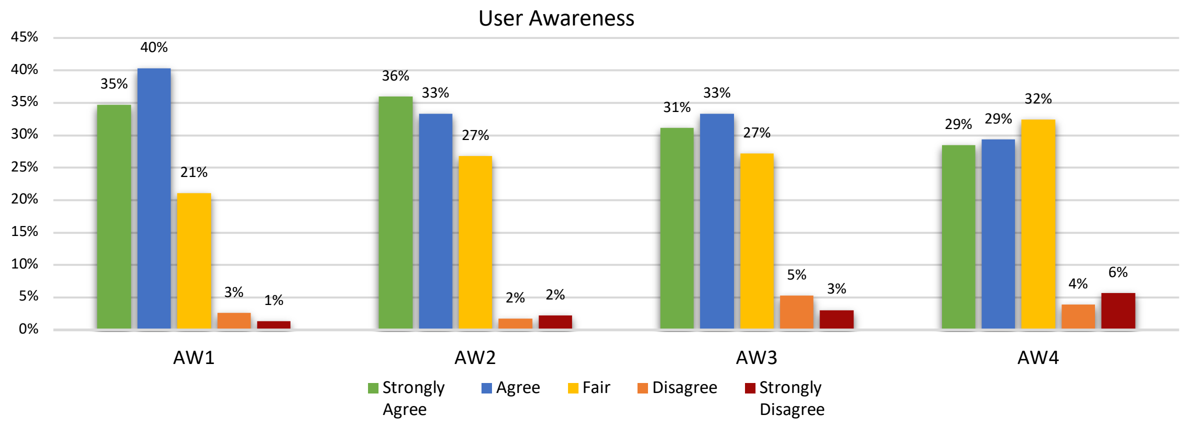

Figure 4.17. 1st Study AW measurements in the student sample

However, 64% of the participating students believed they had a good level of awareness and familiarity with the benefits provided by DLT in the higher education sector (AW3). Lastly, in the item on user awareness of the challenges preventing the adoption of blockchain, more than half the participants thought they had an adequate perception of the challenges of blockchain adoption in higher education (AW4). Accordingly, to ease the process of adopting the concept of smart certificates based on DLT, higher education institutions must improve awareness of the technology among students and other stakeholders.

Efficiency Factor (EF)

In the section on efficiency and cost, the students' perception regarding the efficiency provided by deploying blockchain technology in the certification process was investigated to measure how this affected their intention to adopt this technology.

- **Efficient smart certificate (ESC)**

The first factor in the efficiency section was about the benefits brought by using an efficient smart certificate. It was measured by six items (see Table 4.9 and the results represented in Figure 4.18). This study's results emphasized the importance of the efficiency of the smart certificate produced by DLT in terms of the students' insights about the technology. The results showed that 77% of the respondents believe in the promising idea of the ESC and how it would ease their future search for a career by offering an efficient sharable certification system (ESC1).

Table 4.9: Study 1: The measures related to ESC in the student sample

Factor	Item Code	Statement
ESC	ESC1	Blockchain technology offers an efficient sharable system among employers and students.
	ESC2	Blockchain technology improves the process of generating student records.
	ESC3	Blockchain technology enhances the process of validating students' certificates.
	ESC4	Blockchain technology provides an efficient smart certificate that the student has full access to and control over.
	ESC5	Blockchain technology broadens my approach to other institutions, and I can easily share my educational credentials without any physical barriers.
	ESC6	Blockchain technology helps in managing and measuring the qualification-earning activities in the institution, thus, increasing the overall efficiency of the organization.

More than 74% of the sample agreed that the proposed certification system offered students efficient, sharable, validated, standardized, accessible and effortless credentials. While, around quarter of the respondents were neutral and there was a low percentage of disagreement (ESC2) (ESC3). Moreover, over 70% agreed that using blockchain-based certification systems allowed them to broaden their approach to other academic institutions by the enhanced sharing tasked of educational credentials without any barriers. Meanwhile, 25% were neutral regarding this feature and only 2% disagreed (ESC5).

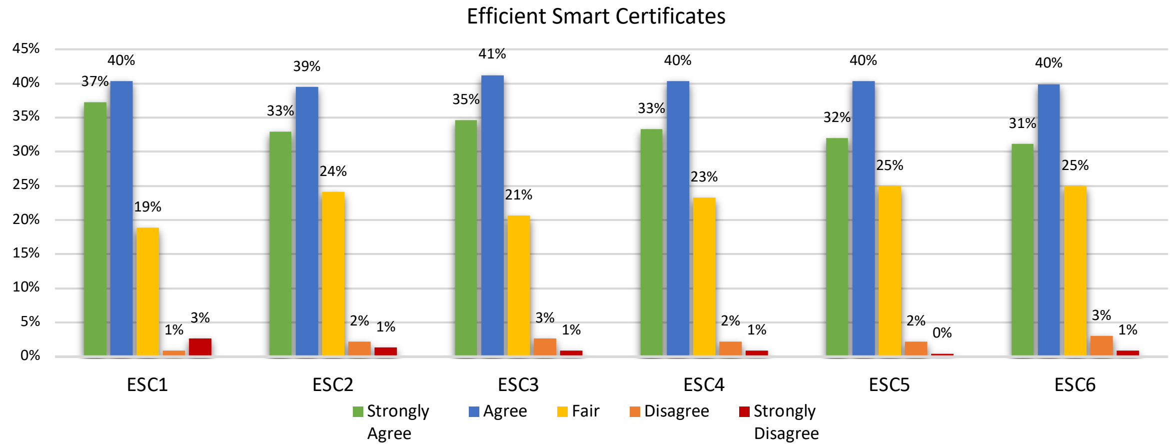

Figure 4.18. 1st Study ESC measures in the student sample

Additionally, 71% of the students agreed that blockchain transparency allow the parties involved to monitor and audit the qualification-earning process, and thus made the HE institution more efficient (ESC6). Thus, the findings for this part of the study are very significant. And there was a high level of agreement about the concept of ESC and its various features.

– **Cost Reduction (CR)**

From the point of view of efficiency, it is important not to forget the value of reducing the cost and time associated with the process of generating the certificates. This factor was measured by three items as shown in Table 4.10, and the obtained results from the students' sample is visually presented in Figure 4.19. In the matter of blockchain reducing the cost associated with the process of generating the students' certificates and the expenses of the centralized data storage the results showed the majority of the respondents (73%) agreed, and around 22% were neutral with a very low number of responses that disagreed (CR1). Low percentage of the students disagreed with the statements related to the blockchain cost and time reduction statements, while more than (70%) agreed, that approach the value of blockchain that is noticed by the students' sample (CR2) (CR3).

Table 4.10: Study 1: The measures related to CR in the student sample

Factor	Item Code	Statement
CR	CR1	Blockchain technology reduces the cost associated with the process of generating and maintaining the students' certificates.
	CR2	Blockchain technology accelerates the time needed to issue the students' certificates.

CR3	Blockchain technology can help reduce the unnecessary cost associated with the transactions and centralized data storage.

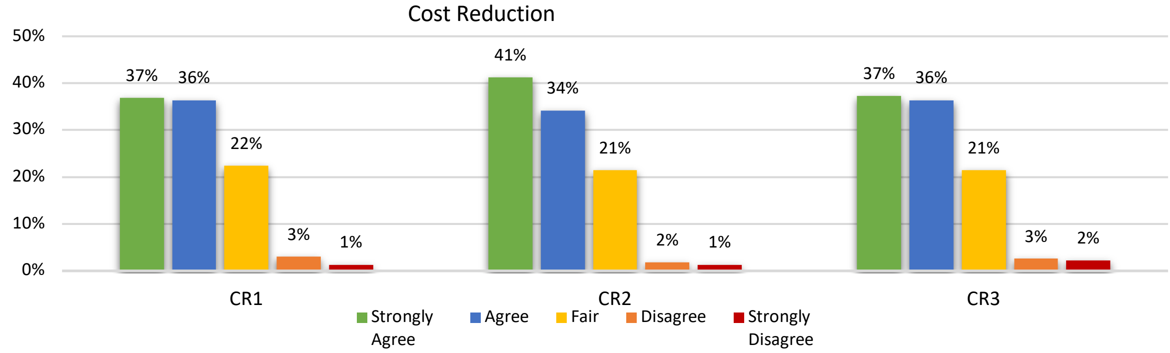

Figure 4.19. 1st Study CR measures in the student sample

To sum up, the data obtained from student sample indicate that the efficiency and cost reduction factors positively influence the acceptance of blockchain technology and the student's intention to adopt it for the certification process.

4.4 Inferential statistical analysis and hypotheses assessment from the students' perspective

In the previous section, an in-depth detailed exploration of the data acquired from the student sample was provided. All the questionnaire items were reviewed and analysed separately to provide a comprehensive picture of the students' views, beliefs and use behaviours. This section presents a descriptive analysis which indicates the possible impact of the hypothesized parameters on the students' degree of adoption intention towards blockchain technology. The descriptive analysis results, comprising the mean, standard deviation, standard error and the result interpretation, will be given in this part to identify the effect of each of the recommended parameters. Furthermore, the relationships between the independent variables (factors) and dependent variable (intention to adopt blockchain) will also be examined. To examine the links between the study model constructs, the correlation coefficient for each hypothesized associated must be obtained. The correlation and tests processes were covered in Chapter 3 of the Research Methodology. The results of these analyses will be used to assess if each of the stated hypotheses of this research is accepted or rejected.

4.4.1 Trust (T)

As described in Chapter 3, Trust has a major impact on the user's intention to adopt blockchain technology. Thus, this research considers trust as one of the important measures of adoption in the certification process. This construct involves three factors in the students' sample, namely, functionality and transparency, knowledge and usability, and ease of access and sharing.

Table 4.11: Study 1: Summary of the descriptive analysis of Trust from the students' perspective

Construct	N	No. of Items	Mean	S.D.	S. E.	Results Interpretation
Trust (T)	**405**	**13**	2.60	.67	**.032**	Moderately Influential
Functionality and Transparency	405	6	2.46	.74	.37	Influential
Knowledge and Familiarity	405	3	2.82	.74	.36	Moderately Influential
Ease of Access and Sharing	405	4	2.45	.78	.38	Influential

To attain an overall mean for each factor, as shown in Table 4.11, the scores from each factor's items were averaged. This section contains the results of the descriptive analysis of each factor with an interpretation of all finding results (see Table 4.11). Moreover, this section is devoted to statistically investigating the influence of trust-related factors on the students' intention to adopt blockchain in the certification process and to discuss all the findings.

Table 4.12. Study 1: Normal Distribution results for TU in the student sample

Construct	No. of Items	Shapiro-Wilk	Skewness Statistic	Kurtosis Statistic
Intention To Adopt	**2**	**.834**	**-.416**	**1.51**
Trust (TU)	**13**	**.835**	**-.772**	**.236**
FT	6	.784	-.763	-.393
KF	3	.829	-.312	1.72
EAS	4	.790	-.530	-.132

According to the results, the average mean value for the trust factor with all the involved elements under it was moderately influential, with an indication of some concerns about the user's knowledge related to the functionality of blockchain technology. Moreover, the normal distribution among the trust construct and its related factors was calculated, as shown in Table 4.12. These results and findings are interpreted to assess the proposed hypothesised relationships for this construct. To test the proposed hypothesis related to each sub-factor under the trust construct, the author dedicated the following sections to measuring and interpreting all the inferential analyses.

Functionality and Transparency (FT)

> ***H1a:*** *Blockchain technology's* ***functionality and transparency*** *positively influence user* ***trust*** *toward blockchain adoption for the certification process.*

From the descriptive analysis results, the FT of blockchain has a positive impact on influencing students to trust blockchain-based systems. The composite score of FT (**M**=2.46) indicates a positive influence on the student's trust towards the blockchain technology. Thus, the hypothesized relationship (**H1a**) between the FT of blockchain technology and trust in the technology is statistically valid according to the descriptive analysis. Moreover, the correlation between FT and Trust in the blockchain from the students' perspective was calculated to discover and validate the strength and direction of the relationship. Before applying the correlation test, the normality distribution for both variables was checked using the Shapiro-Wilk test. The results showed the data was normally disturbed with values $p > .05$ as represented in Table 4.12. Since the data was normally distributed and the sample was considered large, a Pearson Correlation was run to determine and evaluate the relationship between Trust and FT. The result revealed a very strong positive correlation between these two variables ($r = .905$, n = 405, $p < .001$) and this correlation was found to be statistically significant. This indicates that among the participating students, a high level of understanding blockchain functionality and transparency is associated with a high level of trust in blockchain-based systems. Therefore, the results indicate the hypothesis (**H1a**) for the FT factor is valid and supported.

Knowledge and Familiarity (KF)

> ***H1b:*** *User* ***knowledge and familiarity*** *about blockchain positively influences user* ***trust*** *toward blockchain adoption for the certification process.*

The result of the descriptive analysis for KF shows that it has a positive influence on students trusting blockchain-based certification systems. The composite score obtained for this factor was 2.82 which indicates a moderate influence on the students' trust in blockchain technology. These findings validate the hypothesized relationship (**H1b**) between the KF of blockchain technology and trust in the technology. To statistically support this result and support the hypothesis, a correlation test was run to assess the relationship between these variables. First, the normality distribution was tested and, according to the values presented in Table 4.12, the two variables were normally distributed as evaluated by the Shapiro-Wilk test, $p > .05$.

Therefore, Pearson's correlation test was used to determine the strength and direction of the relationship. The variables Trust and KF were significantly and strongly positive correlated ($r = .805$, n = 405, $p < .001$). The result demonstrates a strong relationship between the students being familiar with blockchain and trusting it which leads to their intention to adopt this technology. Thus, the hypothesis (**H1b**) that suggest positive relationship between Trust and KF is valid and supported by these findings.

Ease of Access and Sharing (EAS)

> ***H1c:*** *Easy* ***access and convenient sharing*** *of student credentials positively influence user* ***trust*** *toward blockchain adoption for the certification process.*

The main transactions while dealing with certification system is the ability of students to access and share their certificates. Thus, EAS was investigated and related to the trust factor in order to study its impact on the students' intention to adopt a blockchain-based certification system. Table 4.11 shows the descriptive analysis that was conducted on this factor and the composite score (**M**= 2.45) that indicates a positive influence of EAS on the students' trust in blockchain adoption for the certification process. Accordingly, the assumed hypothesis regarding the relationship between these two factors is valid.

Moreover, to analyse the relationship between trust and EAS with blockchain, a correlation test was used to determine the strength and direction of relationship. Prior to utilising the correlation coefficient test, the researcher checked the normal distribution test for the two variables, the results in Table 4.12 indicate the two variables were normally distributed as evaluated by Shapiro-Wilk test, $p > .05$. Then, the researcher computed the Pearson's correlation test to validate the hypothesised relationship between these variables. The result shows the variables Trust and EAS had a strong and significant positive correlation ($r = .925$, n = 405, $p < .001$). Thus, hypothesis (**H1c**) between EAS and Trust from the student perspective was supported and valid.

Lastly, this section investigates the hypothesis related to student trust and its impact on the user intention to adopt blockchain. From the descriptive analysis of the trust factor shown in Table 4.11, the composite score was 2.6 which indicates a moderate positive influence on the students' intention of adopting blockchain for the certification process. After that, Pearson's coefficient correlation was used to validate the relationship between Trust and students' intention to adopt blockchain for the certification process and to check the strength and the direction of this relationship. The results reflect that trust and students' intention to adopt blockchain have a significant positive correlation (r= .642, n = 405, $p < .001$). Consequently, the assumed relationship in the below hypothesis (**H1**) is valid and supported by this research.

H1. *In the certification process in the higher education sector, an increase in the level of* ***trust*** *toward blockchain technology will increase users'* ***intention to adopt blockchain technology****, given that trust is considered a major determinant of user acceptance*.

Table 4.13 presents the overall results of the correlation coefficient test applied to the trust related factors to test the validity of the aforementioned hypothesised relationships. Figure 4.20 graphically represents the relationship between these variables. SPSS was used to demonstrate the Scarlett plot graph which illustrates there is a strong positive relationship between these factors. A fit line has been used to represent an increase in trust in blockchain due to a large increase in students' intention to adopt it.

Table 4.13. Validating the research Hypotheses of TU by calculating correlation results

Variables Relationship (Hypothesis)	Correlation Coefficient	Sig. (p)	Hypothesis Validation	Results interpretation
TU → Blockchain Adoption	**$.642^{**}$**	**0**	**Yes**	Strong positive relationship
FT → TU	$.905^{**}$	0	Yes	Strong positive relationship
KF→ TU	$.805^{**}$	0	Yes	Strong positive relationship
EAS→ TU	$.925^{**}$	0	Yes	Strong positive relationship

**Correlation is significant at the 0.01 level (2-tailed).

To support the findings of this section, the researcher combined it with some of the interviewees' inputs from the qualitative phase of this research. All the participating head managers in the academic institutes concurred about considering blockchain as a trustworthy technical solution to overcome the current issues in the certification process. One of the interviewed IT vice-chairs said: "*I see great potential and great value. The technology would improve trust, authentication, transparency and security, and help to overcome some* *shortcomings from the current system as it is easy to validate.”.* Therefore, leveraging the higher education sector with innovative technology such as blockchain would be highly recommended and implemented by the high-level management in academic institutes who trusted this technology.

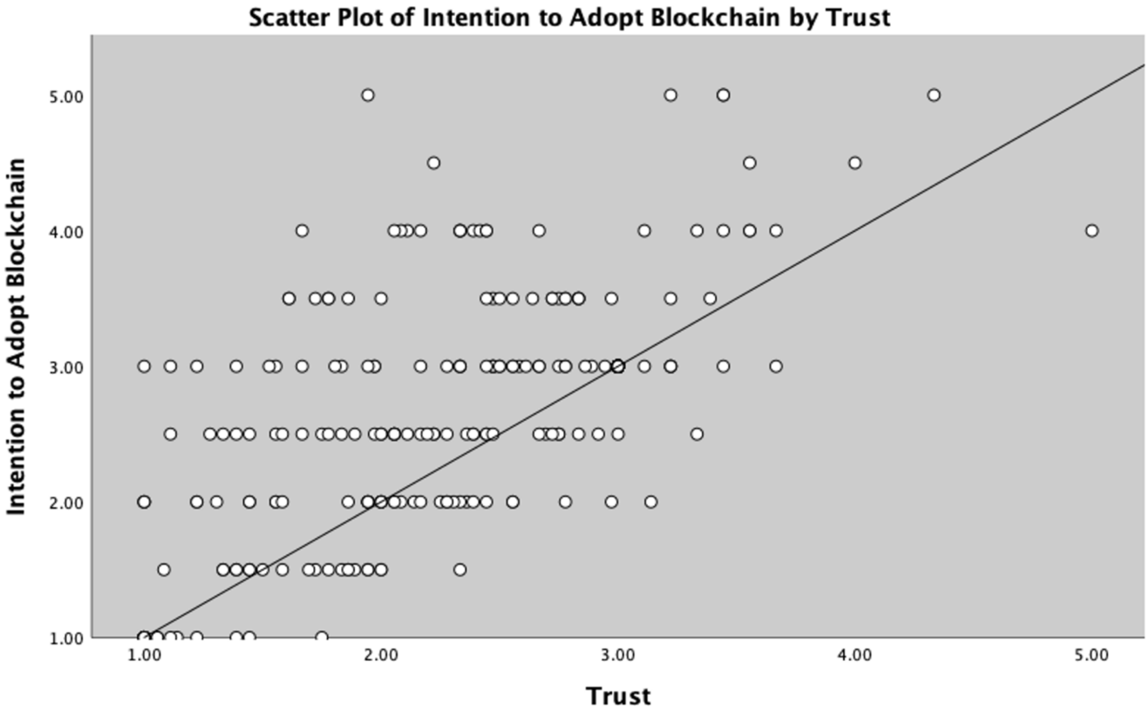

Figure 4.20, Representation of the relationship between T and Intention to Adopt Blockchain

To sum up, trusting innovative technology such as blockchain plays an important role in the students accepting and intending to adopt this technology in the certification process which, to them, is a very vital transaction.

4.4.2 Security and Privacy (SP)

In the matter of adopting new technologies, users are often concerned about how this technology could maintain their privacy and secure their information. Thus, this research considers SP as important factor in the adoption of blockchain for the certification process. This factor consists of two subfactors: PSP and PR, and inferential analysis was conducted to determine the hypothesised relationship of SP on students’ intention to adopt a blockchain-based certification system.

Table 4.14: Summary of the descriptive analysis of SP factors from the students' perspective

Construct	N	No. of Items	Mean	S.D.	S. E.	Results interpretation
Security and Privacy (SP)	**405**	**10**	**2.56**	**.649**	**.032**	Influential
PSP	405	6	2.45	.773	.384	Influential
PR	405	4	2.67	.629	.031	Moderately Influential

The descriptive analysis results applied to the SP related factors are shown in Table 4.14 which reveals that all these factors are influential on the students' intention to adopt blockchain for the certification process.

Table 4.15, Normal Distribution results for SP related factors

Construct	No. of Items	Shapiro-Wilk	Skewness Statistic	Kurtosis Statistic
Intention To Adopt	**2**	**.834**	**-.416**	**1.51**
Security and Privacy (SP)	**10**	**.771**	**-.926**	**.300**
PSP	6	.763	-.742	-.564
PR	4	.739	-1.22	1.50

Moreover, Table 4.15 contains the findings of the normal distribution test that indicated the data among these factors were normally distributed. The following contains a discussion of each sub-factor with the validity of its related hypothesis.

Perceived security, privacy, immutability and reliability (PSP)

> ***H2a:*** *Perceiving security features of blockchain technology* ***(privacy, immutability, security and reliability)*** *positively influences users' understanding of the level of* ***security and privacy*** *provided by blockchain technology for the certification process.*

The PSP factor of the blockchain technology used in this study was measured by a total of six items. These features were combined as they are the most important characteristics of blockchain technology. From the descriptive analysis performed on this factor it was found that the composite score (M = 2.45) reflects a positive influence of PSP on the SP that would lead to reveal the relationship to the student's intention to adopting blockchain. Since the data were normally distributed among these factors, as measured by Shapiro-Wilk $p>.05$, Pearson's correlation coefficient test was then applied to validate the strength and direction of the relationship between SP and PSP. The result revealed that the relationship between these factors was strongly positive and there was a statistically significant correlation as (r= .940, n

= 405, $p < .001$). Thus, an increase on students' perceptions about these features of blockchain technology, leads to increase level of their intention to adopt a blockchain-based certification system. Consequently, the proposed hypothesized relationship (**H2a**) is valid and supported by the findings of this research.

Perceived Risk (PR)

> ***H2c**: The **perception of low risk** associated with the use of blockchain technology positively influences users' understanding of the level of **security and privacy** provided by blockchain technology for the certification process.*

This section is about statically checking the validity of the proposed hypothesis as stated above. PR is composite of four items that are used to measure the students' intention to adopt blockchain certification system. By interpreting the descriptive analysis results as presented in Table 4.16, the composite score (**M**=2.67) reflects a moderate positive influence of PR on the students' perceptions about SP. Lastly, the researcher performed the correlation test to gauge the statistical analysis, then fulfil the validation process of the hypothesized relationship. The Pearson correlation coefficient test was selected to examine the relationship, and found that there was a strongly positive correlation which was statistically significant as (r=.908, n=405, p <.001) as represented in Table 4.16. Therefore, the hypothesis (**H2c**) is valid and supported by this study.

Table 4.16. Validating the research Hypotheses of SP by calculating correlation results

Variables Relationship (Hypothesis)	Correlation Coefficient	Sig. (p)	Hypothesis Validation	Results interpretation
SP → Blockchain Adoption	**.611****	**0**	**Yes**	Strong positive relationship
PSP→ SP	.940**	0	Yes	Strong positive relationship
PR → SP	.908**	0	Yes	Strong negative relationship

**Correlation is significant at the 0.01 level (2-tailed).

To conclude the SP factors, the relationship between SP and students' intention to adopt the blockchain for the certification process need to be investigated. The proposed relationship between these factors is represented by the following hypothesis:

> ***H2:** In the certification process in the higher education sector, an increase in understanding the level of **security and privacy** provided by blockchain technology will increase users' **intention to adopt blockchain technology**, given that this allows for better maintenance of student certificates.*

From the descriptive analysis section, it seems that SP has a positive influence on the students' intention to adopt blockchain where the composite score was (**M**=2.56). Thus, the hypothesis above is supported but the researcher need to verify it more with the statistical analysis findings. Moreover, the correlation between SP and the student's intention to adopt blockchain in the certification process was assessed by Pearson's correlation test. It was found that there was a positive correlation between these two variables as (r= .611, n = 405, p < .001) which was statistically significant. Accordingly, the research hypothesis related to this construct (**H2**) is valid. Figure 4.21 illustrates the trend line representing the relationship between SP and the students' intention to adopt blockchain for the certification process. Thereby, an increase in the level of students recognizing the security and privacy concerns about blockchain, increased the level in their intention to adopt this technology for the certification process.

The results obtained from the descriptive and statistical analyses, were supported by the interview findings. One of the interviewees said, *"I'm unsure about new technology concerns, but any new technology has to go through the cybersecurity authority for data management and systems management regulations."*.

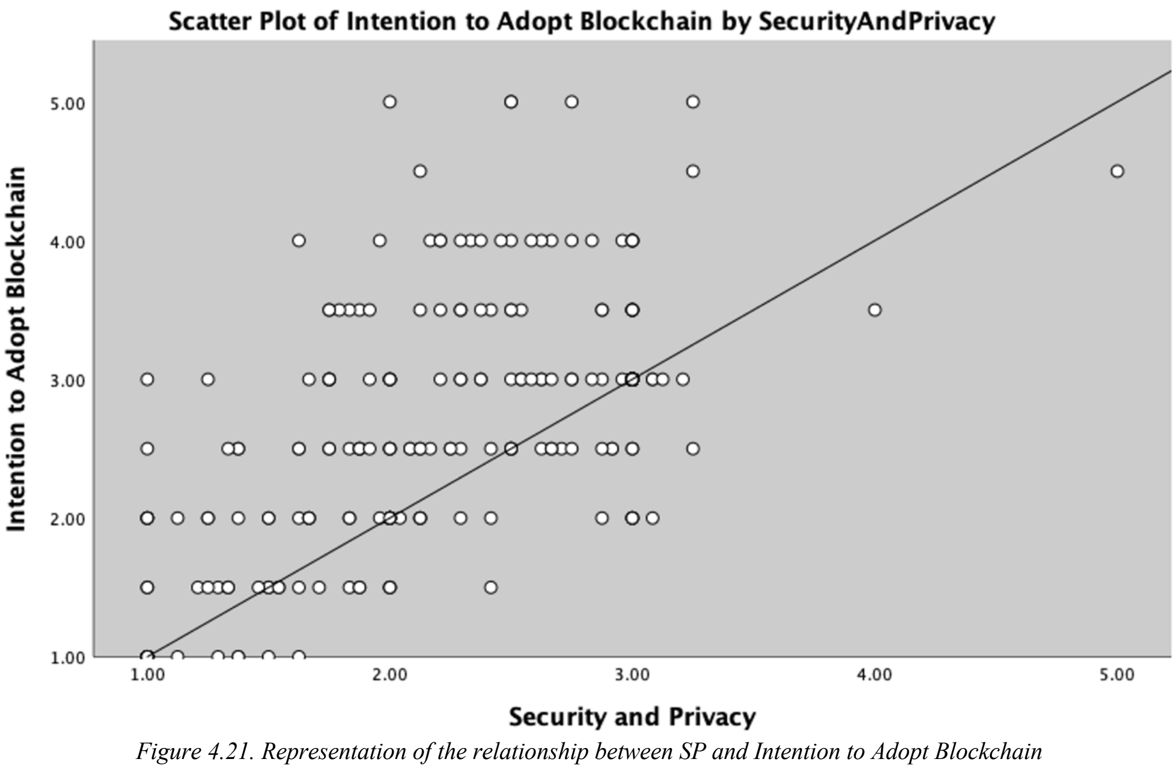

Figure 4.21. Representation of the relationship between SP and Intention to Adopt Blockchain

Moreover, another IT-chair gave her views regarding the impact of SP on blockchain adoption as follows: *"In my opinion, the security and privacy of blockchains are better than* *traditional certification systems. I believe this will be an influential factor that affects people's trust in blockchain technology and promotes adoption.".* From the analysis results and interviewees' responses, it is suggested that SP, which is already recognised as an important factor in the field of DLT, plays a fundamental role in the students' intention to adopt blockchain.

4.4.3 Social Influence (SI)

The social influence construct is considered a very important factor in technology acceptance. Thus, this research considered SI as essential influence in the adoption of blockchain for the certification process. It consists of four items to measure the student's perceptions about the adoption of blockchain in the certification process in Saudi HEIs.

Table 4.17. Summary of the descriptive analysis of SI from the students' perspective

Construct	N	No. of Items	Mean	S.D.	S. E.	Results interpretation
Social Influence (SI)	405	4	2.52	.702	0.34	Influential

The normal distributions of the data on the SI construct were obtained and the results are presented in Table 4.18 below. This section involves investigating the relationship between the SI and students' intention to adopt blockchain technology and checking the strength and direction of this relationship. Finally, the validity of the proposed hypothesized relationship is presented.

Table 4.18. Study 1: Normal Distribution results for the SI factor

Construct	No. of Items	Shapiro-Wilk	Skewness Statistic	Kurtosis Statistic
Intention To Adopt	2	.834	-.416	1.50
Social Influence (SI)	4	.781	-.804	-.037

According to the descriptive analysis results presented in Table 4.17, SI has a positive influence on the students' intention to adopt, as the composite means score was **M**=2.52. This is an indication of the validity of the proposed hypothesis related to the influence of SI (**H3**) as stated below.

> ***H3:*** *In the certification process in the higher education sector, the level of positive* ***social influence*** *is positively associated with users'* ***intention to adopt blockchain technology****.*

Then an investigation of the correlation between two variables, namely, the SI of blockchain with the intention to adopt blockchain from the students' perspective was assessed to validate the proposed relationship. Prior to the correlation test, the normality distribution for both variables was checked; and according to Shapiro-Wilk test the data was normally distributed with values $p > 0.05$, see Table 4.18. Then a Pearson's correlation coefficient test was utilised to evaluate the relationship between these variables. The results revealed that there was a strong positive correlation between SI and students' intention to adopt the blockchain technology and the statistically significant relationship ($r = .505$, n = 405, $p < .001$) is represented in Table 4.19. Thereby, the assumed hypothesis related to SI (**H3**) is valid and supported by this study.

Table 4.19. Validating the research Hypotheses of SI by calculating correlation results

Variables Relationship (Hypothesis)	Correlation Coefficient	Sig. (*p*)	Hypothesis Validation	Results interpretation
SI → Blockchain Adoption	**.505****	**0**	**Yes**	Strong positive relationship

**Correlation is significant at the 0.01 level (2-tailed).

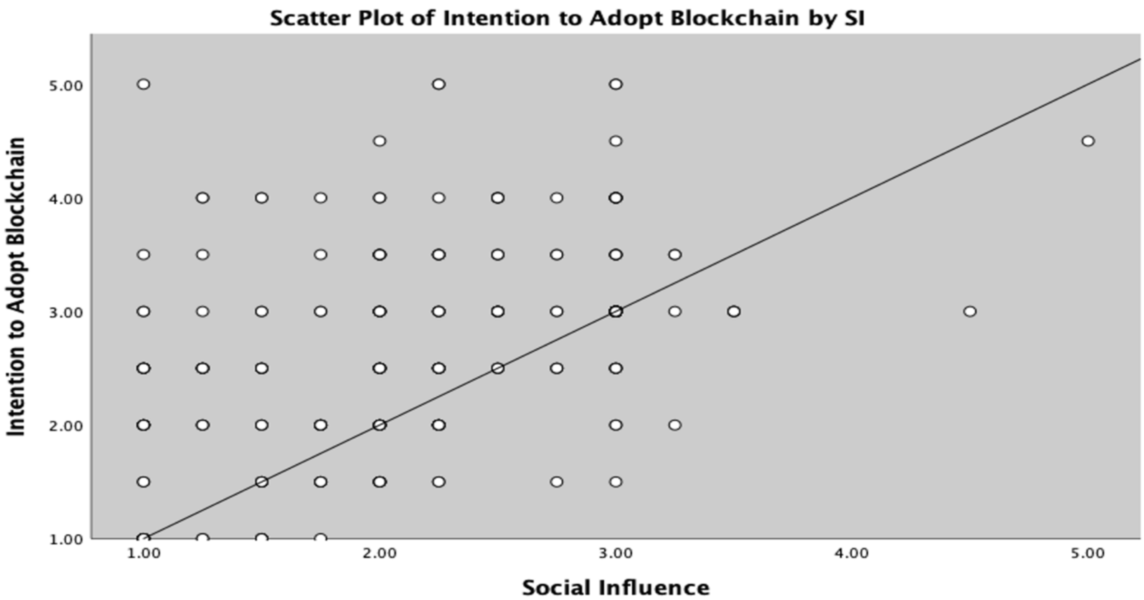

Figure 4.22. Representation of the relationship between SI and Intention to Adopt Blockchain

Figure 4.22 above is a graphic representation of the relationship between SI and the students' intention to adopt blockchain in the certification process. From the trend line it can be noticed that the change in SI leads to an increase in the students' intention to adopt. Finally, the findings of this section were supported by the responses collected in the interviews. However, the top IT representatives interviewed had different perceptions about the impact of SI on the intention to adopt blockchain. One of the IT vice-chairs voiced her opinions about whether it mattered that blockchain has been adopted and deployed by other academic institutes as follows: *"Honestly, I don't think that just one university would volunteer to adopt blockchain technology. The only way BT adoption is likely to happen is if the Ministry of Education implemented it in all Saudi universities."*.

On the other hand, one of the interviewed administrative employees in an academic institute answered to question regarding his perception about the effect of SI on the attitudes of the organization towards new technology such as blockchain as follows: "*I think this it is one of the most influential factors towards the adoption. and since the process of generating and validating certificates is time-and-effort-consuming we would copy any institute that deployed the technology to make this easier."*. Overall, the SI had a positive impact on students' intention to adopt blockchain for the certification process in HEIs.

4.4.4 User Awareness (AW)

User Awareness (AW) is a vital factor that will help to determine the user's knowledge, which leads to acceptance and intention to adopt a new technology. The purpose of this section is to check if students' awareness positively influences their intention to adopt blockchain technology for the certification process. This factor was measured by four items and the results of applying the descriptive analysis on these items is shown in Table 4.20.

Table 4.20. Summary of the descriptive analysis of AW from the students' perspective

Construct	N	No. of Items	Mean	S.D.	S. E.	Results interpretation
User Awareness (AW)	405	4	2.55	.714	.35	Influential

Furthermore, tests were applied to check the normal distribution of data for items relating to AW and the intention to adopt blockchain, in order to apply the suitable correlation test that validate the hypothesised relationship, see Table 4.21. The results indicated that the data for the two variables as assessed by Shapiro-Wilk test were normally distributed with $p > 0.05$.

Table 4.21. Study 1: Normal Distribution results for AW

Construct	No. of Items	Shapiro-Wilk	Skewness Statistic	Kurtosis Statistic
Intention To Adopt	2	.834	-.416	1.50
User Awareness (AW)	4	.774	-.838	.361

The steps taken helped in assessing the validity of the proposed hypothesis (**H4**) about the relationship between AW and the students' intention to adopt a blockchain-based certification system as follows:

> ***H4**: **User awareness** positively influences the users' **intention to adopt blockchain technology** for the certification process.*

The results were analysed to verify the relationship between users' awareness of blockchain technology and users' perceptions about the features and benefits provided by blockchain technology. As shown in Table 4.20, the composite score of the AW (M=2.55) indicates a positive influence on the intention to adopt. Consequently, the hypothesised relationship **(H4)** is accepted according to the descriptive analysis.

These associations were ten investigated using Pearson's coefficient correlation statistical test to evaluate the significance of the relationship. The results indicated a strong, positive and statistically significant relationship between students' awareness and their intention to adopt this technology for handling their certificates (r=.533, n=405, p<.001). Accordingly, the proposed hypothesized relationship (**H4**) is valid and supported.

Table 4.22. Validating the research Hypotheses of AW by calculating correlation results

Variables Relationship (Hypothesis)	Correlation Coefficient	Sig. (p)	Hypothesis Validation	Results interpretation
AW → Blockchain Adoption	**.533****	**0**	**Yes**	Strong positive relationship

**Correlation is significant at the 0.01 level (2-tailed).

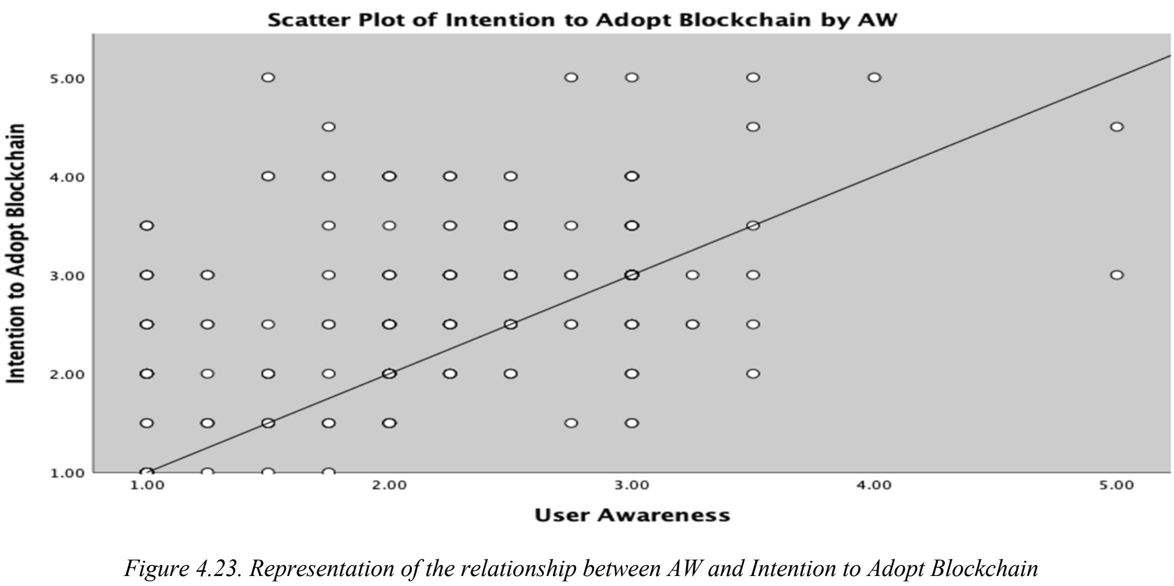

Figure 4.23. Representation of the relationship between AW and Intention to Adopt Blockchain

The trend line in Figure 4.23 represents the relationship between AW and students' intention to adopt blockchain. It is clear that an increase in AW causes a direct increase in the intention to adopt blockchain.

Additionally, the positive influence of AW was recognised by all the interviewees. One spoke about the impact of AW on adopting blockchain as follows: "*The most important factor that would affect the adoption process is user awareness. We would need to explain the technology to upper management, including its benefits and importance. Then, we would need to train the development teams.".*

Other interviewees commented on the question about how to increase AW among academic institutes involving all the prospective users: *"We would need to do the following: educate people on how to use and develop appropriate knowledge; prepare the organizational culture to ensure it is open to the technology; prepare the infrastructure with money and equipment; and check best practices to promote acceptance for the adoption.".* Finally, from all the findings of this section and the descriptive, statistical and interview analysis, user awareness is considered as a very important factor influencing the intention to adopt a blockchain-based certification process.

4.4.5 Efficiency (EF)

As the literature revealed, efficiency as a very influential factor for a technology to be adopted, this study investigated its influence and analysed its impact on adopting blockchain. To fulfil this aim, two analyses were performed on the data, i.e., the descriptive and statistical analyses. This construct involves the impact of two factors (the efficient smart certificates and cost reduction) on the students' intention to adopt blockchain for the certification process. Table 4.23 contains the descriptive analysis results of EF from the students' perspective.

Table 4.23: Summary of the descriptive analysis of Efficiency factors from the students' perspective

Construct	N	No. of Items	Mean	S.D.	S. E.	Results interpretation
Efficiency (EF)	**405**	**9**	**2.43**	**.748**	**.037**	Influential
ESC	405	6	2.45	.751	.037	Influential
CR	405	3	2.42	.803	.399	Influential

Moreover, the researcher performed normal distribution tests on the data related to the EF and the results are presented in Table 4.24 below. These results assess the relationship between EF and students' intention to adopt the blockchain for the certification process. As mentioned previously, investigating the impact of efficiency on the adoption of blockchain improves if students perceive that blockchain can make it faster, easier and more cost-effective to generate and verify certificates in the higher education sector.

Table 4.24. Normal Distribution results for EF

Construct	No. of Items	Shapiro-Wilk	Skewness Statistic	Kurtosis Statistic
Intention To Adoption	**2**	**.834**	**-.416**	**1.50**
Efficiency (EF)	**9**	**.789**	**-.642**	**2.44**
ECS	6	.779	-.706	-.506
CR	3	.785	-.600	-.683

Efficient smart certificate (ESC)

> ***H5a:*** *The* ***efficient smart certificates*** *enabled by blockchain technology positively influence the* ***efficiency*** *of the certificating process.*

The descriptive analysis result embodied in the composite score (**M**=2.45) indicates a positive influence of ESC as result of EF of the blockchain from the students' perspectives. To support the descriptive analysis result it was necessary to statistically calculate the correlation of ESC and EF to test the hypothesized relationship (**H5a**) stated above. The data for these two variables, as shown in Table 4.24, were normally distributed, as demonstrated by the Shapiro-Wilk test, as p>0.05. Since the data was normally distributed and the sample large, the correlation was checked by conducting Pearson's correlation coefficient test. The results revealed a positive and strong correlation between ESC and EF which was statistically significant (r= .961, n=405, p <.001). This indicates the students' opinions regarding efficient smart certificates had a strong influence on the way they recognized EF in blockchain technology. This was as expected from this sample, such as the students were young, and so more likely to understand the concept of a smart certificate more than other aspects of blockchain technology. Consequently, the proposed hypothesis (**H5a**) is valid and supported.

Cost reduction (CR)

***H5b: Cost reduction** provided by blockchain technology positively influences the **efficiency** of the certificating process.*

In the study, four items measured CR from the students' perspective to evaluate its influence on the EF of the blockchain certification process. Accordingly, this would lead to investigating the impact of EF on the students' intention to adopt blockchain technology for the certification process. From the descriptive analysis conducted on the cost reduction factor, the composite score was found to be (**M**= 2.42). That demonstrates a positive influence of CR on the EF of blockchain from the students' perspective. The results of the normal distribution test showed the data of two variables were normally distributed among the given sample, as assessed by the Shapiro-Wilk test with values of $p>0.05$. Then, the strength and direction of the relationship between CR and EF were calculated by running a Pearson's correlation test. The results indicated a strong positive influence and statistically significant correlation between CR and EF (r=.966, n=405, p <.001). Thus, the hypothesised relationship (**H5b**) is valid and supported by the results of this research.

To conclude this section, the researcher needed to measure the impact of EF as influential factor on the students' intention to adopt blockchain for the certification process. To ensure that, the proposed relationship between these two variables was investigated and is presented as the following hypothesis:

***H5**: In the certification process in the higher education sector, an increase in the level of enhanced **efficiency** and reduction in the associated cost in blockchain technology will increase users' **intention to adopt the blockchain technology** for the certification process.*

From the descriptive analysis performed at the beginning of this section, Table 4.23, the composite score of the efficiency was (**M**=2.43) which reflects a moderate positive influence of this factor on the students' intention to adopt blockchain. Thus, the descriptive results support the relationship assumed in this research (**H5**).

Beside the findings of the descriptive analysis, the researcher statistically tested the relationship between these two variables namely, EF and intention to adopt blockchain for the certification process. As presented in Table 4.23 above, the data of these variables were normally distributed thus the researcher performed the Pearson's correlation coefficient to investigate the assumed relationship. The result revealed a moderate positive correlation between these two variables (r=.453, n=405, p > .001) as shown in Table 4.24. Thus, the proposed hypothesis (**H5**) is valid and supported.

Table 4.25. Validating the research Hypotheses of EF by calculating correlation results

Variables Relationship (Hypothesis)	Correlation Coefficient	Sig. (p)	Hypothesis Validation	Results interpretation
EF → Blockchain Adoption	**.453****	**0**	**Yes**	Moderate positive relationship
ESC→ EF	.961**	0	Yes	Strong positive relationship
CR → EF	.966**	0	Yes	Strong negative relationship

**Correlation is significant at the 0.01 level (2-tailed).

Figure 4.24 below, presents the trend line to illustrate the relationship between EF and the students' intention to adopt blockchain. It is clear that an increase in the students' perceptions about the efficiency provided by blockchain results in increase in their intention to adopt blockchain in order to obtaining all the relevant benefits it affords.

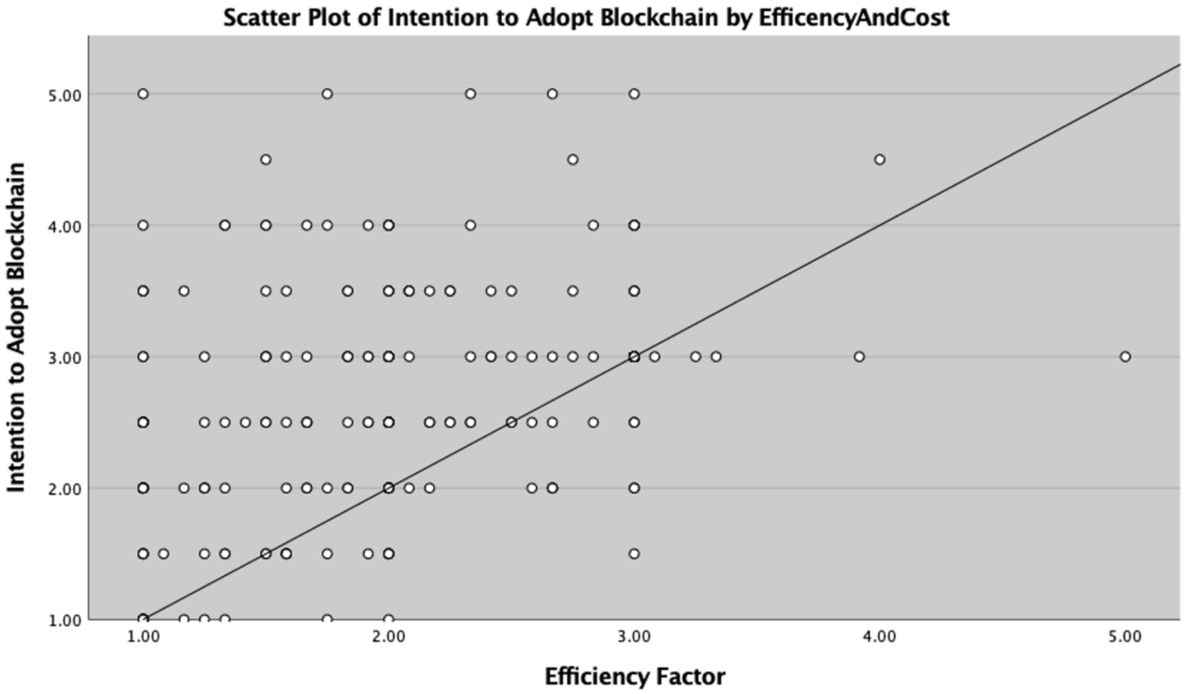

Figure 4.24. Representation of the relationship between EF and Intention to Adopt Blockchain

Additionally, the interviews conducted with top managers in two academic institutes reflected the importance of this factor on the adoption process. One of the interviewees said: *"Blockchain Technology cannot be changed or tampered with, and so it would improve efficiency, transparency and immutability and ensure high creditability. These are issues with the current certification process."* Also, another interviewee answered the question regarding efficiency as follows: *"I think in the certification process the main aspects are speed and accuracy, which could be guaranteed by deploying blockchain in this process"*. All these findings support the proposed positive relationship between this factor and the students' intention to adopt the blockchain for the certification process.

To sum up, this section contains the investigation of all the hypothesised relationships between the influential factors and the students' acceptance and intention to adopt blockchain technology.

4.5 Employer Survey- Descriptive Analysis and Interpretation

In this research, prospective employers were regarded as the prime drivers of the study due to the benefits that stand to be gained if blockchain technology is adopted in the certification process in higher education. The rationale for including prospective employers was because these stakeholders are pivotally concerned with validating student credentials, as a result of which they may impose pressure on HEIs to adopt blockchain-based certificating systems. Thus, this part of the study was designed to investigate the prospective employers' perceptions regarding the intention to adopt the blockchain technology in the certification process in Saudi HEIs. This survey was in three parts, like the students' survey: demographic information, knowledge and experience with blockchain, and the influential factors affecting the employer's intention to adopt the blockchain-based certification system.

4.5.1 Part1: Demographic Information

This section was designed to collect the demographic information of the participating employers; and the influence these characteristics were analysed to discover any external influences upon the level of the aforementioned factors that would affect the intention to adopt blockchain for higher education. The respondents were requested to answer several questions about their gender, age, education level and field domains, as addresses in the following sections.

Age

The results presented in Figure 4.25 indicate that half the respondents were aged between 26 and 35, 41% were aged 36 to 45, and the least number of participants were between 46 and 60 years old. The age distribution was as expected, since this was the age range where the employers are in position to involve in the activities related to human resources. According to (Statista, 2018) and (GASTAT, 2021), the statistics show that in Saudi Arabia, in 2021, approximately 71.81% were aged between 15 and 64 years, with employment to population ratio being 66.77%. That makes the participants' age range representative of the wider population in terms of its spread.

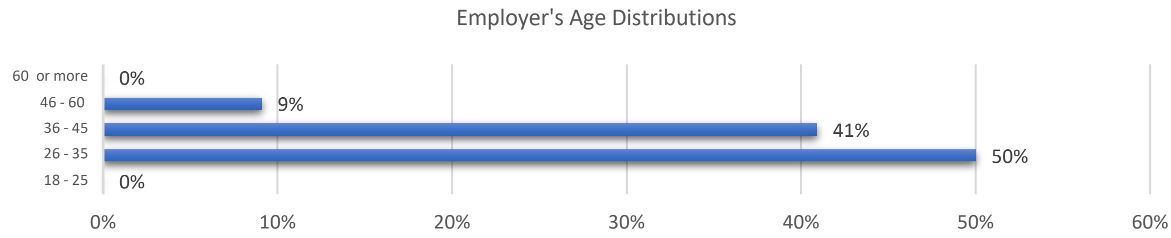

Figure 4.25: Study 1: Employer's sample age distribution

Gender

A gender profile of the sample was required, so the second question was about the gender of the participating employers. The result for the gender distribution is shown in Figure 4.26 which reveals that the majority of the respondent were males and only 27% of employers were females, which is still a good number of women in leading positions in the context of Saudi Arabia. Despite the number of women in the employers' sample being small, in contrast to the large number of female participants in the student sample, these data still arguably make a contribution, due to the lack of female participants in most Saudi studies in this field.

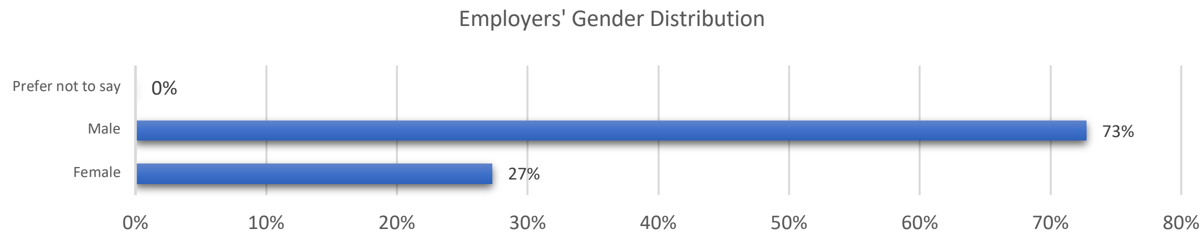

Figure 4.26: Study 1: Employer's sample gender distribution

Educational Level

As shown in Figure 4.27, 59% of the participating employers were 'postgraduates or higher', which means they held Masters or PhD degrees; 36% of the employers had bachelor' degrees, and 5% were below this level. The overall educational level of the employers was as expected and reasonable for the sample, since the study targets employers with the knowledge and ability to use cutting-edge innovations such as blockchain technology.

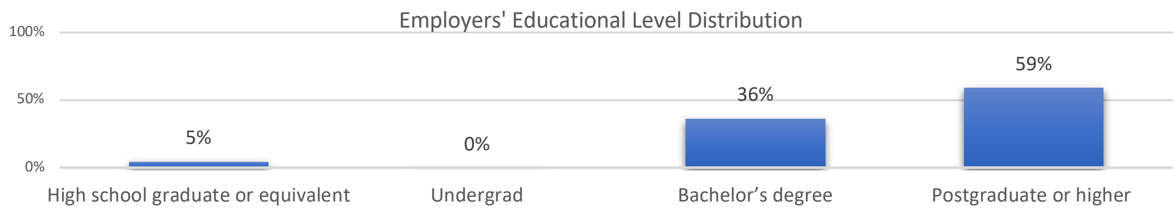

Figure 4.27: Study 1: Educational level distribution in the employers' sample

Field Domain

Lastly, the employers were asked about their speciality domains. More than half of the participating employers were from science, technology or engineering domains, as shown in Figure 4.28; 23% were from business and economics domains and 18% from humanities-related disciplines. The research aimed to target employers in fields related to ITCs (Information and Communications Technologies) to realise the aim of this research to investigate the adoption of blockchain technology. Thus, having most participants under domains familiar with new technologies would help fulfil the research aims.

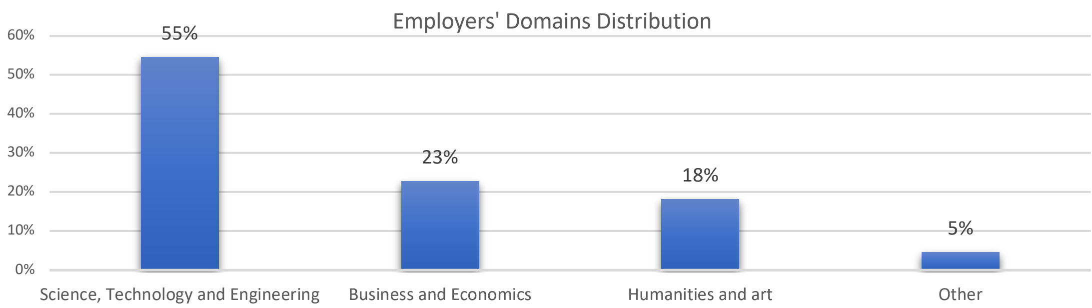

Figure 4.28. Study 1: Employers' sample domains distribution

4.5.2 Part 2: Level of Awareness and Previous Experience about Blockchain Technology

The purpose of this section is to investigate the employers' backgrounds and experience level of blockchain technology and DLT in general. The participants' experiences are considered as a key measure to evaluate whether prospective employers will be able to deal with a blockchain-based certification system. Additionally, the overall result from this part is helpful for the researcher to understand the background of employers in the sample regarding blockchain and its effect on their intention to adopt the technology. Also, the participants were asked about the skills and training they had received to enhance their knowledge of blockchain technology.

Awareness: The level of familiarity and awareness among the participating employers was investigated in order to understand the sample's background in blockchain technology. Figure 4.29 represents the results that indicate different levels of knowledge amongst the employers, whereby 41% said they were slightly aware of blockchain; about a third of the employers considered their knowledge 'moderate' while only 13% evaluated themselves as being highly aware of this technology, and 14% said they had no awareness about blockchain technology at all. Targeting different levels of familiarity with blockchain among the employers was a research goal so as to be able to evaluate the influential factors from various perspectives, which helps the research objectives.

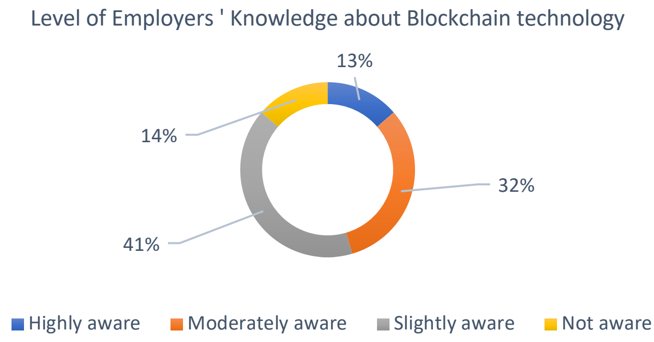

Figure 4.29:Study 1: Level of Employers' awareness about blockchain

Experience: The second item in this part was about prospective employers' experiences with developing or using systems based on blockchain technology. The result, shown in Figure 4.30, shows that most of the employers did not have any kind of experience with blockchain technology. Moreover, employers have a moderate level of knowledge about this technology and a low level of developing or experiencing blockchain-based systems.

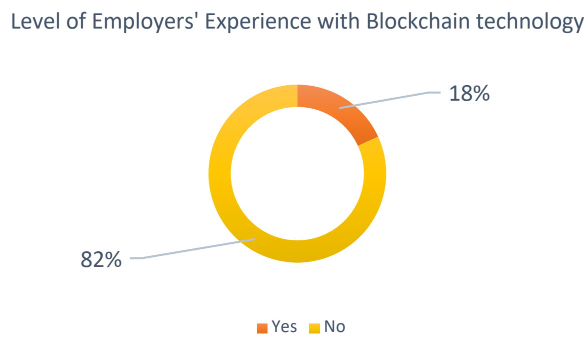

Figure 4.30: Study 1: Level of Employers' experience about blockchain

Skills and Training: Based on the data regarding the employers' attendance of workshops/seminars about blockchain technology, the majority of the employers had attended some sort of workshops in this field, see Figure 4.31. Moreover, this measure included investigating if the employers had received adequate training in using an aspect of blockchain technology from their firms. The participants were also asked to evaluate their skills and whether they considered them sufficient to be able to handle such systems. More than half of the respondents positively evaluated themselves, saying they held the appropriate skills, while a third of the sample disagreed. The results indicated that only 35% of the respondents reported they had received training either from their institutes or as a form of self-development. Thus, the institutes have to devoted time, efforts and plans for training programmes to enhance their employees' skills to be able to handle such technologies especially in the domine of DLT which will facilitate the adoption process.

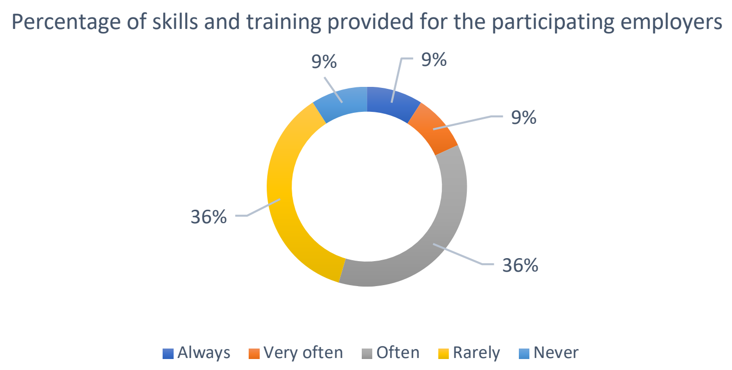

Figure 4.31: Study 1: Results of skills and training provided for the participating employers

Influential Factors: This section addressed the factors affecting the adoption of blockchain technology in the field of higher education from the employers' perspective. Figure 4.32 represents the employers' choices when reacting to the factors they were presented with. The results indicate that 44% of the employers believed in the influence of trust on the intention to adopt blockchain for the HE sector; and 33% believed that privacy and security concerns would impact their decision about adopting a blockchain-based system. In the matter of the quality and authentication of the provided documents by the system, an equal number of the employers (6%) agreed they would be factors affecting blockchain adoption for the certification process.

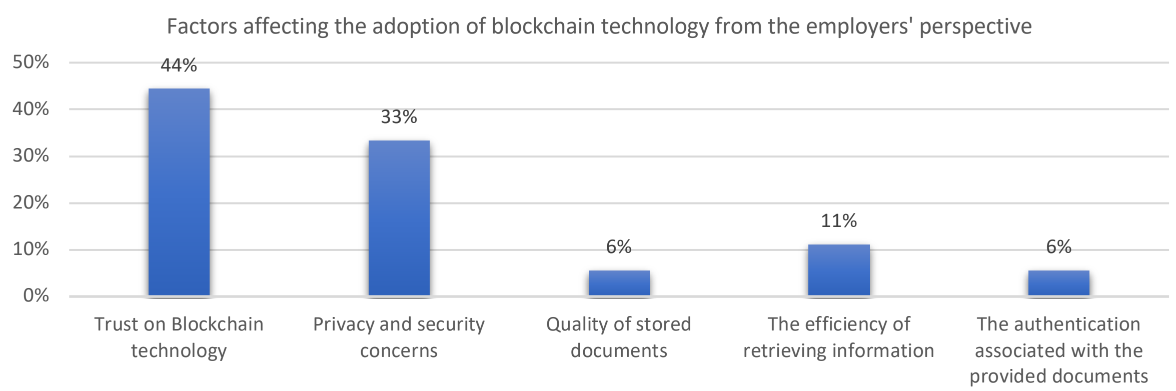

Figure 4.32: Factors affect the adoption of blockchain technology from the employers' perspective

As expected, trust, security and privacy were seen as playing a tremendous part in adopting a new technology and would affect the users' acceptance of blockchain for the certification process. These results give an indication that all the participating employers in this study knew about the challenges brought about by the adoption of blockchain technology. The results also indicate that the employers' sample had a reasonably good technological background.

4.5.3 Part 3: Factors affecting the adoption of blockchain technology for higher education

This section of the questionnaire was designed to measure the impact of each factor in the proposed model of adoption of blockchain technology in the certification process for higher education, from the employers' perspective. As in the survey for students, this section of the questionnaire involved five dimensions trust, security and privacy, social influence, user awareness and efficiency. Moreover, all the sub-factors are listed in Chapter 3, (Table 3.1) to give a general overview of the influential measures and how the employers in the sample reacted to each item.

Trust Factor (T)

The employers were given several statements regarding the trust factor and all the other constructs related to it. In the conceptual model proposed in this research, from the employers' perspective, the trust factor has three measures: functionality and transparency, knowledge and familiarity, and applicants' certificate authenticity.

- **Functionality and Transparency (FT)**

The first measure of the trust factor was the participants' perception of the functionality and transparency of blockchain in the certification process. Table 4.26 shows the statements given to the participants regarding this factor; and the results are represented in Figure 4.33. In the items about their understanding of the technology's functionality, most of the participants (86%) agreed about blockchain's transparency making it a suitable option for managing educational certificates (FT1). Moreover, an even higher percentage (91%) agreed about blockchain's ability to handle all forms of academic credentials, transcripts and certificates with only 5% disagreeing about this functionality (FT2). Additionally, majority of the employers (91%) showed substantial interest in blockchain adoption as a way to store prospective applicants' credentials to avoid fraud or dishonesty (FT3) (FT4).

Table 4.26.Study 1: Statements related to FT in the employers' sample

Factor	**Item Code**	**Statement**
FT	FT1	Blockchain technology transparency makes it a suitable option for managing educational certificates.
	FT2	Blockchain technology can handle all forms of academic credentials, transcripts and students' certificates.
	FT3	Blockchain technology provides a high level of trust to employers by eliminating any dishonesty.
	FT4	Adopting blockchain technology in higher education enables students to share their official documents directly with anyone requesting them.
	FT5	Blockchain technology emphasises the actual learning outcomes and alumnis' skills and accomplishments.
	FT6	Blockchain technology's immutable feature will give me full trust in the certificates provided.

Likewise, (78%) of employers believed that the technology provided a high level of trust by eliminating dishonesty through an emphasis on actual learning outcomes and alumni skills and accomplishments (FT5). The results also indicated that 88% of employers agreed that blockchain enabled students to share their official documents directly with external parties with the feature of immutability, which guarantees complete trust in the provided certificates (FT6). The large degree of agreement among the employers about this factor is an indication of the impact it has on their trust in blockchain technology and consequently affects their intention to adopt the technology.

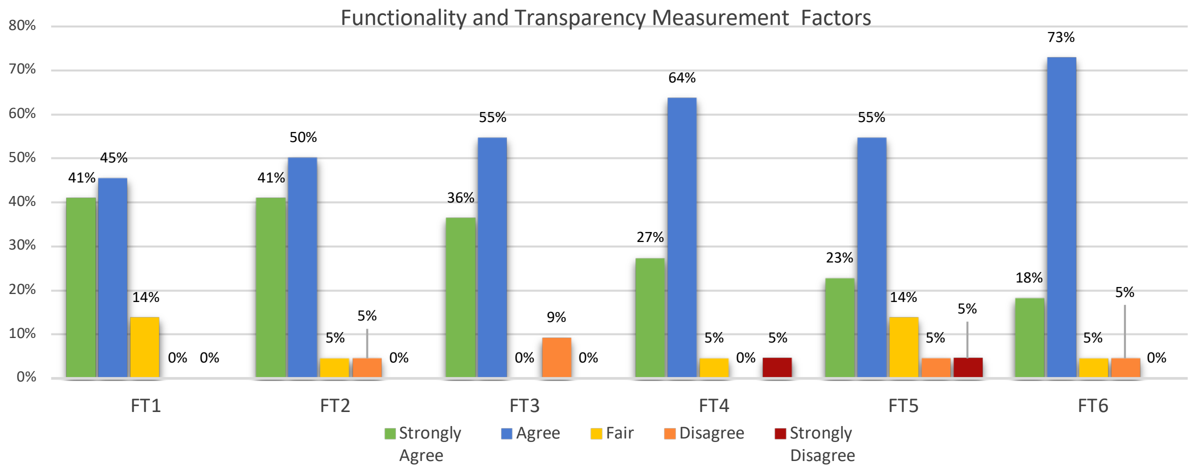

Figure 4.33.1st Study FT measures in employer's sample

- **Knowledge and Familiarity (KF)**

The second sub-factor in this section was the employers' knowledge and familiarity. Table 4.27 demonstrates the three measures used to investigate KF; and Figure 4.34 below shows the results from the respondents. Most of the participants (86%) reported that they were familiar with the benefits associated with using blockchain technology with only 9% saying they were not familiar with blockchain's advantages (KF1). About half of the participants refused to trust blockchain without any knowledge of its functionality while 36% agreed they would trust it without having fully understood it (KF2). Moreover, 87% of the participants agreed that they were aware about how to educate themselves about the concept of blockchain technology (KF3).

Table 4.27.Study 1: Statements related to KF in employer sample

Factor	Item Code	Statement
KF	KF1	I am familiar with the benefits associated with using blockchain technology.
	KF2	I trust blockchain technology even without any knowledge about its functionality.
	KF3	I am aware about how to get the information needed to understand the concept of blockchain technology.

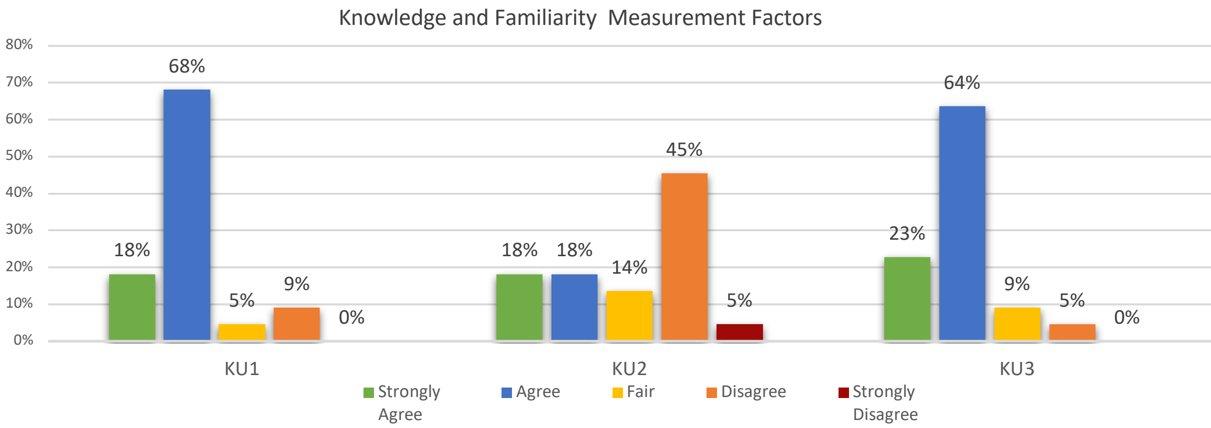

Figure 4.34. 1st Study KF measures in the employers' sample

- **Applicants' Credentials Authenticity (CA)**

This section on the authenticity of applicants' credentials, was designed only for the prospective employers' survey. to evaluate their perceptions about the adopting blockchain because of the authenticity of the provided credentials by prospective employees. For this sub-factor five statements were used to measure the employers' feedback about trust in credential authenticity, as shown in Table 4.28. The results. as shown in Figure 4.35, indicate that around

90% of the employers believed that three main features were enabled by blockchain: it helps to streamline the process for prospective employees and guarantee qualified candidates; it allows the organization to check the authenticity of the applicant's credentials; and it opens up the outputs of the institution to applicants worldwide (CA1, 2 and 3). Likewise, (91%) of the respondents agreed that using blockchain-based certification system allowed them to easily validate the provided qualifications while only 9% were neutral about this feature (CA4). Lastly, almost all the participating employers, around (95%), believed such system would enhance the learning outcomes from higher education systems (CA5).

Table 4.28. Study 1: Statements related to CA in employer sample

Factor	Item Code	Statement
CA	CA1	I believe that benefits will be achieved by using block chain technology in education and value will be generated for the employment process.
	CA2	Blockchain technology helps in streamlining the process for prospective employees and guarantees they are qualified candidates.
	CA3	I believe that employing blockchain technology in higher education opens up the outputs of the institution to a worldwide application.
	CA4	Using blockchain technology will allow the organisation to check the authenticity of the applicant's credentials.
	CA5	Adopting blockchain technology encourages improvement in teaching practice thus in learning outcomes.

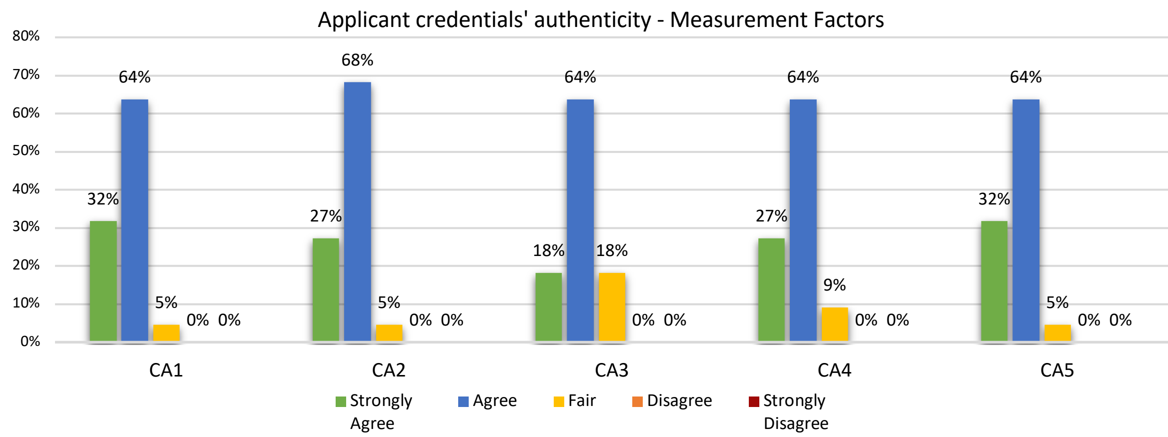

Figure 4.35. 1st Study CA measures in the employers' survey

Thus, all the findings in this section demonstrate a high level of positive agreement from prospective employers regarding their trust in a blockchain-based certification system and indicates strong intention to adopt by employers.

Security and Privacy Factor (SP)

It is very important to investigate and address the impact of security and privacy in adopting blockchain in higher education systems, since these two factors are the subject of much debate in this field. This factor was measured by two sub-factors to include all the issues surrounding SP in blockchain technology.

- **Perceived security, privacy, immutability and reliability (PSP)**

The perceived privacy and security factor, as presented in Table 4.29, consists of eight measures and all the results are illustrated in Figure 4.36. The results indicated that 95% of the employers agreed about the general importance of security-related benefits in integrating blockchain technology into higher education (PSP1). Furthermore, 91% of the participants were neutral about believing in the ability of blockchain to maintain a high level of security, including data protection, integrity and privacy, which influences the level of trust (PSP2).

Table 4.29: Study 1: The measures related to PSP in the employers' sample

Factor	Item Code	Statement
PSP	PSP1	Security is an important benefit of integrating blockchain technology in higher education.
	PSP2	Knowing that blockchain is maintaining a high level of security including data protection, integrity and privacy could affect my trust toward it.
	PSP3	Blockchain technology helps in attaining high levels of security and privacy for smart certificates stored on the chain that affect decisions about the prospective employees' qualifications.
	PSP4	Blockchain technology enhances prospective employees' certificates' reliability and transparency.
	PSP5	Blockchain technology can establish secure connections between all included parties and ease interactions between them.
	PSP6	Blockchain technology can be very useful in authenticating students' original identities as well as their authentic smart certificates.
	PSP7	Blockchain technology decreases the probability of duplication of educational certificates.
	PSP8	Blockchain technology supports storage, management, preservation, authentication and retrieval of student content safely.

In the matter of the reliability of blockchain technology, more than 95% of the participants agreed that blockchain enhances the reliability and transparency of prospective employees' certificates by establishing secure connections between all included parties and easing their interactions. Meanwhile, only 5% were neutral with no disagreement (PSP4 and PSP5). Moreover, almost all of the participating employers agreed that blockchains are useful for authenticating student identities and smart certificates (PSP6), and they also suggested that the use of the technology can reduce the risk of duplication and fraud (PSP7). Thus, the effect of employers' perceptions regarding their trust in blockchain technology have a significant impact on their intention to adopt a blockchain-based certification system.

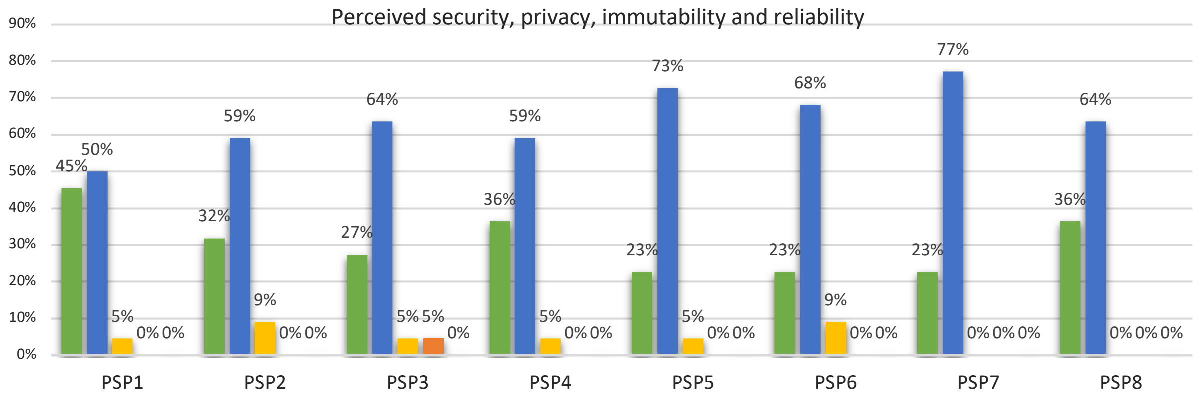

Figure 4.36.1st study PSP measures in the employers' sample

- **Perceived Risk (PR)**

Participants' perceptions about the risk of adopting blockchain technology for the certification process, were measured by three items (see Table 4.30). The perceived risk items were associated with a high level of acceptance, as displayed in the results in Figure 4.37. This was supported by a high percentage of participants (95%) agreeing that the use of blockchain does not lead to privacy or security risks in their organisation (PR1). Moreover, almost all of the participating employers (96%) believed that applicants' credentials and information were secure if the issuer can control who sees them (PR3).

Table 4.30. Study 1: Statements related to PR in employer's sample

Factor	Item Code	Statement
PR	PR1	I think using blockchain technology would not risk my privacy or security as an organisation and prospective employer.
	PR2	I feel very confident while using and verifying my applicants' credentials through blockchain technology.
	PR3	I feel applicants' credentials information is secured if the issuer can control who is seeing them.

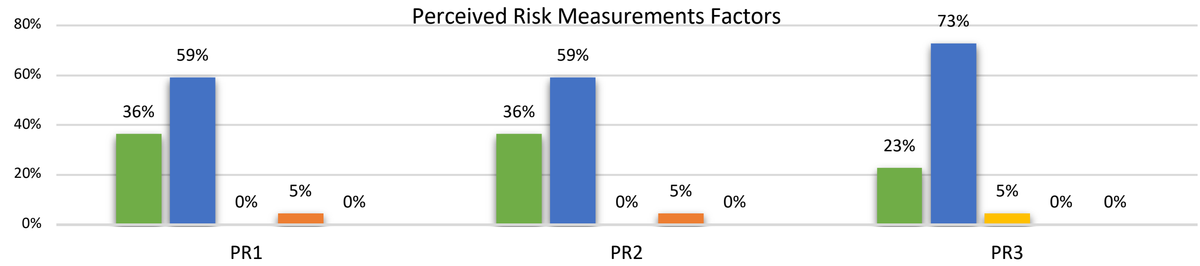

Figure 4.37. 1st study PR measures in the employers' survey

- **Fraud and Dishonesty (FD)**

Employers' attitudes towards the issue of fraud and dishonesty were measured by three items as shown in Table 4.31. More than 95% of the employers agreed on the benefits provided by blockchain technology in providing an authentic and attractive environment for the related stakeholders (FD1). They all concurred that this helps to reduce fraud and dishonesty in the applicants' credentials as approved by all the participating employers with no disagreement (FD2).

Table 4.31. Study 1: Statements related to FD in employer's survey

Factor	Item Code	Statement
FD	FD1	Blockchain technology contains high quality content could be used as a marketing tool to entice staff, students, and funding for the organisation
	FD2	Adopting blockchain technology helps in reduce the applicant's credentials frauds and dishonesty.
	FD3	Digital repositories increase transparency and quality of applicants provided qualifications.

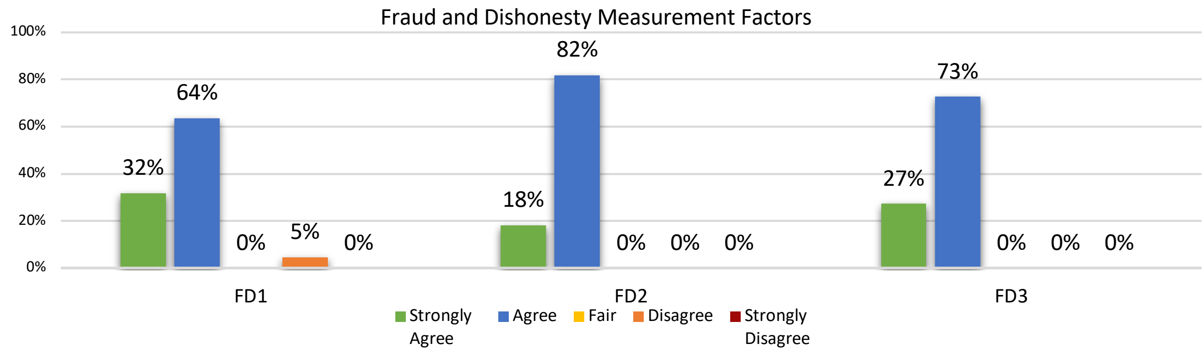

Figure 4.38. 1st study FD measures in the employers' sample

Likewise, the employers believed that the decentralised digital storage as nature of blockchain technology would result in increasing the transparency and quality of applicant's provided qualifications (FD3). Finally, the findings from the privacy and security section were a good indication of the employers' confidence while using and verifying the applicants' credentials through blockchain technology, while having a high degree of trust that the process would protect the qualifications from dishonesty issues.

Social Influence Factor (SI)

The results of the empirical study reflected that the employers considered social influence important in the adoption of blockchain technology (see Figure 4.39). More than 90% of the employers believed the adoption of blockchain encourages educational institutions to have the same transparency level in terms of their outcomes and so produces more qualified prospective employees for the labour market (SI2).

Table 4.32.Study 1: Statements related to SI in employer's survey

Factor	Item Code	Statement
SI	SI1	Adopting blockchain technology creates better qualified prospective employees for my organisation.
	SI2	Adopting blockchain technology encourages educational institutes to have the same transparency level to their outcomes.
	SI3	Adopting blockchain technology encourages prospective employees in building productive skills needed to support their career decisions.
	SI4	Blockchain technology reputation in various fields, should persuade higher education to adopt it.
	SI5	Adopting blockchain technology in higher education reducing overwhelming administrative tasks that helps in increasing employee's productivity.

Moreover, the majority of the employers (95%) agreed that adopting this technology motivates prospective employees to build the productive skills needed to support their career decisions (SI3).

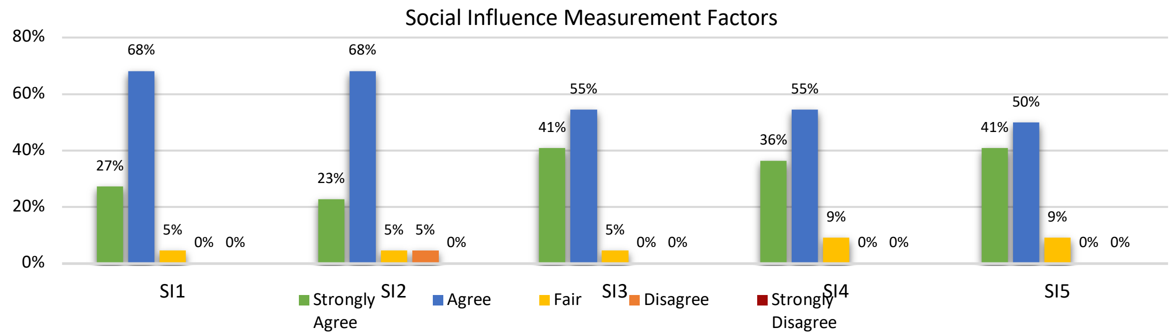

Figure 4.39. 1st study SI measures in the employers' survey

In the matter of the higher education sector, 91% of the employers believed that the reputation of blockchain in various fields would persuade HEIs to adopt it (SI4). Consequently, most of the participants (91%) agreed that blockchain adoption for higher education may help to reduce the overwhelming burden of administrative tasks, thereby improving employee productivity (SI5).

Efficiency Factor (EF)

As in the students' sample of this study, the efficiency factor was investigated to measure the employer's perceptions of the effect of blockchain adoption for higher education, particularly concerning efficient smart certificates and a reduction of the cost associated with the certification process. The results for this section provide a measure of the impact of this factor on the employers' intention to adopt a blockchain certification system.

- **Efficient smart certificates**

An evaluation was made of the employers' perceptions about the efficiency of the proposed smart certificates to investigate the impact on their intention to adopt a blockchain certification system. This measure contained four items, as shown in Table 4.33. The results indicated that more than 85% of the participants believed that blockchain maximized the visibility of an institution and created observable outputs such as students' performance (ESC1).

Table 4.33. Study 1: statements related to ESC in employers' survey

Factor	Item Code	Statement
ESC	ESC1	Adopting blockchain technology maximizes the visibility of an institution and student outputs are easily observed.
	ESC2	Blockchain technology enables several features measure and evaluate the students' performance.
	ESC3	Blockchain technology offers an efficient sharable system among employer and students.
	ESC4	Blockchain technology can allow institute to interoperate with other university systems and maximise efficiencies between them by sharing information.

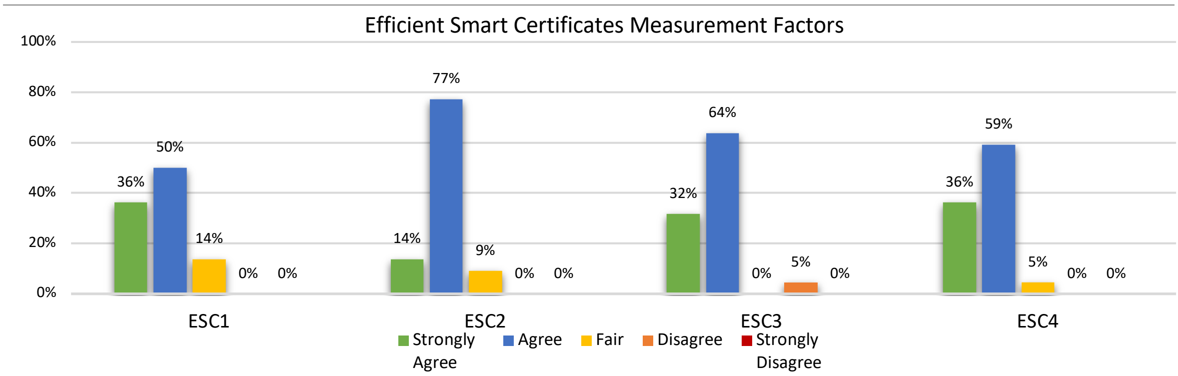

Figure 4.40. 1st study ESC measures in the employers' survey

Moreover, (91%) agreed that blockchain enabled the evaluation of students' performance (ESC2). Also, almost all the participating employers agreed that blockchain allowed institutions to interoperate with other university systems and maximize efficiencies via sharing information (ESC3 and ESC4).

- **Cost reduction**

On the matter of cost reduction, four items were designed to measure employers' perceptions of the reduction in cost and time provided by blockchain which contributed to evaluating the efficiency factor. The four measures are presented in Table 4.34 and the results are illustrated in Figure 4.41.

Table 4.34. Study 1: Statements related to CR in the employers' survey

Factor	Item Code	Statement
CR	CR1	Blockchain technology reduces the cost associated with the process of verifying and authenticating the applicants' certificates.
	CR2	Blockchain technology can help reduce the unnecessary cost associated with the transactions and centralized data storage.
	CR3	Blockchain technology minimizes the time required to verify the applicants' credentials.
	CR4	It is a cost-efficient approach for the organisation.

Most of the participants (90%) agreed that blockchain reduced the cost arising from the process of verifying and authenticating applicants' certificates (CR1). Likewise, more than (95%) believed that blockchain assisted in reducing the unnecessary cost associated with transactions and centralized data storage (CR2).

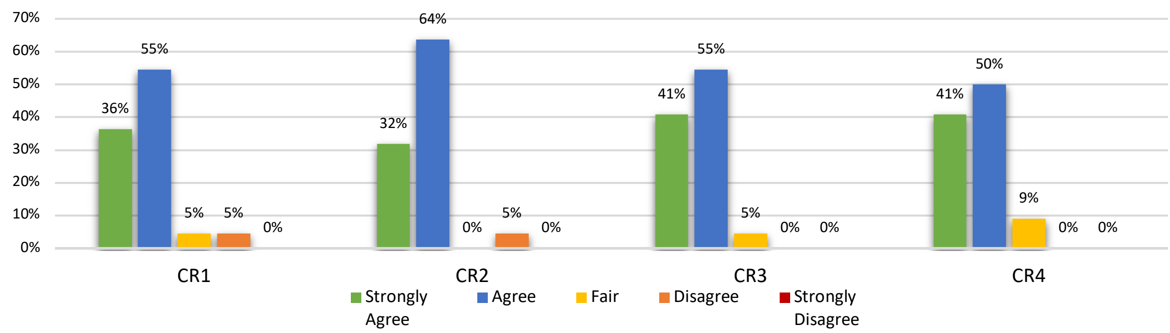

Figure 4.41.1st study CR measures in the employers' survey

In short, the participants considered adopting blockchain was a cost-efficient approach for organizations (CR4). To sum up, the results indicated that half of the employers were aware of the benefits, disadvantages and perceived risks associated with using blockchain technology in the certification process for higher education institutions. Additionally, the employers showed a positive and strong desire to validate applicants' certificates using an immutable and reliable system based on blockchain technology to prevent unauthenticated qualifications. Lastly, the participants considered a blockchain-based certification system motivated prospective employees to enhance their skills since the transparency feature allowed employers to get the most qualified applicants.

4.6 Inferential statistical analysis and hypotheses assessment from the employers' perspective

In the employers' sample, the average mean value for the weighted means of the studied factors was in the highly accepted level. There was a good indication among prospective employers toward blockchain acceptance for the certification process. The deep analysis for the data collected from the prospective employers' sample has been detailed and presented in section 4.5. All the suggested components' items were reviewed and analysed separately to provide a comprehensive picture of the employers' views and perceptions about blockchain adoption. This section is divided as follows: an analysis of the descriptive results with interpretation is followed by an investigation of the hypothesised relationships between the factors and the employers' intention to adopt blockchain. Lastly, the findings for each factor are supported by the responses collected from the interviews conducted in this study.

4.6.1 Trust (T)

This research has clarified the importance of studying the impact of trust in blockchain on the users' intention to adopt it. In this section, the results from the employers' sample are assessed and analysed. In this study, trust is a composite of three sub-factors, namely: a system's functionality and transparency, knowledge and usability and the authenticity of the applicants' provided credentials. Table 4.35 contains all the descriptive analyses of the trust construct along with its related factors. The results indicated a strong positive influence of the trust (T) sub-factors on employers' intention to adopt a blockchain-based certification system. Additionally, the normal distribution among T and its related sub-factors has been calculated, and is shown in Table 4.36. These results and findings are interpreted to assess the proposed hypothesised relationships for this construct. The following sections include the analysis for each trust sub-factor that has been measured along with the tests for the proposed hypotheses related to each of them.

Table 4.35. Summary of the descriptive analysis of T from the employers' perspective

Construct	N	No. of Items	Mean	S.D.	S. E.	Results interpretation
Trust (T)	**22**	**14**	**1.90**	**.673**	**.168**	Influential
FT	22	6	1.83	.748	.186	Influential
KF	22	3	2.15	.860	.215	Influential
CA	22	5	1.74	.525	.131	Highly Influential

Table 4.36. Normal Distribution results for T-related factors

Construct	No. of Items	Shapiro-Wilk	Skewness Statistic	Kurtosis Statistic
Intention To Adoption	**2**	**.877**	**.787**	**-.351**
Trust (TU)	**14**	**.922**	**1.18**	**1.86**
FT	6	.760	1.94	4.00
KU	3	.940	.667	-.18
CA	5	.908	.840	.743

Functionality and Transparency (FT)

H1a: *Blockchain technology's* ***functionality and transparency*** *positively influence user* ***trust*** *toward blockchain adoption for the certification process.*

Firstly, blockchain's functionality especially the transparency and the impact of this on the employer's trust in this technology was investigated. The results of the FT descriptive analysis gave a composite score of (**M**=1.83) which indicates it has a positive influence on employers' trust in a blockchain-based certification system. Thus, the proposed hypothesis for this factor is accepted and supported by the descriptive analysis results. The normal distribution of the data among the T and FT was tested by the Shapiro-Wilk test which showed the data was normally distributed (p > 0.05). By using Pearson's test, the correlation between the two variables was calculated to assess the strength and direction of the relationship between them. The result reveals a very strong, positive correlation between T and FT as (r=.915, n=22, p <0.01). Additionally, this correlation was found to be statistically significant. This means the presence of a high level of understanding of blockchain functionality and transparency is associated with a high level of trust in using blockchain-based systems from the employers' perspective. Therefore, the research found that hypothesis (**H1a**) for the FT factor was valid and supported by this research.

Knowledge and Familiarity (KF)

> ***<u>H1b:</u>*** *User **knowledge and familiarity** about blockchain positively influence user **trust** toward blockchain adoption for the certification process.*

From the descriptive analysis results presented in Table 4.35, this factor has a positive influence on the employers' trust in a blockchain-based certification system as the composite score was (**M**=2.15). This supports the hypothesis regarding this factor. Furthermore, to support this result, the researcher calculated the correlation between two variables, KF and T, to find the strength and direction of their relationship. The result of the normal distribution test of the data for these variables indicated a normal distribution. Thus, Pearson's correlation coefficient test was utilised, and the results showed a statistically significant and very strong positive relationship between KF and T ($r = .958$, $n=22$, $p < 0.01$).

These findings are interpreted as having knowledge and familiarity with the blockchain strongly influences the employers' intention to use blockchain-based systems. Thus, the proposed positive hypothesis (**H1b**) is supported and accepted.

Applicants' Credentials' Authenticity (CA)

> ***<u>H1d:</u>*** ***Trust in applicants' accreditations** positively influences employers' **decisions** toward blockchain adoption for the certification process.*

It was very important to measure the employers' acceptance level about the authenticity of the provided credentials which is the main outcome from the smart certification system. First, the result from the descriptive analysis revealed the composite value of CA was (**M**=1.74) indicating a very positive influence on the employers' trust in blockchain-based certification systems. Thus, the proposed hypothesised relationship between CA and T is supported by the descriptive analysis results.

Then, the correlation between CA and T was examined to add more evidence to support the hypothesis. Prior to running the correlation coefficient test, the normal distribution for the two variables was tested. As shown in Table 4.36, the data were normally distributed as shown by the Shapiro-Wilk test, ($p<0.05$). Then, Pearson's correlation coefficient test was used to determine the strength and direction of this relationship. The result revealed a positive and strong correlation between CA and T as follows: (r= .928, n=22, p <0.01) which is statistically significant. Thus, the proposed hypothesised relationship about CA and T (**H1d**) was supported and accepted in this research.

To conclude the investigation of the Trust factor, its impact on the employers' intention to adopt blockchain needed to be measured. Thus, the relationship between these two variables namely, T and employers' intention to adopt the blockchain for the certification process was examined and tested the following hypothesized relationship:

> ***H1.*** *In the certification process in the higher education sector, an increase in the level of* ***trust*** *toward blockchain technology will increase users'* ***intention to adopt blockchain technology****, given that trust is considered a major determinant of user acceptance*.

The results from the descriptive analysis of T presented the composite score (**M**=1.90) which indicated a strong positive influence on employers' intention to adopt a blockchain-based certification system. This finding supports the hypothesized relationship regarding the impact of the trust factor on intention to adopt blockchain. Moreover, the correlation between these variables, T and intention to adopt blockchain, was tested by Pearson's correlation coefficient test. The result revealed a significant positive relationship between employers; trust in blockchain and their intention to adopt it as follows: (r=.915, n = 5, p > .05). These results were expected since the targeted employers had a sufficient background in this technology. Thus, the findings from the descriptive analysis of this factor as well as the correlation result showed the hypothesized positive relationship (**H1**) was valid.

This relationship is graphically presented in Figure 4.42, which shows an increase in the employers' trust in blockchain leads to an increase in their intention to adopt it for the certification process. Moreover, Table 4.37 above contains all the correlation coefficient test results along with the interpretation to analyse the proposed hypotheses related to the Trust factor from the employers' perspective.

Table 4.37. Validation of the research hypotheses for the Trust by calculating correlation results

Variables Relationship (Hypothesis)	Correlation Coefficient	Sig. (p)	Hypothesis Validation	Results interpretation
TU → Blockchain Adoption	**.915****	**0**	**Yes**	Strong positive relationship
FT → TU	.944**	0	Yes	Strong positive relationship
KU→ TU	.958**	0	Yes	Strong positive relationship

CA→ TU	.928**	0	Yes	Strong positive relationship

** Correlation is significant at the 0.01 level (2-tailed).

Moreover, the findings about the positive impact of the Trust factor on the employers' intention to adopt a blockchain-based certification process were supported by some of the interview data. One of the interviewees, a top manager in an academic institute said: *"Currently, in the deanship of the admission and registration department, data are verified by many different departments before the final version is approved. Therefore, although certification is the responsibility of the deanship of the admission and registration department, it is reliant on the colleges submitting their graduate lists on time."* Also, a solution to this issue was proposed by this manager: *"I expect that if we come to apply blockchain technology in the certification process, it would become a much smoother and trustworthy process."*

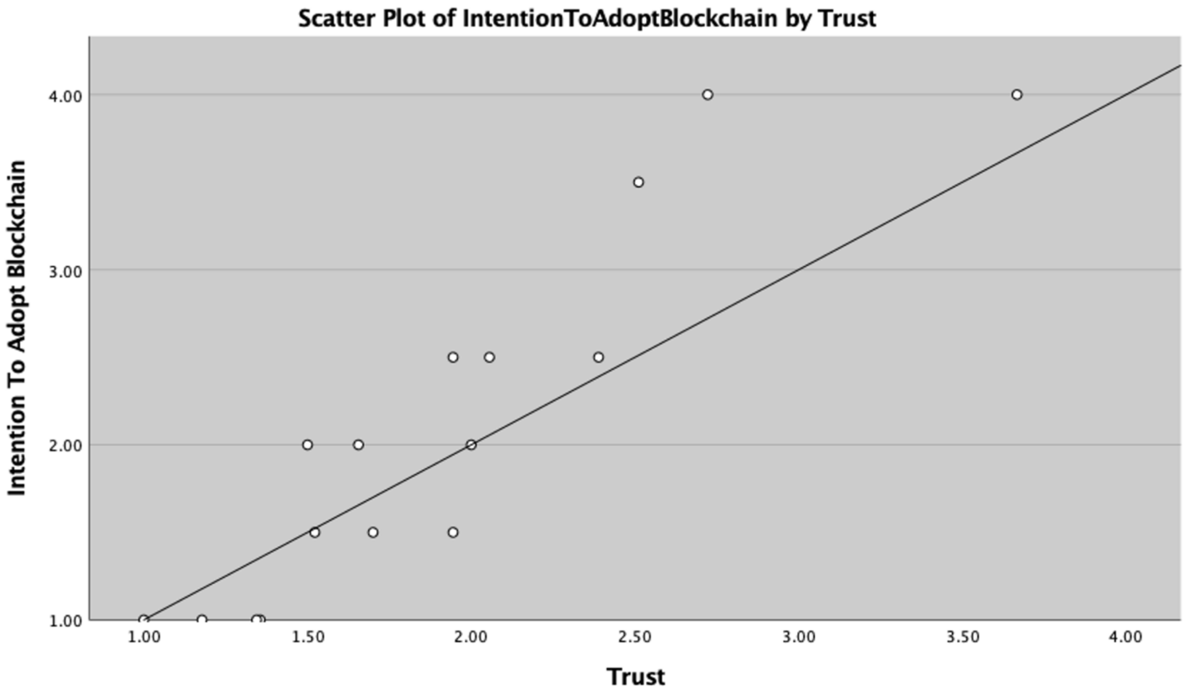

Figure 4.42. Representation of the relationship between T and the employers' intention to adopt blockchain

4.6.2 Security and Privacy (SP)

As mentioned before, this research considers SP as an important factor of blockchain adoption for the certification process. This construct comprised two factors, namely: Perceived security, privacy, immutability and reliability (PSP) and Perceived Risk (PR). This section includes the investigation about the proposed relationship between SP and employers' intention to adopt a blockchain-based certification system from a statistical perspective.

Table 4.38. Summary of the descriptive analysis of SP from the employers' perspective

Construct	N	No. of Items	Mean	S.D.	S. E.	Results interpretation
SP	**22**	**14**	**1.65**	**.437**	**.112**	Highly Influential
PSP	22	8	1.63	.461	.119	Highly Influential
PR	22	3	1.64	.672	.173	Highly Influential
FD	22	3	1.66	.356	.092	Highly Influential

Table 4.38 below presents the descriptive analysis results for SP combined with their interpretation. These findings show the positive influence of these factors on employers' intention of adopting blockchain-based certification system. Additionally, the summary of all the normal distribution tests is presented in table 4.39, which indicates whether or not the data were normally distributed among the employer sample.

Table 4.39. Normal Distribution results for SP-related factors

Construct	No. of Items	Shapiro-Wilk	Skewness Statistic	Kurtosis Statistic
Intention To Adoption	**2**	**.877**	**.787**	**-.351**
SP	**14**	**.938**	**.722**	**1.47**
PSP	8	.949	.126	-.715
PR	3	.774	2.034	5.57
FD	3	.826	-.809	-.404

Perceived security, privacy, immutability and reliability (PSP)

> ***H2a:*** *Perceiving security features of blockchain technology* ***(privacy, immutability, security and reliability)*** *positively influences users' understanding of the level of* ***security and privacy*** *provided by blockchain technology in the certification process.*

This factor measured the main characteristics of blockchain technology related to the security dimension. It consists of eight items to investigate the employers' attitudes regarding the nature of SP in blockchain. From the descriptive analysis shown in Table 4.38, the composite score (**M**= 1.63) indicates a very positive influence of this factor on the employers' perceptions about the level of security and privacy provided by a blockchain-based certification system. Therefore, the assumed hypothesised relationship is valid, but more evidence was provided by running a correlation test for this relationship. Prior to applying correlation test, the normal distribution among the data of PSP and SP factors was checked, and the scores obtained in Shapiro-Wilk's test showed that the data for the two variables were normally distributed (p>0.5). Then, the correlation was assessed using Pearson's correlation coefficient test for the relationship between PSP and SP. The result revealed a statically significant and positive relationship between these factors as (r=.908, n=22, p <.01). Thus, the hypothesised relationship (**H2a**) is valid and supported by the findings of this research.

Perceived Risk (PR)

> ***H2c**: The **perception of low risk** associated with the use of blockchain technology positively influences users' understanding of the level of **security and privacy** provided by blockchain technology in the certification process.*

This factor was measured by three items, and in the descriptive analysis, the composite value (**M**=1.64) showed that PR was very influential on SP and to the employers' intention to adopt blockchain. To support this finding, the relationship between PSP and SP was statistically investigated and the proper correlation test applied. The data for these two factors were not normally distributed, as assessed by the Shapiro-Wilk test (p <.05). Lastly, a correlation test was conducted to gauge the statistical analysis and fulfil the validation process for the hypothesized relationship. Spearman's correlation coefficient test was utilised to examine the relationship, and found a strong positive relationship between PR and SP as (r_s=.930, n=22, p <.001). That demonstrated the impact of the employers' perceptions of risks associated with blockchain technology on their understanding of blockchain SP characteristics. Consequently, the hypothesized relationship (**H2c**) was valid and supported.

Fraud and Dishonesty (FD)

> ***H2b:** The possibility of eliminating certificate **fraud and dishonesty** positively influences users' understanding of the level of **security and privacy** provided by blockchain technology in the certification process.*

As mentioned in section 4.5.3, the majority of the employers agreed on the immutable nature of blockchain that helps to reduce fraud and dishonesty in the applicants' credentials. Thus, the impact of FD was statistically investigated and the descriptive analysis conducted on this factor produced the composite score (**M**=1.66) which indicated FD has a positive influence on the employers' understanding of the level of security and privacy provided by blockchain technology in the certification process. That supported the hypothesis regarding the relationship between the FD and SP factors. Moreover, to analyse the relationship between SP and FD, a Spearman's correlation test was used to determine the degree of relationship, since the data for these variables were not normally distributed, as evaluated by the Shapiro-Wilk test, ($p<.05$), see table 4.39. The results indicated there was a significant and strong positive correlation ($r_s = .743$, n = 22, $p < .001$). Thus, the hypothesis (**H2b**) about the relationship between FD and SP is supported and valid.

Table 4.40. Validating the research hypotheses of the SP by calculating correlation results

Variables Relationship (Hypothesis)	Correlation Coefficient	Sig. (*p*)	Hypothesis Validation	Results interpretation
SP → Blockchain Adoption	**.792****	**0**	**Yes**	Strong positive relationship
PSP→ SP	.908**	0	Yes	Strong positive relationship
PR → SP	.937**	0	Yes	Strong positive relationship
FD→ SP	.735**	0	Yes	Strong positive relationship

** Correlation is significant at the 0.01 level (2-tailed).

To conclude this section, SP positively impacts on the employers' intention to adopt a blockchain-based certification system, as stated in the following hypothesis:

> ***H2:*** *In the certification process in the higher education sector, an increase in understanding the level of* ***security and privacy*** *provided by blockchain technology will increase users'* ***intention to adopt blockchain technology****, given that this allows for better maintenance of student certificates.*

The descriptive analysis results show the composite score (**M**=1.65) and indicated a high level of influence on the employers' intention to adopt blockchain for the certification process. Thus, the hypothesis above is supported but was further verified with a statistical analysis. To validate the normal distribution procedure among the data of these variables (SP and intention to adopt blockchain) the Shapiro-Wilk test was applied as shown and the findings verified the data were normally distributed as $p>.05$. Pearson's correlation coefficient test was then utilised to assess the relationship between SP and the employers' intention to adopt blockchain for the certification process. The result revealed a very strong positive relationship between the employers' perception of the level of SP in blockchain and their intention to adopt it, and was found to be statistically significant as ($r_s = .792$, $n=22$, $p <.001$) (see Table 4.39). This indicated that a high level of understanding blockchain SP features was associated with a high level of employers' intention to adopt blockchain-based systems. Figure 4.43 below is a graphical representation of the relationship between these variables. Therefore, the researcher found the hypothesis (**H2**) is valid and supported by the findings.

To add more evidence to the findings about SP, they were supported by data collected during interviews with top management in the academic institutes. One of the interviewees said: *"The high level of security provided by blockchain, especially in terms of immutability and transparency, will also improve the security level of the certification process."* Another interviewee agreed that SP was an influential factor in blockchain adoption saying: *"The main drive to adopt blockchain will relate to the security and privacy provided by the technology."*. All these findings and results revealed that SP could be considered as one of the most influential factors on intention to adopt blockchain for the certification process.

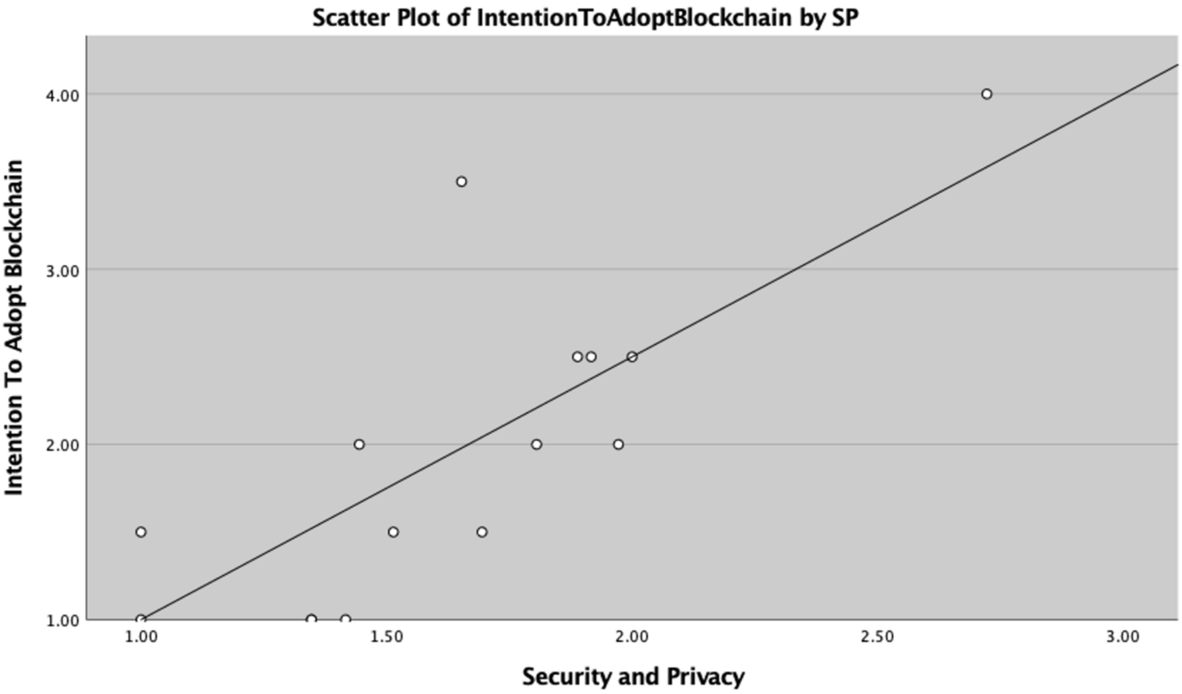

Figure 4.43. Representation of the relationship between SP and employers' intention to adopt blockchain

4.6.3 Social Influence (SI)

This section assesses the impact of SI as an essential factor in the employers' intention to adopt a blockchain-based certification system. It was measured by four items. The summary the of the descriptive analysis for the SI factor and interpretations of the results are presented in Table 4.41.

Table 4.41. Summary of the descriptive analysis of the SI factor from the employers' perspective

Construct	N	No. of Items	Mean	S.D.	S. E.	Results interpretation
Social Influence (SI)	22	4	1.65	.544	.136	Highly Influential

Moreover, this investigation included the results of the normal distribution tests to verify whether the data for SI was normally distributed (see Table 4.42). These results show evidence of the relationship between SI and the employers' intention to adopt the blockchain. The proposed hypothesis below (**H3**) is about this relationship.

H3: *In the certification process in the higher education sector, the level of positive* ***social influence*** *is positively associated with users'* ***intention to adopt blockchain technology****.*

From the descriptive analysis results in Table 4.41, a composite score of (**M**=1.65) indicated SI has a strong positive influence on the employers' intention to adopt blockchain for the certification system which supports the proposed relationship in H3.

Table 4.42. Normal Distribution results for SI factor

Construct	No. of Items	Shapiro-Wilk	Skewness Statistic	Kurtosis Statistic
Intention To Adoption	2	**.877**	**.787**	**-.352**
Social Influence (SI)	4	.854	1.33	1.41

Then, the relationship between the proposed variables was checked for the strength and direction their relationship. Prior to this investigation, the normal distribution results of the SI and intention to adopt blockchain variables were calculated. According to the results shown in Table 4.42, the data was not normally distributed as assessed by the Shapiro-Wilk's test where p>0.05. Therefore, the correlation was calculated by Spearman's correlation coefficient test. The results indicated a strong positive correlation between SI and employers' intention to adopt blockchain-based certification system (see Table 4.43), as (r_s=.810, n=22, p <.001). An increase of social influence pressure is associated with increase in employers' intention to adopt blockchain; thus, the proposed hypothesized relationship (**H3**) is valid and supported by this study.

Table 4.43. Validating the research Hypothesis of SI by calculating correlation results

Variables Relationship (Hypothesis)	Correlation Coefficient	Sig. (*p*)	Hypothesis Validation	Results interpretation

SI → Blockchain Adoption	**.810****	**0**	**Yes**	Strong positive relationship

** Correlation is significant at the 0.01 level (2-tailed).

There was a noticeable positive relationship between SI and the employers' intention to adopt, as shown in Figure 4.44. Moreover, some interview data also supported all the findings about the positive impact of SI on the employers' intention to adopt a blockchain-based certification process. One of the interviewees said: *"Of course, I have no doubt that social factors will influence the decision for adoption."*. Most of the literature reviewed by this research also indicated the impact of social influence on the adoption of the blockchain technology (e.g., (Alshamsi et al., 2022)).

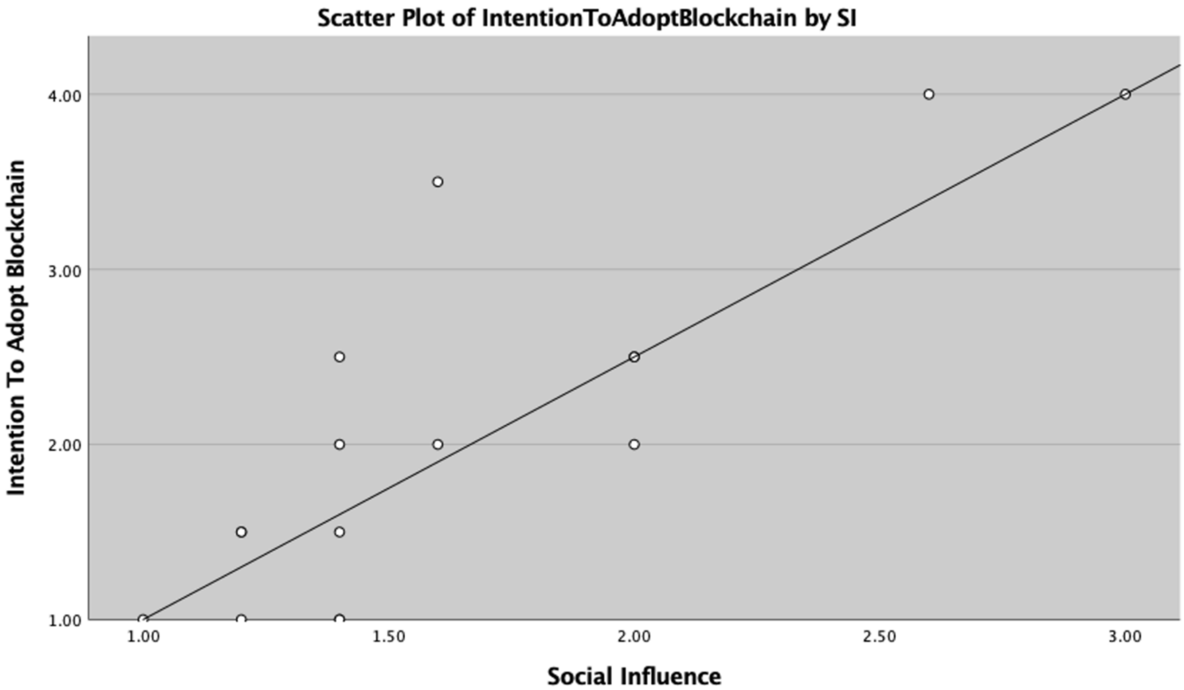

Figure 4.44. Representation of the relationship between SI and employer's intention to adopt blockchain

4.6.4 User Awareness (AW)

User Awareness is a very important measure when it comes to adopting new technology, and investigating it helps the researcher determine the users' knowledge which influences their behaviour. This factor was measured by three items that would be beneficial in assessing the relationship between AW and the employers' intention to adopt blockchain for the certification process.

Table 4.44. Summary of the descriptive analysis of AW from the employers' perspective

Construct	N	No. of Items	Mean	S.D.	S. E.	Results interpretation
User Awareness (AW)	22	3	2.14	.860	.215	Influential

The results of the descriptive analysis are presented in Table 4.44, and show the positive influence of AW on the employers' intention to adopt blockchain. Furthermore, Table 4.45 presents the value obtained from applying tests on the data to check if they can be considered as normally distributed.

Table 4.45. Normal Distribution results for AW

Construct	No. of Items	Shapiro-Wilk	Skewness Statistic	Kurtosis Statistic
Intention To Adoption	2	.877	.787	-.351
User Awareness (AW)	4	.940	.667	-.18

The findings of these statistics helped in determining the validity of the hypothesised relationship between AW and the employers' intention to adopt blockchain technology for the certification process that is:

> ***H4: Users' awareness*** *positively influences their* ***intention to adopt blockchain technology*** *for the certification process.*

As mentioned above, the descriptive analysis results of AW had a composite score of (**M**=2.14) indicating the positive influence of AW on the employers' intention to adopt blockchain. Consequently, the proposed relationship between these two factors was valid according to the descriptive analysis. Then, the correlation between the two variables was calculated to validate the proposed relationship. Besides, applying the correlation test helped in determining the strength and direction of the relationship between AW and employers' intention to adopt blockchain technology. Since the data among the two variables were normally distributed as assessed by Shapiro-Wilk test with $p > 0.05$, the Pearson's correlation test was then used to assess the relationship here. The result revealed a strong positive correlation between these two variables (r=.895, n=22, p<.001) (see Table 4.46). Thus, the hypothesized relationship (**H4**) is valid and supported in this research.

Table 4.46. Validating the research hypothesis of AW by calculating correlation results

Variables Relationship (Hypothesis)	Correlation Coefficient	Sig. (*p*)	Hypothesis Validation	Results interpretation
AW → Blockchain Adoption	.895**	0	Yes	Strong positive relationship

** Correlation is significant at the 0.01 level (2-tailed).

Figure 4.45 below depicts the graphical illustration of the relationship between AW and the employers' intention to adopt a blockchain-based certification system. It shows that as the level of user awareness increases, this results in an increase in the level of the intention to adopt blockchain. The important role of user awareness was also clear from the data collected during the interviews with top management in the academic organisations. Regarding awareness, the vice dean of one of these organisations said: "*As faculty, we are aware of blockchain technology. There are already many initiatives in place to improve our system, but we still have some awareness issues that need to be resolved before we can move on to new technology such as blockchain. "*. Finally, the findings indicated employers had a high level of awareness about blockchain technology which positively influenced the high level of their intention to adopt this technology.

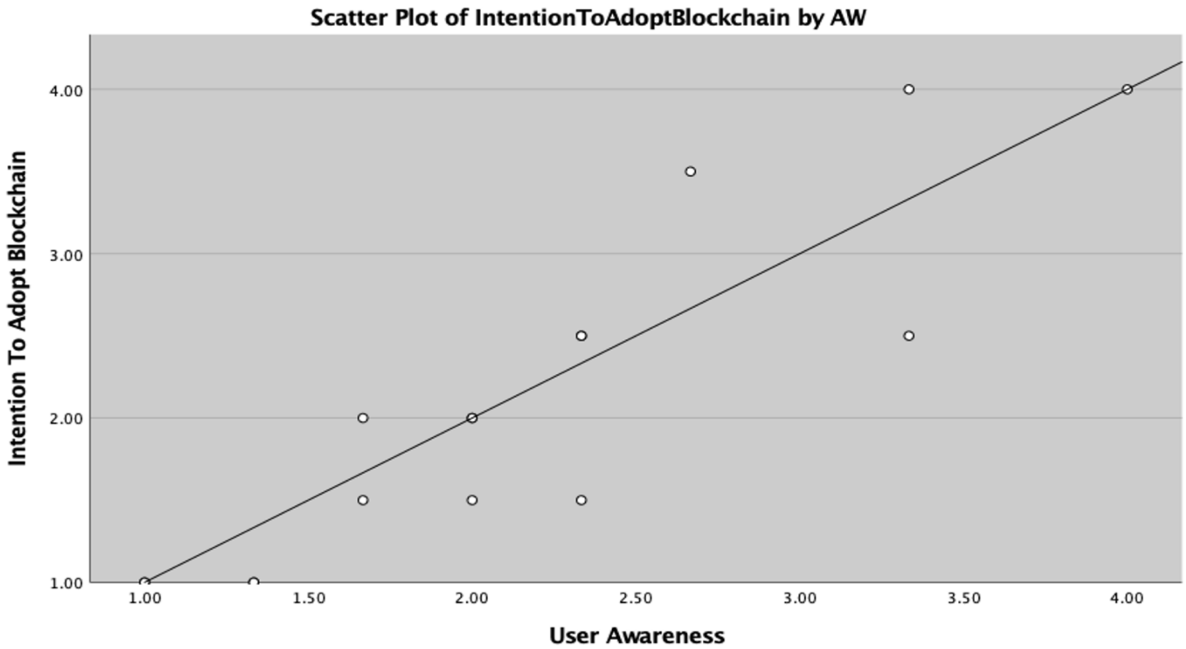

Figure 4.45. Representation of the relationship between AW and employers' intention to adopt blockchain

4.6.5 Efficiency Factor (EF)

This study aimed to measure the impact of EF on the users' intention to adopt blockchain, since according to the literature, it is one of the most notable aspects of blockchain (Zhao, Fan, & Yan, 2016). In this study, this factor consisted of two major constructs namely, the efficient smart certificate and cost reduction. Table 4.47 provides a summary of the descriptive analysis of all EF sub-factors with interpretations of the results. It is clear from the descriptive analysis that EF and its related factors have an influence on the employers' intention of adopting blockchain for the certification process in HEIs.

Table 4.47. Summary of the descriptive analysis of EF factors from the employers' perspective

Construct	N	No. of Items	Mean	S.D.	S. E.	Results interpretation
Efficiency (EF)	**22**	**8**	**1.66**	**.533**	**.133**	Highly Influential
ESC	22	4	1.71	.554	.138	Highly Influential
CR	22	4	1.60	.612	.153	Highly Influential

Table 4.48 below contains all the results of the normal distribution tests applied to the data to determine whether the data in these variables was normally distributed. The results confirmed that the data among EF related factors was not normally distributed. These tests helped in assisting the investigation of the validity of each hypothesis about the relationships between the measured factors to evaluate intention to adopt blockchain adoption, from the employers' perspective. The following paragraphs include the details of the analysis results and validation of the proposed relationships.

Table 4.48. Normal Distribution results for EF-related factors

Construct	No. of Items	Shapiro-Wilk	Skewness Statistic	Kurtosis Statistic
Intention To Adoption	**2**	**.877**	**.787**	**-.351**
EF	**8**	**.850**	**1.70**	**4.60**
ESC	4	.883	1.22	2.91
CR	4	.865	1.22	2.10

Efficient smart certificates (ESC)

H5a: *The* ***efficient smart certificates*** *enabled by blockchain technology positively influence the* ***efficiency*** *of the certificating process.*

The immutability feature of blockchain provides the smart certificates with the advantage of being able to remain unmodified, verifiable and authentic. From the employer's point of view this efficient type of qualification enhances the recruitment process. ESC included four items in total to measure the employers' perceptions about smart certificates. From the descriptive analysis result, as shown in Table 4.47, the composite score for ESC (**M**=1.71**)** indicated a very positive influence of ESC on the employers' perception about efficiency as an influential factor in the certification process. Then, the researcher investigated the correlation between ESC and EF to validate the proposed hypothesised relationship. While the data was not normally distributed in these variables, the Spearman's correlation test was utilised to assess the relationship's strength and direction. The results confirmed that there was a strong positive relationship between ESC and EF (r_s=.806, n=22, p <.001) as shown in Table 4.47. The relationship was statically significant; hus, the hypothesised relationship (**H5a)** is valid.

Cost reduction (CR)

> ***H5b: Cost reduction*** *provided by blockchain technology positively influences the* ***efficiency*** *of the certificating process*

The descriptive analysis results indicated that CR had a strong positive influence on the employers' perception about the efficiency provided by blockchain on the certificating process with a composite score (**M**=1.60**).** As mentioned above, the results of the Shapiro-Wilk normal distribution test revealed that the data of CR and EF was not normally distributed as p < .05. Thus, Spearman's correlation coefficient test was utilised to investigate the strength and direction of the relationship. A strong positive correlation which was statistically significant (r_s= .871, n=22, p <.001) was found (see Table 4.49). Thus, the proposed hypothesis about this factor **H5b** is supported and valid in this study.

After validating the relationships between the EF-related factors, the relationship between EF and the employers' intention to adopt a blockchain-based certification system was investigated. The proposed relationship is represented in the following hypothesis:

> ***H5****:* *In the certification process in the higher education sector, an increase in the level of enhanced* ***efficiency*** *and reduction in the associated cost of blockchain technology will increase users'* ***intention to adopt blockchain technology*** *for the certification process.*

As shown in Table 4.47, the result of the descriptive analysis reflects a very positive influence of EF on the employers' intention to adopt a blockchain-based certification system. The composite score for EF was (**M=1.66)** which was an indication of the influence of EF on the intention to adopt blockchain. The data for EF was not normally distributed (as assessed by Shapiro-Wilk test $p < .05$). Therefore, the Spearman's correlation test was deployed to validate the proposed hypothesis. The result revealed a strong positive correlation between these two variables (r_s=.635, n=22, p >.001) and this correlation was found to be statistically significant. Thus, the proposed hypothesis (**H5**) is supported and valid in this study.

Table 4.49. Validating the research hypotheses of EF by calculating correlation results

Variables Relationship (Hypothesis)	Correlation Coefficient	Sig. (*p*)	Hypothesis Validation	Results interpretation
EF → Blockchain Adoption	**.635****	**0**	**Yes**	Strong positive relationship
ESC→ EF	.806**	0	Yes	Strong positive relationship
CR → EF	.871**	0	Yes	Strong negative relationship

** Correlation is significant at the 0.01 level (2-tailed).

The summary of the overall results of the correlation coefficient test applied to the EF related sub-factors to check the validity of their hypothesized relationships are addressed in Table 4.49. Moreover, Figure 4.46 is a graphical representation of the relationship between these variables. It is clear from this figure that there is a moderate positive relationship between efficiency and intention to adopt blockchain. An increase in the perceptions of efficiency by the employers in the study sample, resulted in increasing the level of their intention to adopt blockchain for the certification process. Additionally, the interviews conducted with top managers in two academic institutes reflected the importance of efficiency in their attitudes towards adopting blockchain for the certification process. One of the interviews responded to a question about the benefits associated with blockchain as follows: *"Decentralising the certification process would improve accuracy and increase efficiency"*.

As expected, the results and findings revealed the impact of efficiency which is considered a huge influence. As stated by ("Benefits of blockchain - IBM Blockchain | IBM," n.d.), blockchain brings several benefits into organisations, including the cost savings from the increased speed and efficiency and the reductio in paperwork and human error. Moreover, the efficiency of blockchain for employers and organisational management is that it is significantly reduces overheads and transaction costs.

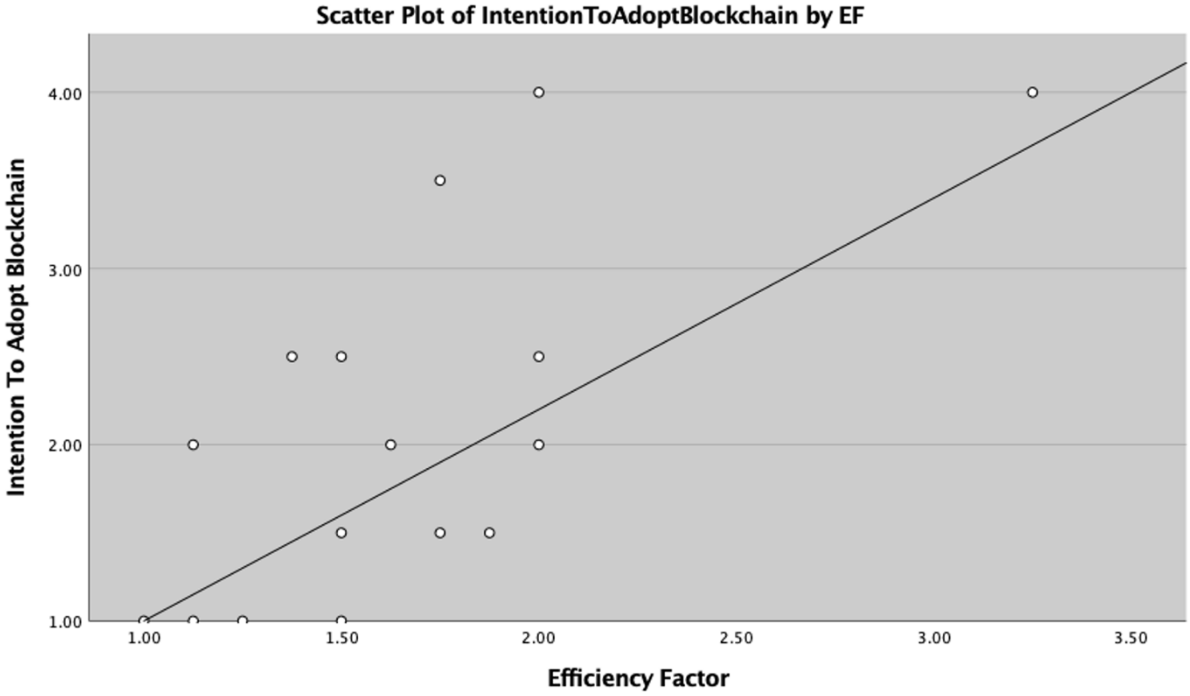

Figure 4.46. Representation of the relationship between EF and the employers' intention to adopt blockchain

4.7 The Revised Conceptual Model

This research investigated the critical influences on the adoption of blockchain technology for the certification process in Saudi higher education. To this end, an integrated research model based on the TAM and TOE models combined with DOI was developed and validated.

Table 4.50. Summary of the results of the hypothesised relationships in the 1st study

	Variables Relationship (Hypothesis)	Hypothesis Validation	Results interpretation
Students'	T → Intention to Adopt Blockchain	Yes	Strong positive relationship
	SP → Intention to Adopt Blockchain	Yes	Strong positive relationship
	SI → Intention to Adopt Blockchain	Yes	Strong positive relationship
	AW → Intention to Adopt Blockchain	Yes	Strong positive relationship
	EF → Intention to Adopt Blockchain	Yes	Moderate positive relationship
Employers	T → Intention to Adopt Blockchain	Yes	Strong positive relationship
	SP → Intention to Adopt Blockchain	Yes	Strong positive relationship
	SI → Intention to Adopt Blockchain	Yes	Strong positive relationship
	AW → Intention to Adopt Blockchain	Yes	Strong positive relationship
	EF → Intention to Adopt Blockchain	Yes	Strong positive relationship

The proposed conceptual model extended the existing models by including extra variables that made it more appropriate for an innovation such as blockchain and that would suit the context of Saudi Arabia as a developing country.

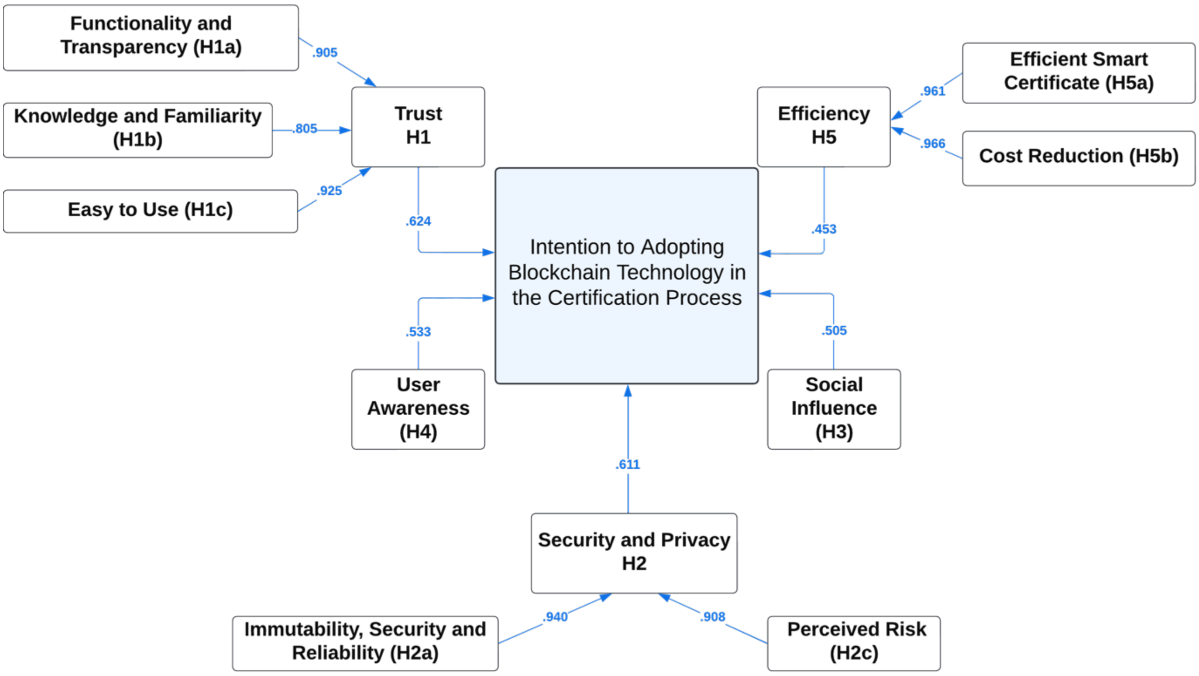

Figure 4.47. 1st Study: The Revised Conceptual Model for the Students' Sample

From the collected data, the findings from the 1st study student survey determined a high level of acceptance for the adoption of blockchain technology for the certification process. The leverage benefits from DLT privacy and security factors in the certification process were quite unclear from the students' point of view, which is reflected in the impact of this factor on their intention to adopt blockchain technology, as shown in previous studies (Alshamsi et al., 2022). The result of this study is that both groups of respondents in this study had reasonable perceptions of blockchain technology and a noticeable desire to adopt the technology in higher education. From the student's sample, all the five factors have a positive influence on the sample's intention to adopt blockchain where the highest impact was from the trust and its related sub-factors which is supported that the trust factor plays an important role in the students' intention to adopt a blockchain certification system as proposed; and this was also found by other studies (Brookbanks & Parry, 2022). The second highest positive influence factor from the students perspective was the security and privacy related factors.

Moreover, the social influence and awareness factors were at an moderate positive level and the results collected regarding their impact on the intention to adopt showed a strong positive influence. Consequently, more effort is needed to educate students and spread awareness about the impact of blockchain technology on their future and credentials. Additionally, the students were moderately aware of the features of smart certificates and how efficient they could be for generating immutable records for qualifications. This also implies the students' enthusiasm toward realizing the process of validating their qualifications with high transparency; and indicates the impact of these factors.

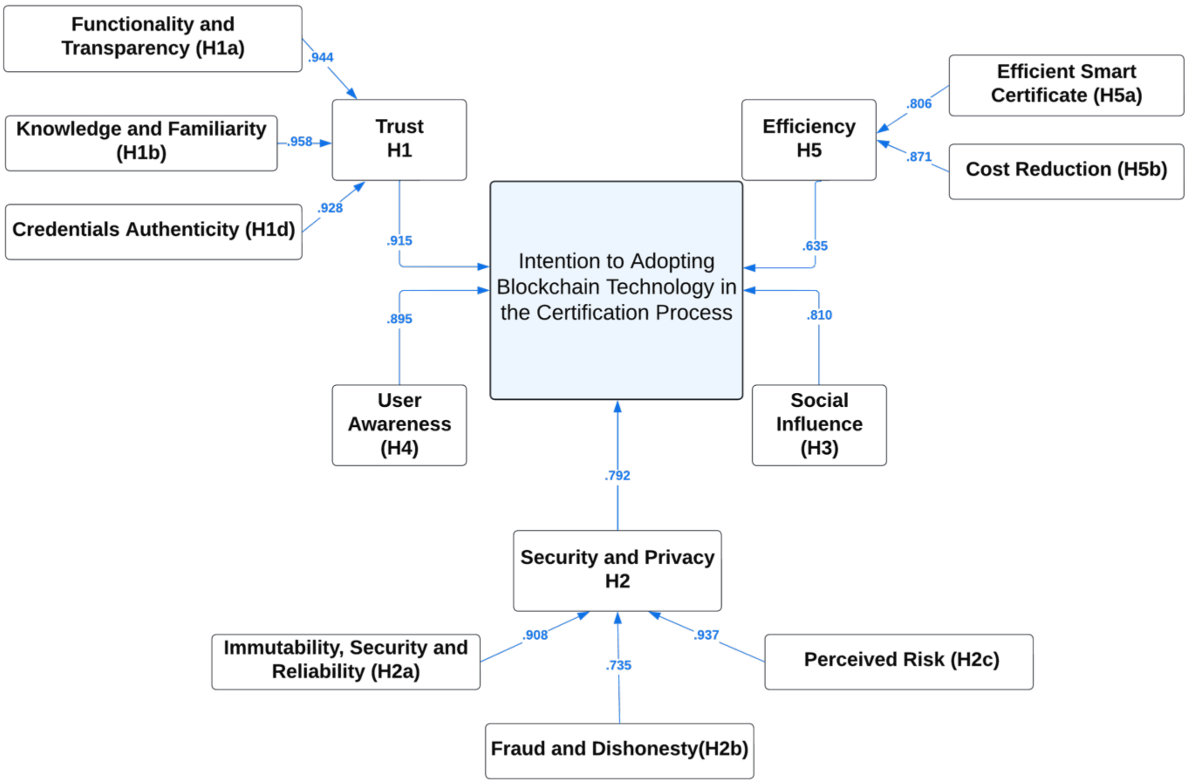

Figure 4.48. 1st Study: The Revised Conceptual Model for the Employers' sample

In the employers' sample, the results for the chosen factors indicated a high level of acceptance among the participants for the employers' survey. There was a good indication among prospective employers of intention to adopt blockchain for the certification process. The efficiency factor had the lowest level compared to the other four factors. This is considered a reflection of employers' need to learn more about the benefits and features of DLT. In contrast, privacy and security factors had the highest average mean, which reflected the understanding that blockchain could enable security and privacy for smart certificates. Accordingly, this affects the decisions that employers make about applicants' qualifications.

The social influence and trust factors achieved similar results regarding the effect on intention to adopt blockchain technology and encouraging educational institutions to operate with the same transparency level in their outcomes. Also, it indicated the perception among employers about the utility of blockchain technology in offering an efficient sharing system for employers and students in higher education. In short, all the achieved results collected is showing a positive intention by students in higher education and prospective employers to adopt a blockchain based certification system.

4.8 Contribution to Women's Studies

In this study, the majority of the student sample was female, which is an important matter regarding studies in developing countries like Saudi Arabia. The relevant literature reveals that there are currently very few studies in Arabic countries which proportionally represent the female population in these countries in technology-related studies (Alghamdi, 2017), (Alshihi, 2006), (Alsaif, 2013). This happens due to the fact, that currently the majority of researchers, conducting surveys and interviews in the technology area, are men who are therefore unable to get access to female participants due to cultural norms in Arabic countries. Thus, many of the previous studies suffered from a gender bias, whereby women's opinions were not proportionately represented. However, women play an important role in technology acceptance decisions, and are increasingly an active functional group in Arabic societies. Moreover, in 2019, 55.8% of graduates in Saudi Arabia were women (Statista, 2020). Therefore, this study goes some way to closing this gap in information about Saudi women's attitudes to technology and helps to reduce the existing gender bias and limitations of previous studies that largely focus on male participants.

This research provides novel data on Saudi women's views on technology acceptance, which was not previously available. In this section only the Trust factor has been investigated to evaluate the relationship of it with the gender parameter in this study. Spearman's correlation coefficient was used to determine the degree of relationship and influence between gender and all the items listed under the trust factor in this study, including functionality and transparency, knowledge and familiarity and ease of access and sharing. In Spearman's correlation, statistical significance is set at ≤ 0.05. As shown in Table 4.51, there was a weak positive correlation between being female and trust in blockchain technology for the certification process.

Table 4.51. Relationship between Gender and Trust

Constructs	Correlation Coefficient	Sig.	Analysis
Gender – Trust	0.053	0.286	Weak Positive
Gender – FT	0.038	0.450	Weak Positive
Gender – KF	-0.012	0.809	Weak Negative
Gender – EAS	0.050	0.312	Weak Positive

Moreover, this relationship indicates a negative association between female gender and level of knowledge and familiarity with blockchain technology. These findings could be interpreted as a lack of experience with blockchain technology since the majority of participants were between 18 and 25 years old. Also, blockchain is considered an innovative technology that is mostly related to cryptocurrencies. Even though the results did not show a strong correlation between being female and trusting in blockchain technology for the certification process, the study is important because most of the participants were female, and the study gave participants an opportunity to report what factors enhanced their intention to adopt this new technology. Other factors proposed by this research can be investigated in future studies due to the researcher's time limitation at this stage.

4.9 Summary

To sum up, this chapter addresses the main findings of the first study of this research. It includes the results obtained from the three target groups sampled for this research namely, students, top management in academic institutes and prospective employers. The survey results were used to improve the initially proposed model. Quantitative analysis indicated that five influential factors have a substantial impact on students' and prospective employers' acceptance of blockchain technology. This showed the validity of the model's structure and that it was ready to be implemented and the user feedback subsequently tested. In conclusion, both groups of survey respondents in the 1st study had reasonable perceptions of blockchain technology and a noticeable desire to adopt the technology in higher education. Statistical analysis confirmed that the data collection instrument was valid and applicable in evaluating employers' and students' acceptance levels of blockchain technology. However, the results also indicated that the students had a limited awareness of the benefits, disadvantages and perceived risks associated with using blockchain technology in the certification process for higher education institutions. The results for the chosen factors in the employers' sample indicated a high level of acceptance among the participants for the employers' survey. According to the findings, all factors had a significant positive impact on employers' intentions to integrate a

Blockchain-based certification system. Moreover, the data obtained from employers indicate a strong desire to validate applicants' certificates using an immutable and reliable system based on blockchain technology (e.g., DASC) to prevent fraud and dishonesty. the results indicated that there is a need from the users to test a proof-of concept system that enables the sample to understand and visualise a blockchain-based certification system. Additionally, interviewees' responses were also presented to support the findings from the descriptive and inferential analyses.

Chapter V

5 DASC Architectural Design

This chapter addresses the structure of the Decentralised Application of Smart Certificates (DASC), its components and its logical representations. The DASC is specifically designed to support efficient smart certificates for higher education institutes. After conducted the 1st study, the results reveal a positive intention from the targeted users to adopt Blockchain-based certification process. The idea was new, and no such systems are reachable for the users. Therefore, the researcher wants to measure their intention after they test the DASC that represents all the features they have been asked about in the 1st study. This chapter will also include a logical demonstration, system requirements and functionalities, scenarios and cases for the user and detailed user graphical interfaces with descriptions of the proposed solution, which is the decentralised application for smart certificates (DASC).

5.1 Proposed Solution DASC

This section highlights a proposed solution to overcome current problems in the field of higher education, especially in the certification process as was published in previous research (Alshahrani et al., 2020). It consists of three subsections: the proposed system framework, a high-level conceptual infrastructure, and demonstrations of the system logic. Using blockchain technology helps eliminate the need for a third-party authority and enhances the interactions between all related participants. To overcome the abovementioned challenges and issues in the current process of handling and posting student certificates, the structure and functionality of the DASC has been proposed. As shown in figure 5.1, the system has five main actors: students, alumni, administrators, instructors and prospective employers.

The DASC aims to maintain a log of student data, including credits, skills, badges and course registrations. The system should have the ability to enable student data sharing with authorised stakeholders, including prospective employers, university staff and university administrators. The high level of transparency afforded by the system should also allow HEIs to design and implement distinctive and personalised teaching methods for each student. The DASC should function as a standard information repository integrating students' information – including transcripts (a summary of a student's academic performance and progress to date) other achievements and digital certificates – from different HEIs. Therefore, it will be possible for students to maintain authentic records of their certificates for use as a long-term e-portfolio, along with a complete log of their grades, courses and achievements. Given that prospective employers will be allowed to use the proposed system to verify the authenticity of a candidate's qualifications and transcript, it will eliminate certificate fraud and dishonesty.

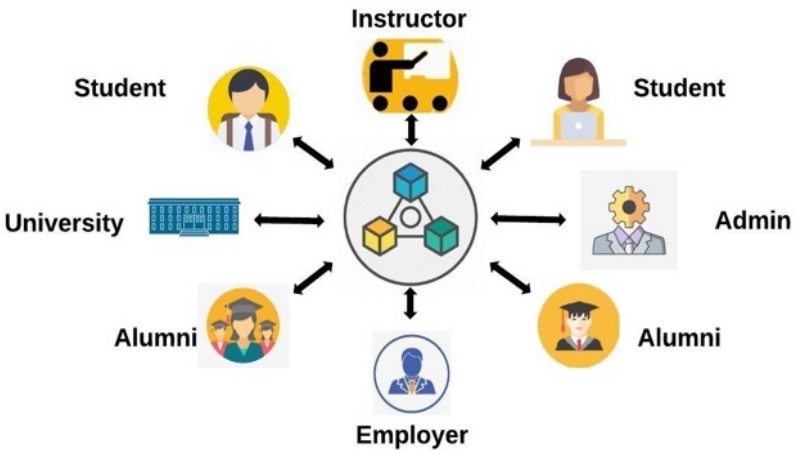

Figure 5.1 Actors in the proposed system

To achieve the research aims and goals, the DASC should provide solutions as answers to the following questions: What are the benefits of blockchain technology in resolving the current problems faced in the higher education sector when generating learner certificates and accreditations? How can blockchain systems improve the efficiency of generating certificates in the higher education sector?

The DASC should serve as a single repository of information that consolidates students' digital certificates, transcripts and achievements from different educational institutions. Thus, students will be able to keep authentic records of all their accreditations for use as a permanent e-portfolio and full record of their achievements, grades and courses. With prospective employers allowed to check the authenticity of a job candidate's transcript, accreditation fraud and dishonesty will accordingly be eliminated. The data gathered by this study have been used to enhance the initial proposed model (see Chapter 4 for details of the survey findings). Statistical analysis revealed that the five suggested factors having a huge influence on their acceptance of the blockchain technology. Therefore, these findings showed that the stated hypotheses about the influences of proposed factors on targeted users' intentions to adopt blockchain technology in the certification process are validated and accepted.

5.1.1 High-level Conceptual Infrastructure

The DASC's high-level conceptual infrastructure as shown in figure 5.2, which represents the blockchain as the left dashed box (noted as '**on-chain** transactions'), directly connected to the front-end system and centralised database systems (**off-chain** transactions).

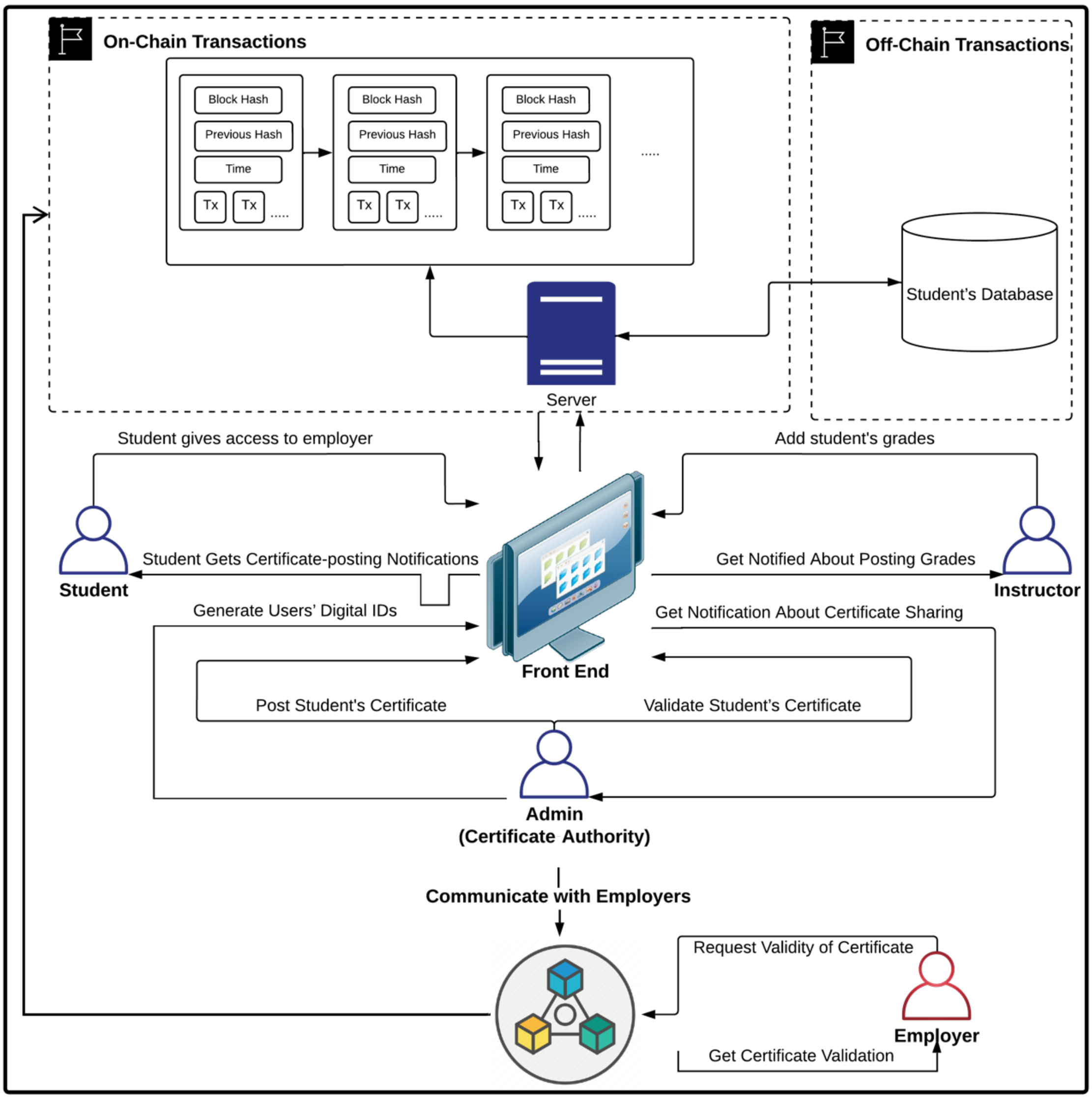

Figure 5.2. High-level conceptual infrastructure of the DASC.

On-chain transactions are the transactions that take place directly on the distributed ledger network, whereas off-chain transactions describe the external transactions performed outside the distributed ledger (Ramamurthy, 2020). The off-chain data demonstrates the general data about students, courses, enrolment dates and so on. While, in on-chain data the system will store all the connection between the data that makes these data more exposed, the nature of the data in on-chain transaction is a valuable and cherished data. The researcher borrows the principle disgusting between on-chain and off-chain data from the security strategy of information that follow different standers such as ISO, IEEE standards.

The proposed system (the DASC) allows students to get a single view of their certificate and credentials data with a guarantee of data integrity. Such a view can be shared with external parties with the student's permission. As represented in the conceptual infrastructure, the DASC allows direct interactions between prospective employers and front-end systems which are controlled by system administrators giving the appropriate permissions.

5.1.2 Demonstrating the DASC Logic

A major step in developing a software application is to clarify the proposed solution's requirements, scope, limitations, exceptions and expected outcomes by using visual representations. To fulfil this aim, this section presents the logic of the proposed DASC by using unified modelling language (UML).

UML is defined as a graphical representation for visualising, modelling and documenting object-oriented systems (Object Management Group, 2015). Using UML standards helps software engineers and developers understand the functions and data attributes of the proposed system (Rocha & Ducasse, 2018). First, use case diagrams are employed to model behavioural structure; then, sequence diagrams are used to illustrate direct interactions between the system's participants.

- **Use Case Diagram**

This section focuses on the interactions between the actors and the system. Figure 5.3 shows the use case diagram of the DASC that describes system behaviour. The use case diagram is a user-facing diagram that helps in the analysis of the requirements of a problem statement from the user's perspective (Ramamurthy, 2020).

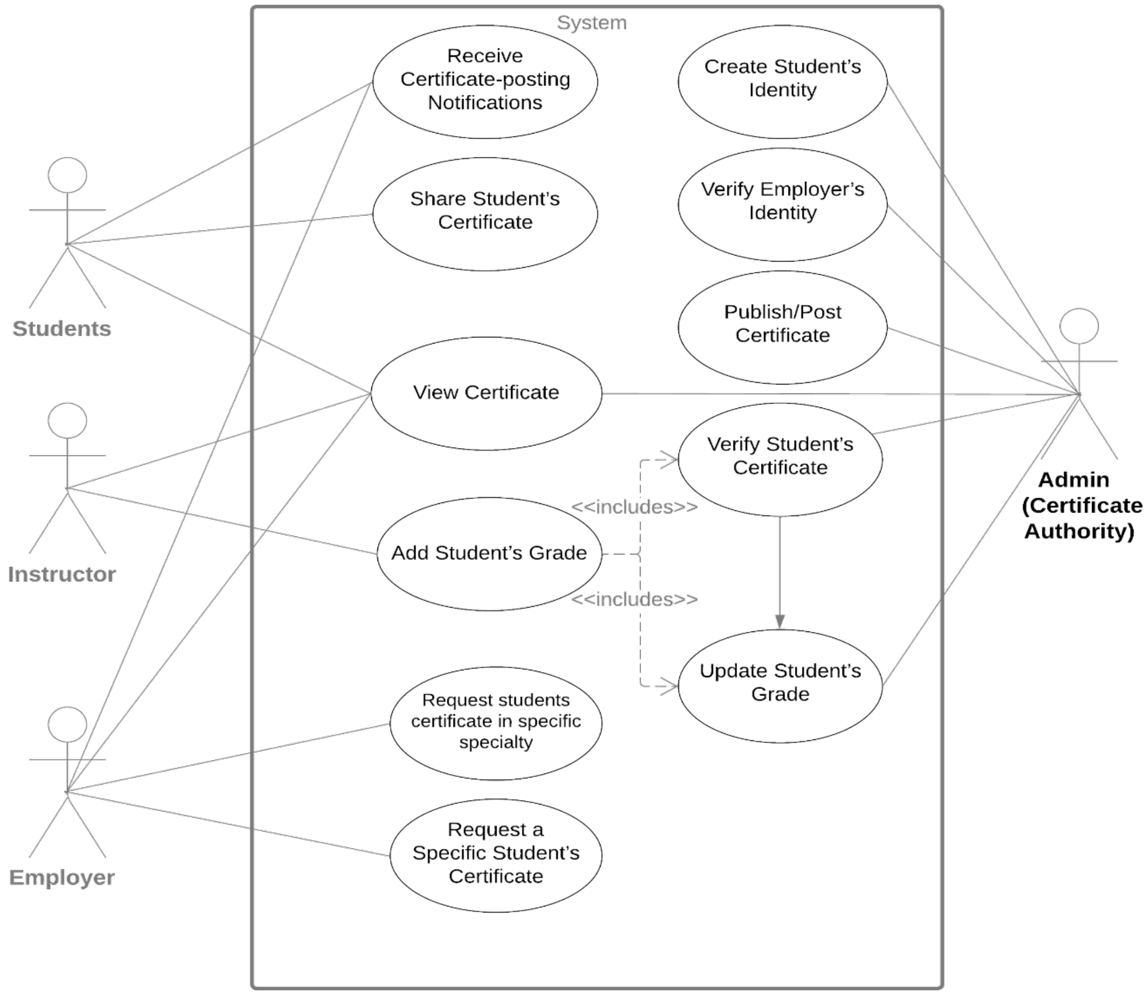

Figure 5.3. DASC Use Case diagram

This diagram shows all the system's actors and the main functionality they can perform while using the system. For instance, students can interact with the DASC to obtain a full view of their digital portfolio, receive updates and share certificates or achievements with others. The main actor in the system, the certificate authority (Admin), has the authority to create and verify digital identities for other actors, post student certificates, verify student certificates before posting them in the portfolio and update student grades.

- **Sequence Diagrams**

As noted by Ramamurthy (Ramamurthy, 2020), using sequence diagrams helps illustrate the operations and interactions between the user and different objects of the system in a timeline. In the case of the DASC, the system consists of many operations that need to be illustrated in order to emphasise the interactions between the system's actors and objects. System objects include the centralised database that will be used to store the off-chain data.

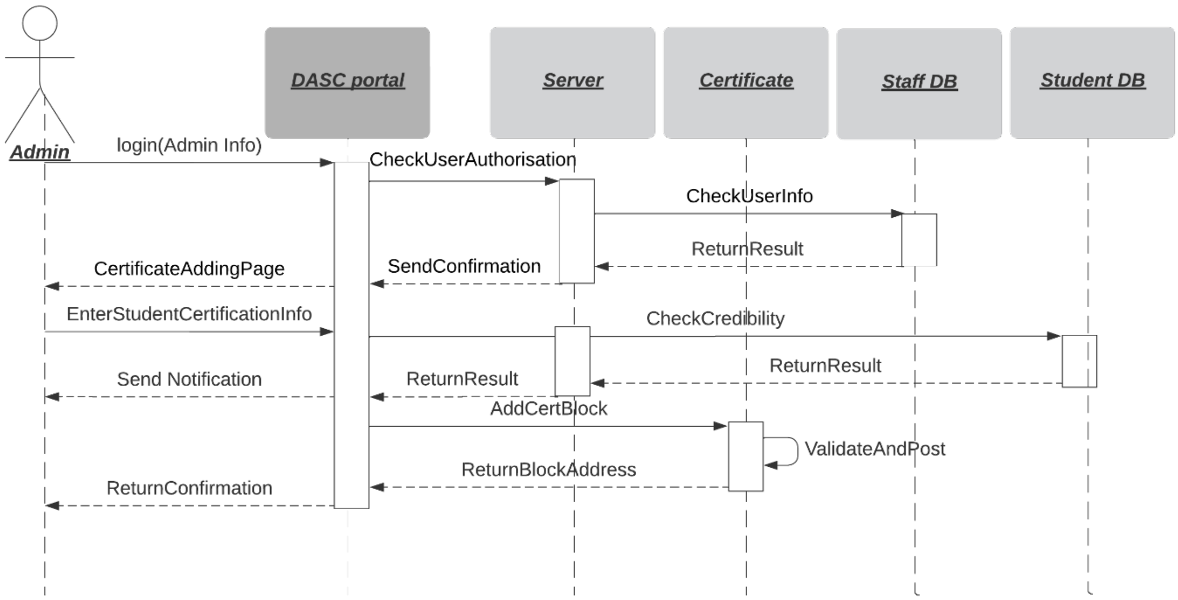

Figure 5.4. Sequence diagram to add student certification

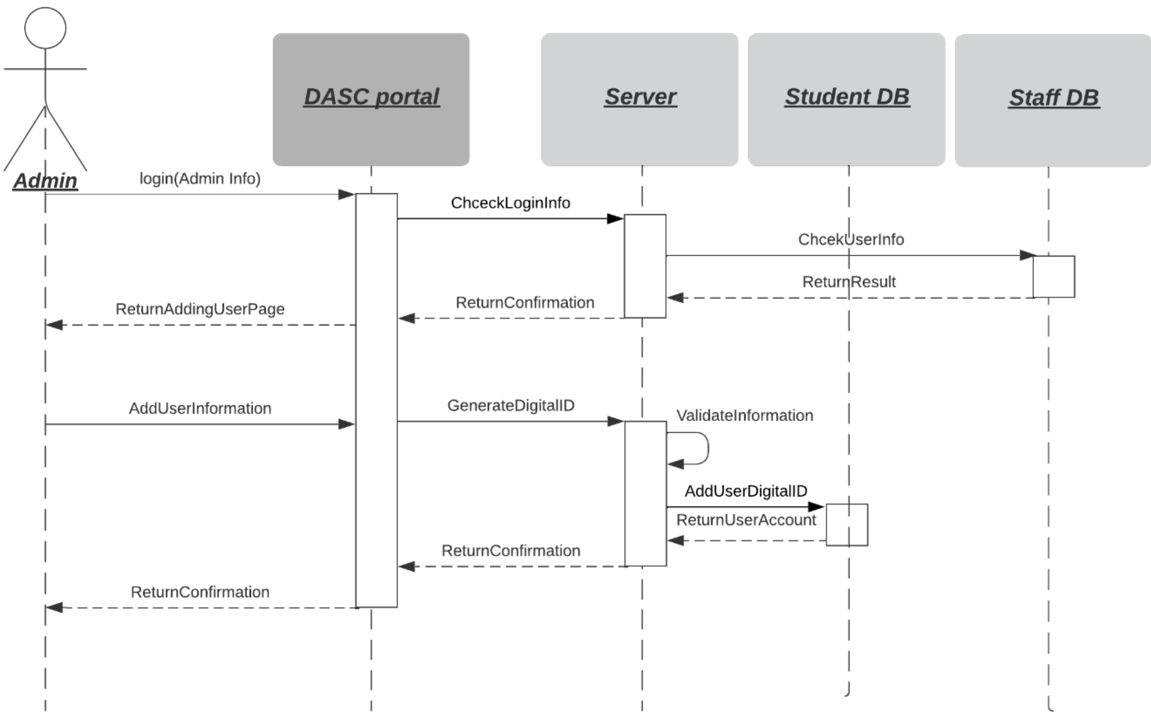

Figure 5.5. Sequence diagram to create user digital identification

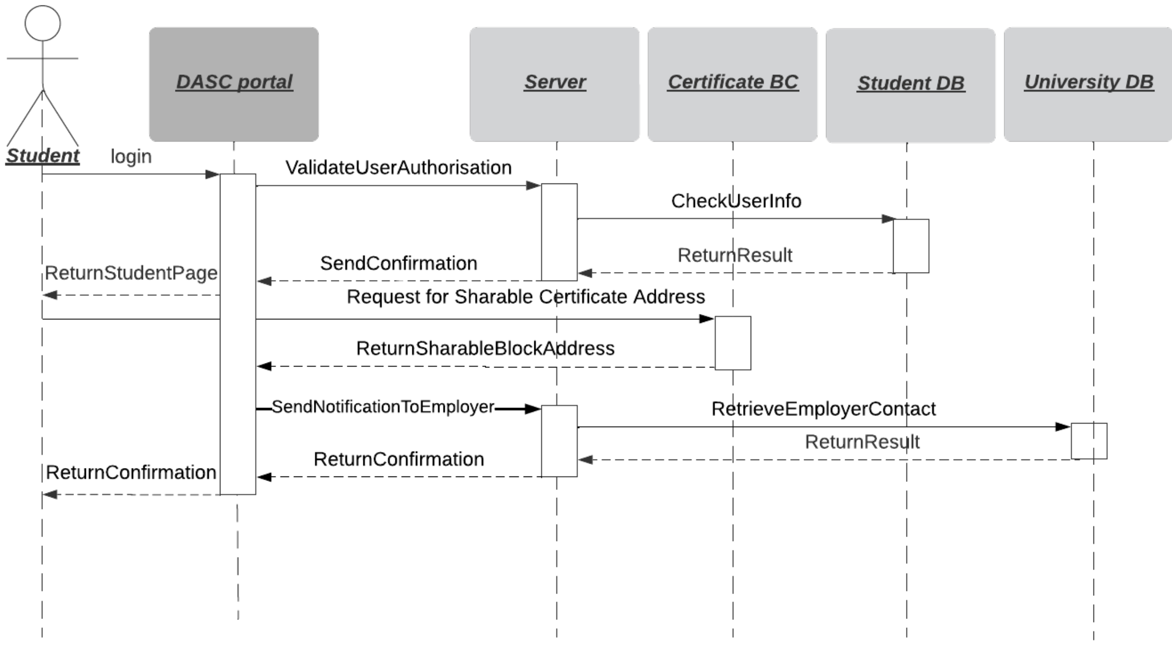

Figure 5.6 Sequence diagram to share a student's certificate

Data are stored off chain to reach the goal of not storing all related data on the chain. Thus, illustrating that the system's main interactions with the actors should facilitate the implementation process for developers (Torre et al., 2018). For instance, the 'Admin' actor represents the main certificate authority in the system. For this actor, all the processes revolve around giving privileges, initiating digital identities and issuing student certificates. Figures 5.4, 5.5, and 5.6 show three main processes in the DASC illustrated by sequence diagram standards which are add certificate, create ID and share student's certificate.

5.2 System Requirements and Functionalities

Regarding the technical aspects of DASC, Regarding the technical aspects of DASC, it is recommended that the system be developed on the Hyperledger consortium platform and used with the Python programming language. The system is typically composed of two parts, namely a traditional software system, running on servers and/or on mobile devices, communicating with users and external devices (Note that at this stage of the research this is not a real university system, just a simple demo). The second component is the Blockchain technology infrastructure, which includes Smart contracts (SCs) that run on the Blockchain network. The traditional software system will have a centralised data storage system to prevent the high cost related to the large volume of data flooding into the blockchain. This is called off-chain storage and activity, which will hold full detailed information about students, courses, colleges and instructors. The stockholders associated with the system will include university admin or certificate authority, student or recipient, instructor or issuer and lastly, the employer. All the associated stockholders are defined below:

Admin: The first and most important actor is the admin, which represents the main certificate authority of the system. For admin, all the processes are about giving privileges, initiating digital identities and issuing students' certificates. The admin will be given access, and the system will allow the admin to generate users' digital identities and set user privileges, where the users will be students and instructors. The system will allow the admin to verify and validate the grades entered by instructors and issue students' certificates after the grades are entered by the instructors. The system will also allow the admin to post and publish student certificates. Apart from that, the admin will also be able to modify his/her own account or any user's account. Whenever there is any request from any employer to verify the certificate authenticity, the admin will be notified and allowed to verify the request for any certificate verification.

Student (Recipient): The second actor of the system is the student or recipient. Students will have access to their achievements and certificates as well as granting employers access to their data. The system will allow the students to show their own information in the form of a profile consisting of the student ID, department, school, date of birth and list of all the earned certificates. The system will allow the student to share or grant access to external parties or employers. This could be done by sending the achievements or certificates to external parties or employers. The students will also receive notifications about posting new certificates by the system, and it will allow the students to claim the certificate in case an error has occurred. Apart from that, the students will also be able to save the QR code of the certificate.

Instructor (Issuer): The system will allow the instructor to view and update his/her profile, including name, degree, department, college, teaching courses and contact information. The system will also allow the instructor to enter the course grades of all the registered students in the course, along with viewing specific student profiles or certificates. The system will notify the instructor about any certificate claimed, and the instructor will be able to revoke a claimed certificate.

Employer: The employer, as an actor in the system, will be able to verify the authenticity of any prospective employee's certificate. The system will allow the employer to browse the sharable certificates and receive the link to any certificate shared by students. The system will also send notifications to the employer if any specific student has earned any certificate. The employer will not have direct access to the system, however, they can request information about students in specific majors from the admin. The system also allows the employer to scan the QR code from the home page and ask for certificate authenticity. After the desired certificate is authenticated, the system will notify the employer by email.

Certificate: The certificate is the main asset of the system. It should be stored in the blockchain to maintain all the benefits and features of the blockchain data. It should contain the details, including student's name, course details, date of issue, college name issuer and hash value. hashing is one of the most important characteristics of blockchain technology. It is defined as the function that satisfies and maintains the encryption properties to perform blockchain transactions (Srivastava et al., 2019).

5.3 Scenarios and Cases for Users

This section presents the leading cases and scenarios the DASC system's users experience while using the system. It will be divided among the four types of system users: students, admin, instructors and prospective employers. Three main case scenarios encountered by the systems' users are discussed; and describe the foremost transactions conducted by different types of users while using the system.

In this section, the use case scenario is shown to be able to represent various potential transactions with indications of all the efficient functionality provided by the system. The user experience scenarios illustrate the common transactions faced by the user in both a graphic format and descriptive text. The purpose behind this is to show how blockchain technology is deployed to remedy these situations. These scenarios are models of real situations used in a design process while implementing a DASC. These three foremost transactions are summarised in the table below along with their associated users:

Table 5.1 Main DASC use case scenarios.

ASSOCIATED USER	TRANSACTION
STUDENT	Share certificate with prospective employer.
EMPLOYER	Verify the certificate by the DASC system.
ADMIN	Post (Add) new student's certificate

In conclusion, the use case scenario diagrams and descriptions provided the survey participants with an overview of the main selected blockchain certificating process transactions. This was to inform their perceptions of the blockchain uses-cases to enable them respond to the corresponding questions.

5.3.1 Sharing the student's certificate with prospective employers.

This process emphasises the idea of sharing students' or alumni's certificates; and comes as one of the main benefits the blockchain can offer as new technology in this field. The sharing process in the case of a blockchain-based system is performed by the students which will be given the ability to share their credentials with third parties. The sharing certificate feature allows the students to have the right to present their earned qualifications with others at any point in time with no extra effort or permissions. Figure 5.7 above shows the flow chart of the process that the student will follow to share any posted certificate with an external party.

The following steps summarize how to obtain this process via the DASC:

The process starts once the student logs in to the system with authenticated access information. The student can then access a list of their certificates by clicking 'Documents List'. The student can choose the desired certificates and browse all related information. To share this document, the student simply presses the 'Share' button, and a popup window opens to allow student to enter the relevant employer's official email. The email is submitted to allow the system to send the certificate to the employer. Finally, the student receives a confirmation message indicating the certificate has been sent to the employer.

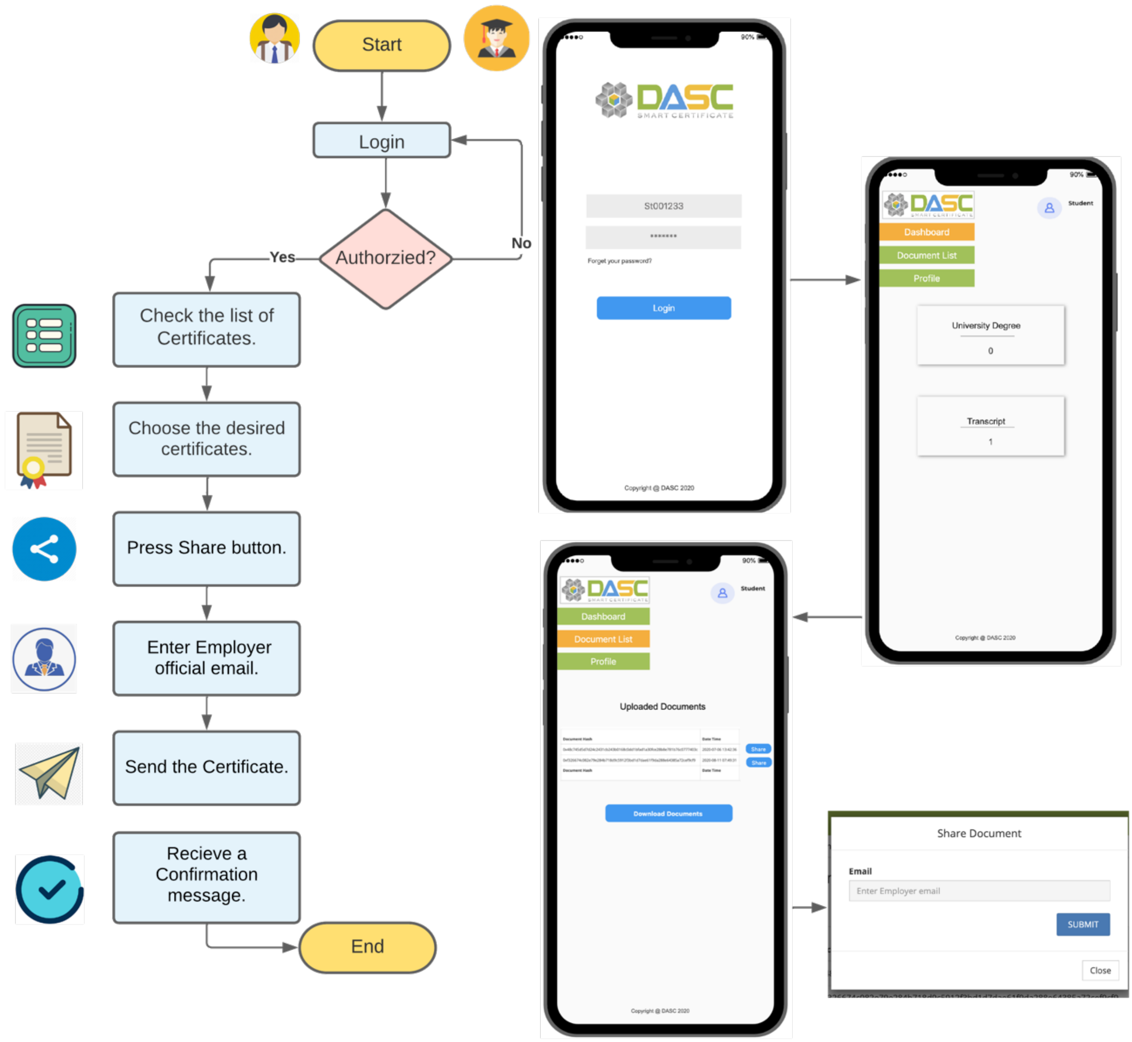

Figure 5.7 Sharing student's certificate scenario

5.3.2 Verifying the certificate through the DASC.

This process starts with the employer's desire to verify any qualifications or credentials that have been received from prospective candidates. As the proposed system relies on the architecture of blockchain technology, this process can be carried out with great trust from the employer side. The verification process guarantees that the applicant holds all the assumed qualifications. As shown in figure 5.8, The employer has two options to get access to the desired student's certificate by either:

a. Using the DASC system to search for the certificate either by student details or university name.

b. Receiving a sharable link by email

The following steps summarize how to do this process via the DASC:

For option (a): the employer clicks the ‘prospective employer’ button on the home page. The employer then has two options:

1. Entering the student’s personal details (name and email)
2. Entering the institution’s information (University name, document type).

They then press the search button, and the system shows the search result with all the information about that student or the document type. The employer can then contact the student via email.

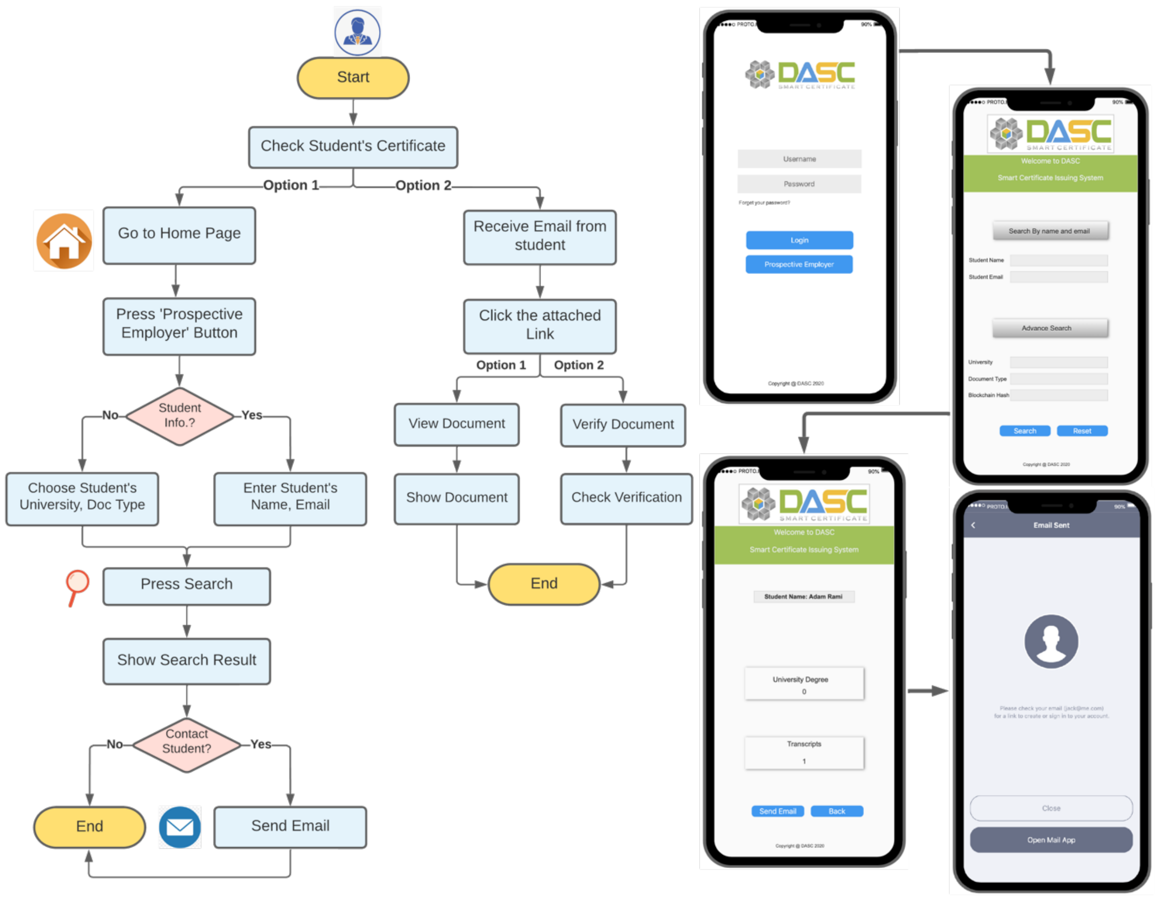

Figure 5.8 Verifying the student's certificate through the DASC

For option (b): this process starts once the employer receives a sharable link from the student or alumnus in question. The link is specified to a particular document that has been shared by the student; therefore, the employer doesn’t need a permission to login or access the system. The employer then presses the link to be transferred to the DASC page and can then choose to view or verify the attached document. If they choose to view the document, the system shows the certificate information which can be saved by the employer. If they choose to verify the document, the system shows a page containing a message about whether certificate is verified or not.

5.3.3 Posting (Adding) new student certificates.

As stated previously, the main benefit of using blockchain in generating information about students' qualifications is leveraging the properties which can be represented in this process. The process starts once the student has earned a new certificate and the university's admin wants to post the certificate on the chain, so the student can maintain a full record of earned qualifications with no extra effort. Moreover, the student can share this certificate with other parties such as prospective employers. Figure 5.9 represents the flow of the steps involved in this process along with the screenshots from the actual prototype of the DASC.

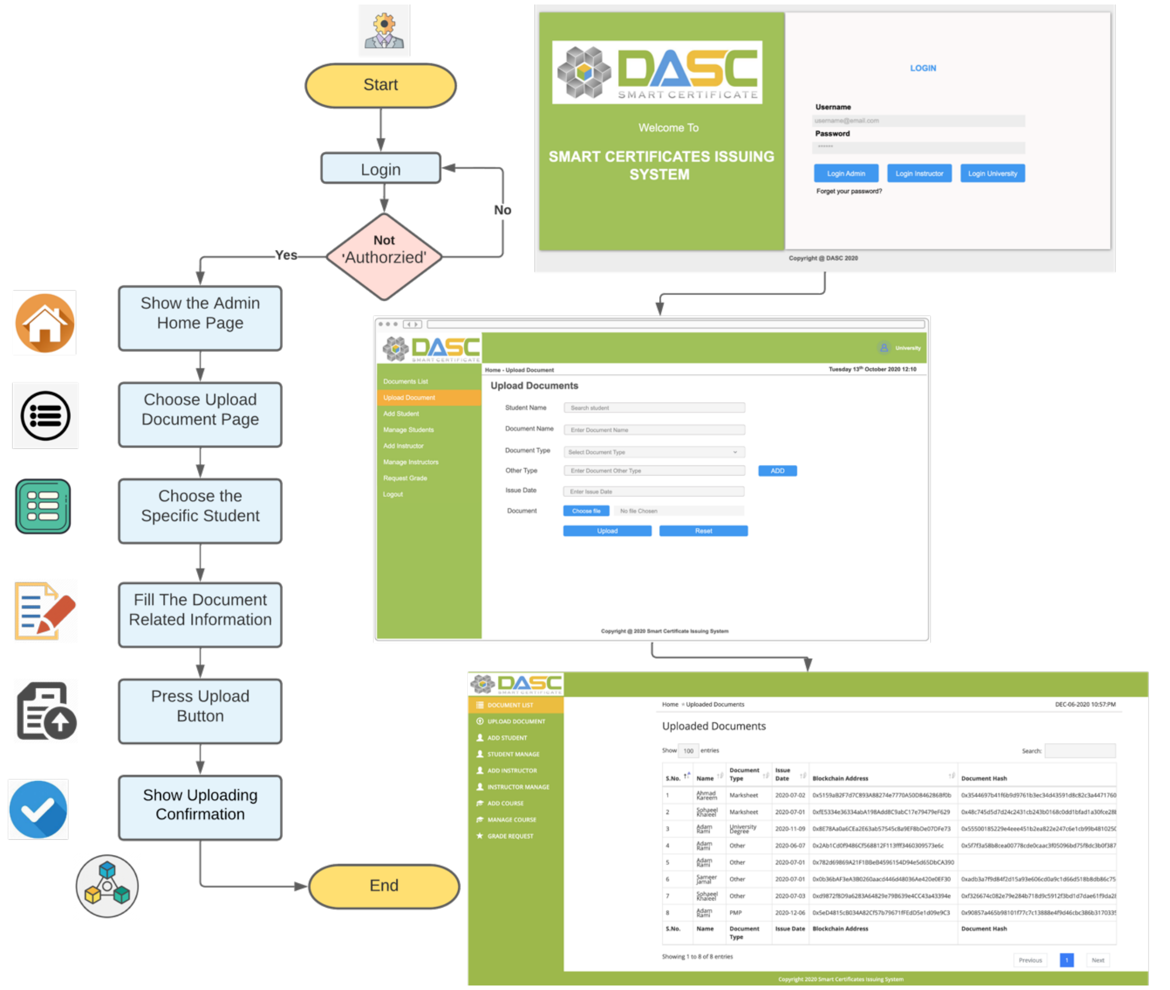

Figure 5.9 Posting a student's certificate by Admin

The following steps summarize how to do this process via the DASC:

The admin logs in to the system; if the login is authorized then the home page will be open. If the information access has not been accepted the system reopens the login page. The home page for the admin opens to allow the user to choose the appropriate tab for this process named ‘Upload Document’. Firstly, the admin is asked to choose a specific student name from the list associated with the university and fill the other related information about the certificate including the type of the certificate with the issue date in order to request a copy of that certificate. The admin then presses the ‘upload’ button to upload the certificate to the blockchain. Finally, the system shows a confirmation message that the certificate has been successfully uploaded to the student’s profile.

5.4 Screens Design: Detailed User's Graphical Interfaces

This section illustrates the system screens according to the type of user. This can be considered as a system manual in case the user faces any issues related to the transactions during any testing of the system.

5.4.1 The student

This section covers all the transactions the student can do while using the DASC; especially the process of sharing their earned certificates with others.

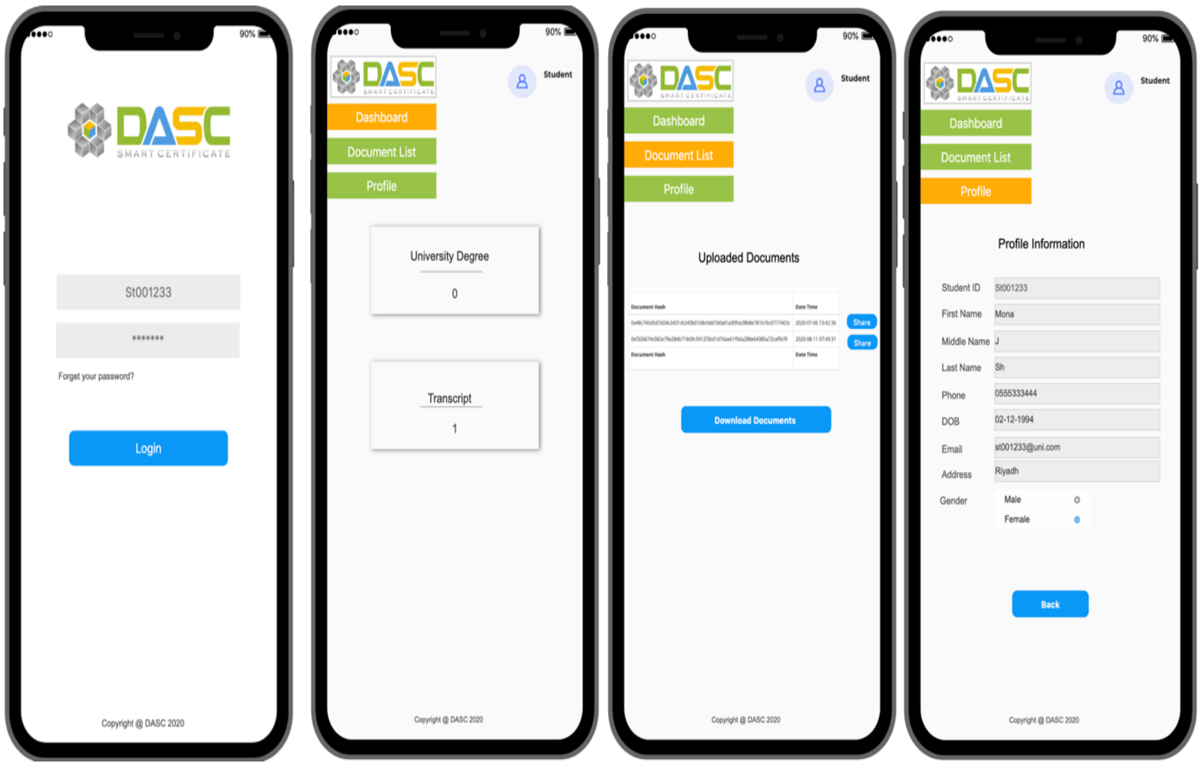

Figure 5.10 Student's screens

First, the student logs on to the system by giving a username starting with 'St' and a password set by the system's admin. If the student successfully logs in to the system, the home screen will be shown which called 'Dashboard'. On the 'Dashboard' screen, the student can check their earned certificates, transcripts or awards posted by the university. It shows the number of qualification and their level and type with no other details on this screen. The 'Documents List' screen shows all the detailed information regarding the qualifications earned by the students. For each document there is information about the issuer, document name, type, blockchain address and document hash. This screen allows the student to print the whole record of his/her achievements (see Figure 5.10). Moreover, for each qualification. the student can check and download the file. Also, the student can click the ‘Share’ button to share this document with other parties or employers. Sharing the document with a prospective employer is done simply by entering the employer’s email address then clicking ‘submit’ (as shown in figure 5.11). After submitting a valid email, a message saying ‘Document shared successfully’ will appear on the screen.

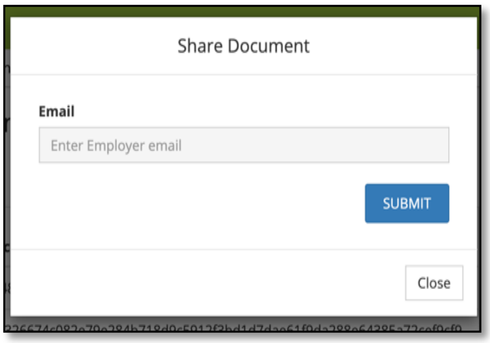

Figure 5.11 Sharing a document with a prospective employer

The Profile screen is the screen where students can check their profiles. The information shown about the student can be just retrieved and checked by the student without the authority to change or update anything. In cases where a student wants to change the information about their profile, the admin has to be contacted.

5.4.2 The Employer

This section covers all the transactions the prospective employer can make while using the DASC; especially, the process of verifying the authentication of a specific student’s certificate. The employer can interact with the system from the home page (login screen), from this screen they can access the system to check information about any student certificates and credentials. By pressing the ‘Prospective Employer’ button the search screen appears; the user can search in two ways. Firstly, by using the student’s personal information (name and email); and secondly by choosing the university name, type of the credentials and blockchain hash (if it is shared with the employer). Once the system finds a match to the information entered by the employer, it shows the student’s name along with all the credentials earned by that student. The system allows the employer to contact the student by email if they wish through the search result screen.

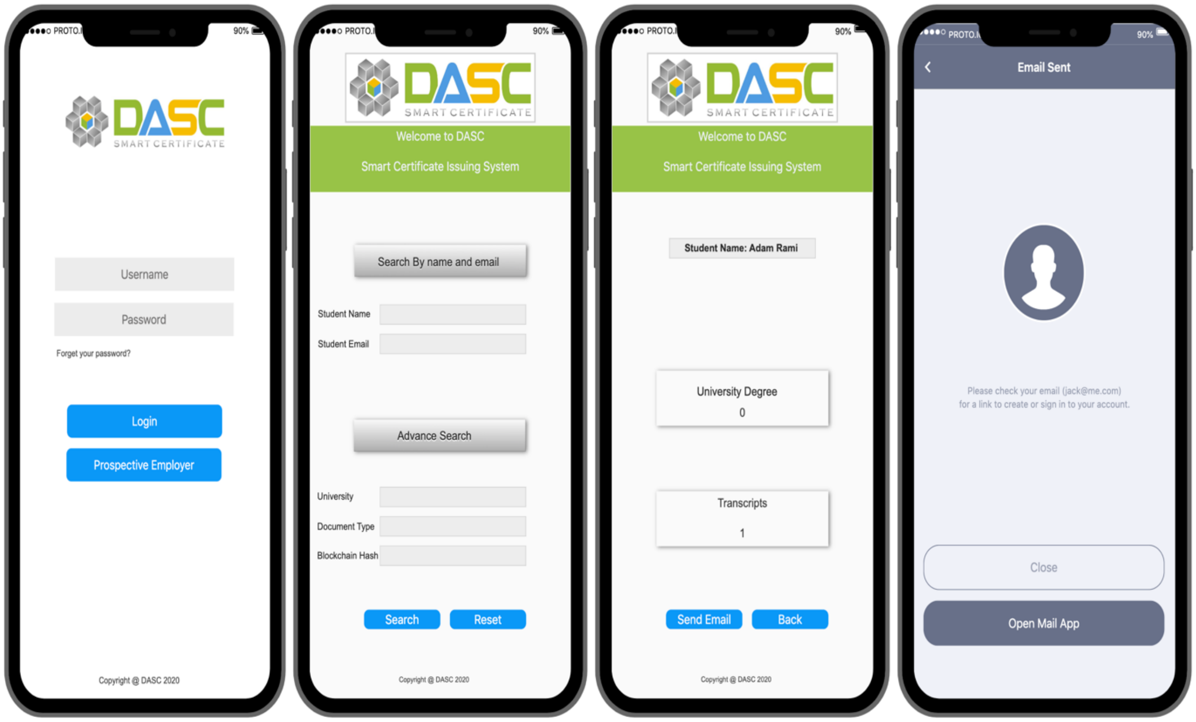

Figure 5.12 Employer's screens

5.4.3 The University's Admin

If an Admin wants to add a new university to the system, they first log on using the system's main page. This requires the admin to enter a username and password which has already been given by the DASC developers.

Figure 5.13 DASC login screen

From the main dashboard the admin can check the main summary of the number of universities in the system, the number of registered students and the total of uploaded certificates in the system. This page summarizes all the main statistics of the DASC.

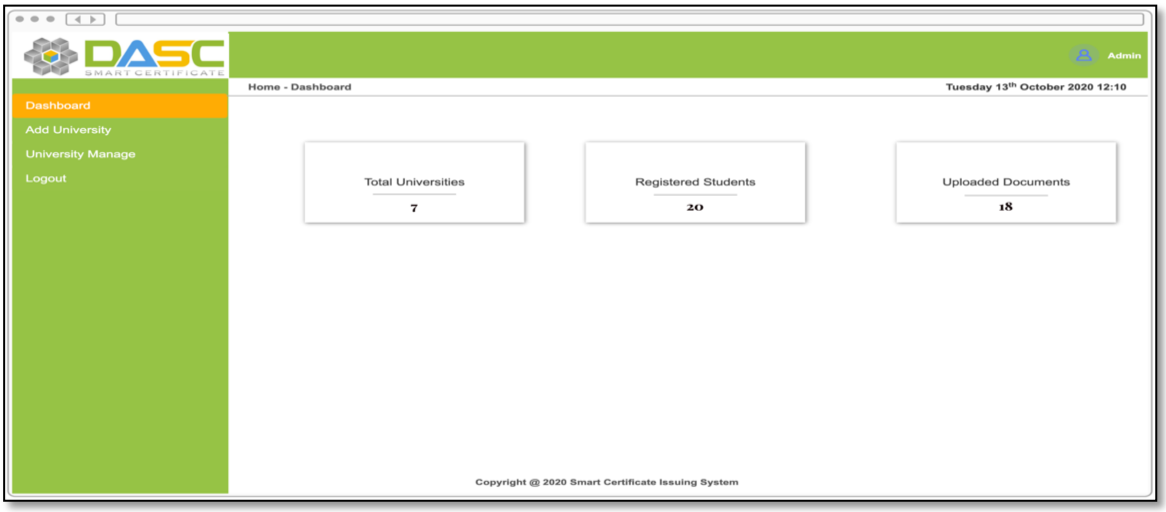

Figure 5.14 Admin dashboard screen

To add a university to the DASC, the admin presses the ‘Add University’ tab to enter all the required information regarding the university; i.e., the-wallet address, the university’s name, name of the person responsible for the account, a detailed address, email and password.

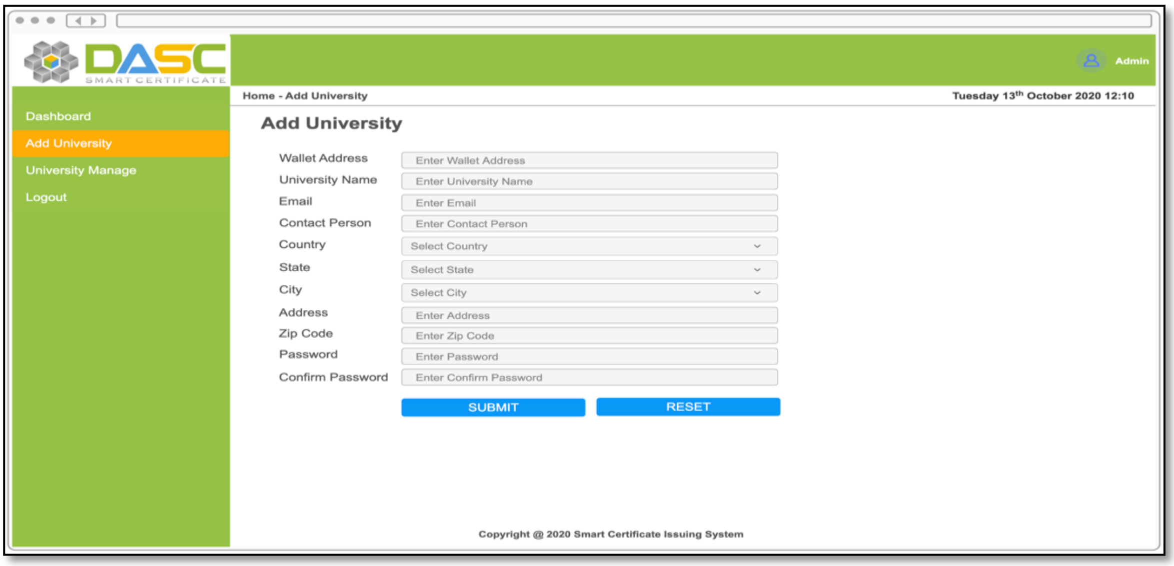

Figure 5.15 Add new university screen

The admin can check all the registered universities in the system. That includes all the university’s related information such as name, blockchain address, blockchain hash and other data related to that university.

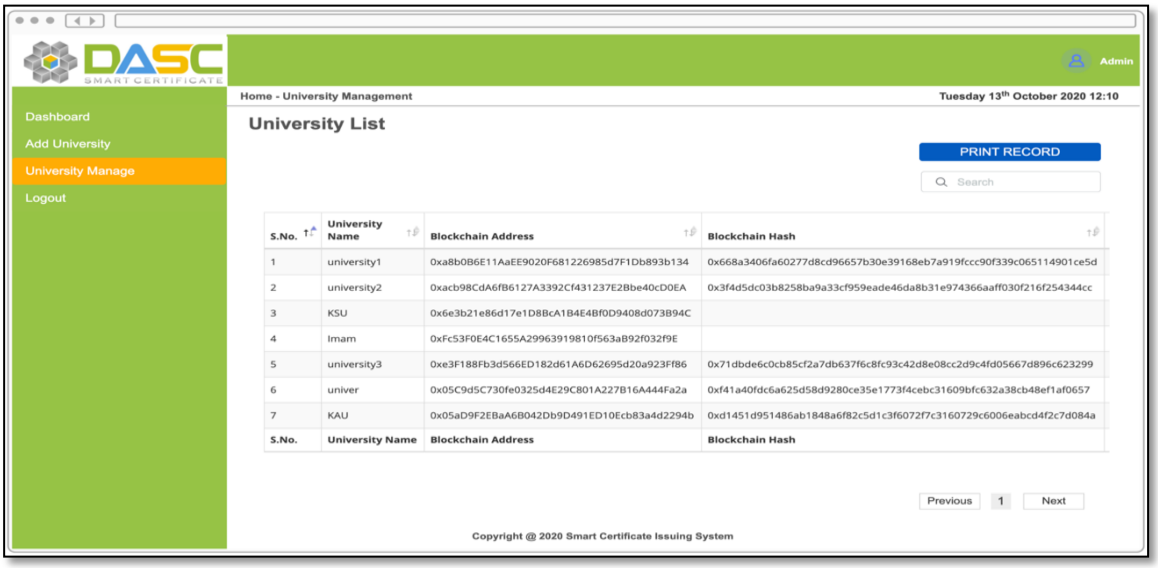

Figure 5.16 University list screen

If the university admin wants to add an instructor or student to the university, they can use the login screen then choose the appropriate tab for the desired transaction either to add a new student or academic instructor. As shown in Figure 5.17, there are different data required to fill in regarding either the student or instructor.

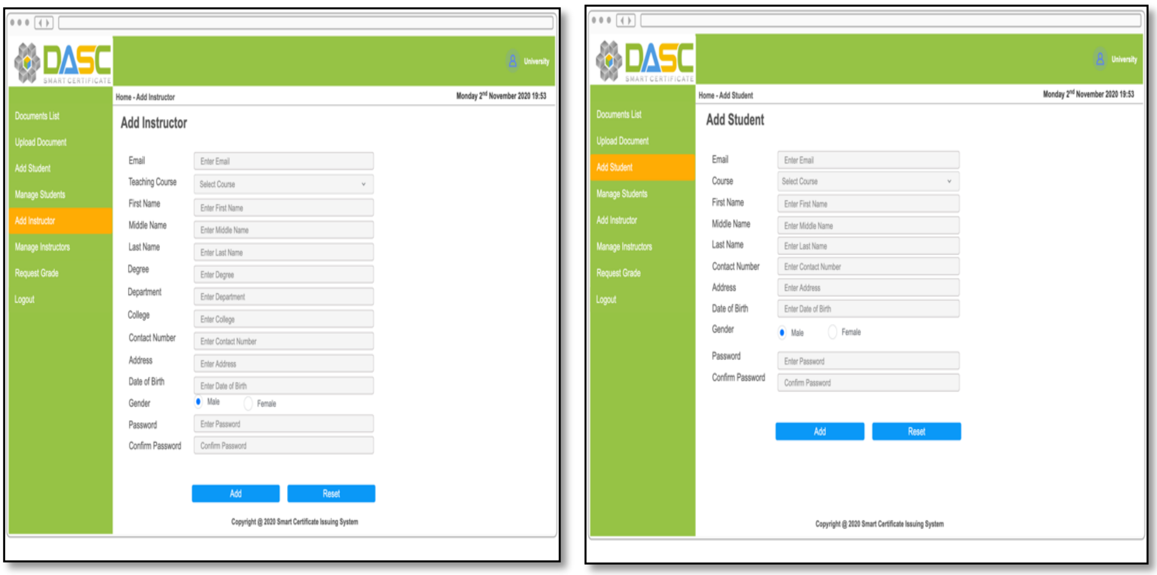

Figure 5.17 Add instructor/ student screens

Once the admin finishes adding a new user (either a student or an instructor); the admin can check all the registered students by choosing the 'Manage Students' tab. This screen shows all the registered students in the university along with all the information related to each student (see Figure 5.18).

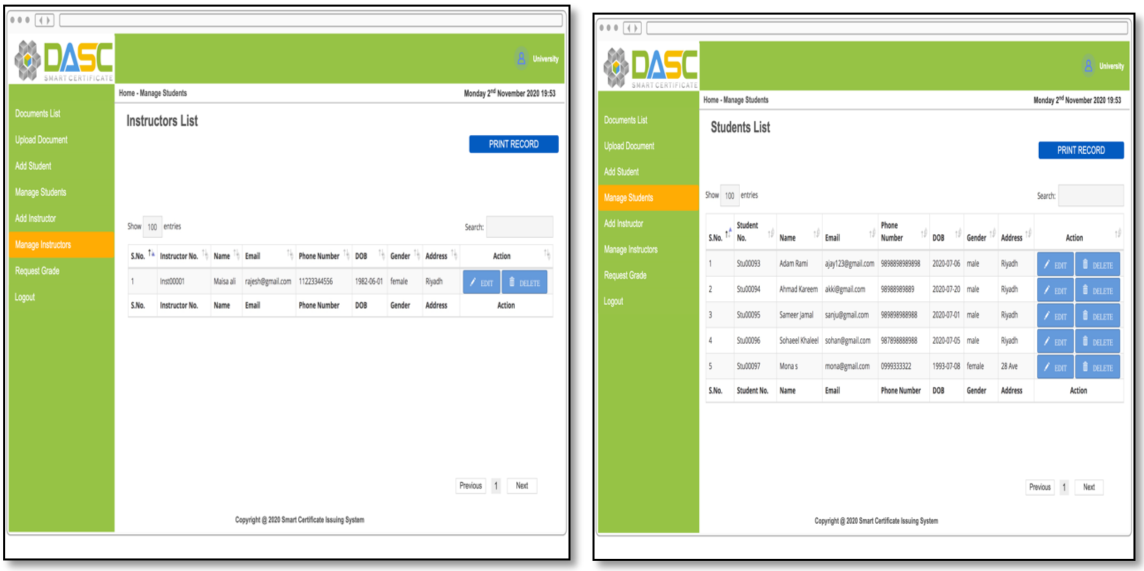

Figure 5.18 List of registered students and instructors' screens

If an admin wants to post a new certificate to a specific student on the system; they can log in and post specific student certificates or awards by choosing the 'Upload Document' screen (see figure 5.19). The admin choses the main information related to that document including the student's name, document's name and type and issue date. Also, the admin has the authority to add a new document type if the desired document is of a different type to those already available.

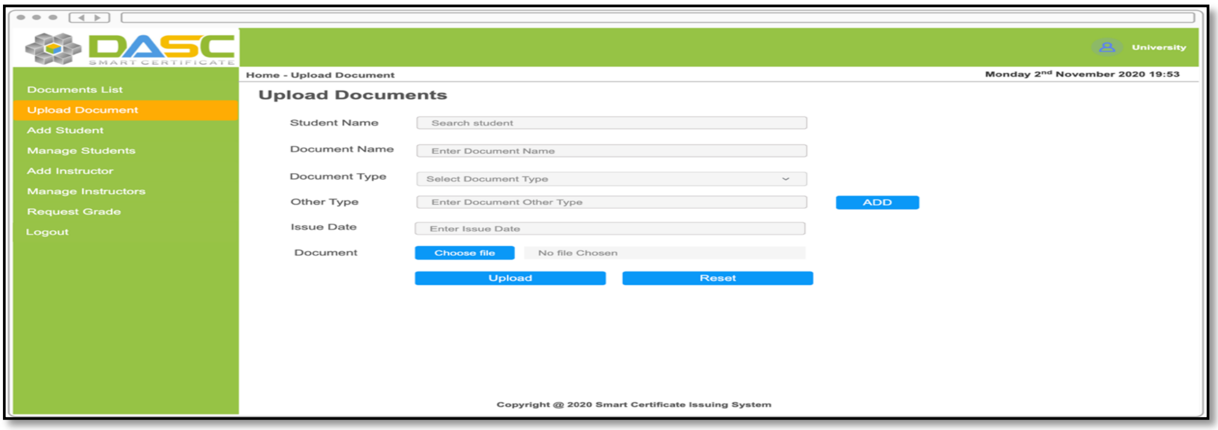

Figure 5.19 Upload certificate screen

5.4.4 The Instructor

If an academic instructor wants to browse all the registered students on his/her courses, they can log in then choose the appropriate tab for the desired transaction: either to browse all the registered students or their associated earned certificates.

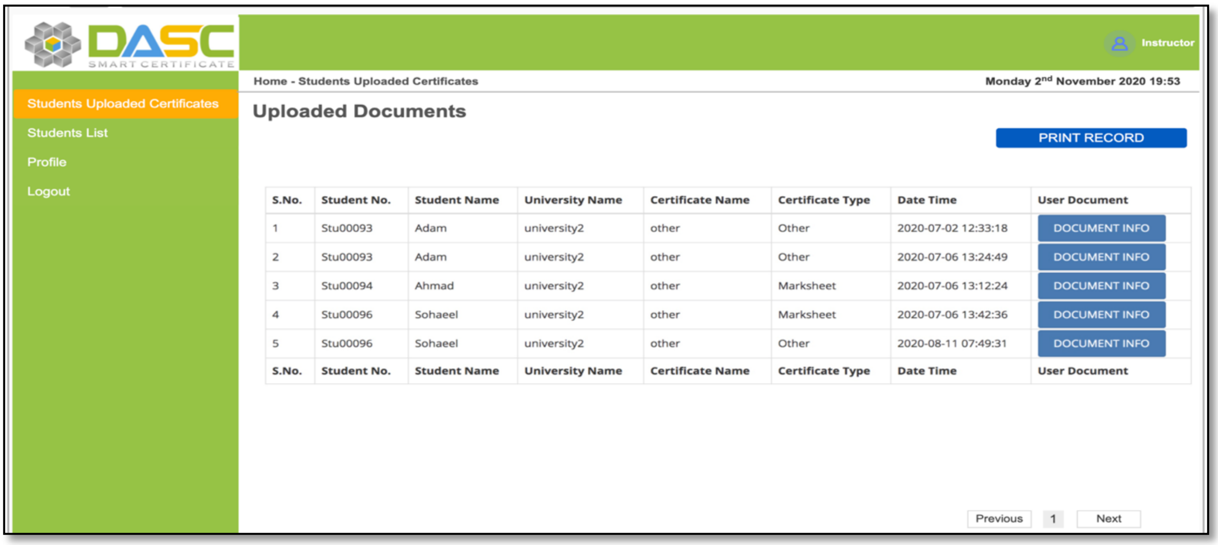

Figure 5.20 Student's List for specific instructor

As shown in Figure 5.20, there is a list of students who are currently studying a course with the instructor; and for each student, the instructor can check the uploaded certificates with all related information. If an academic instructor wants to enter a student's grade, they must tap on the 'Student's list' button to open the associated screen.

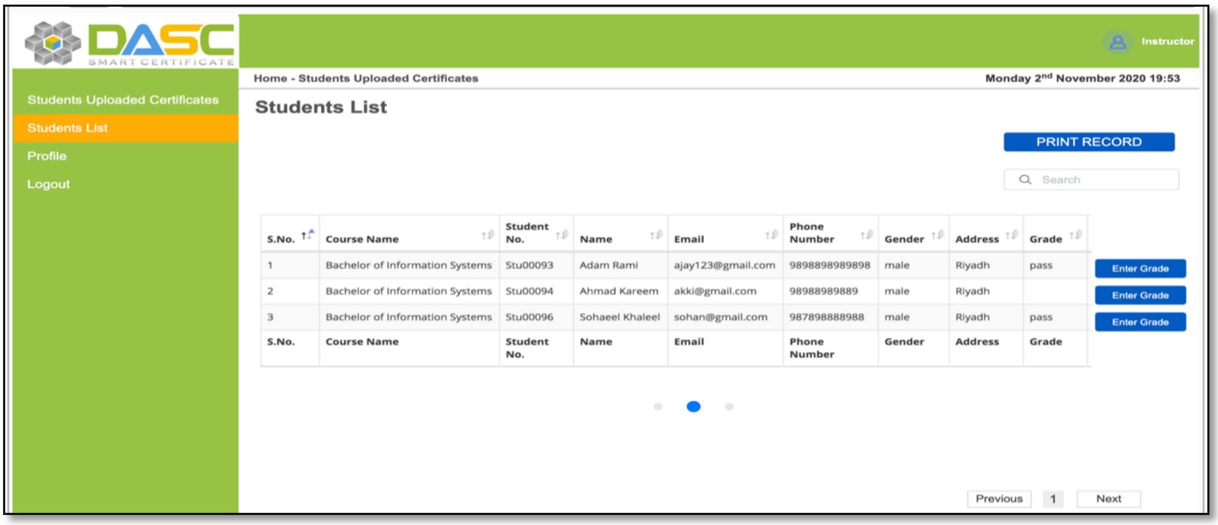

Figure 5.21 Student's list screen – Instructor's view

As shown in figure 5.21, an assorted list of all the registered students is displayed to the instructor who can then choose a student to add a course grade to. This would be accomplished by pressing the 'Enter Grade' button that will allow the instructor to add a grade for this specific student.

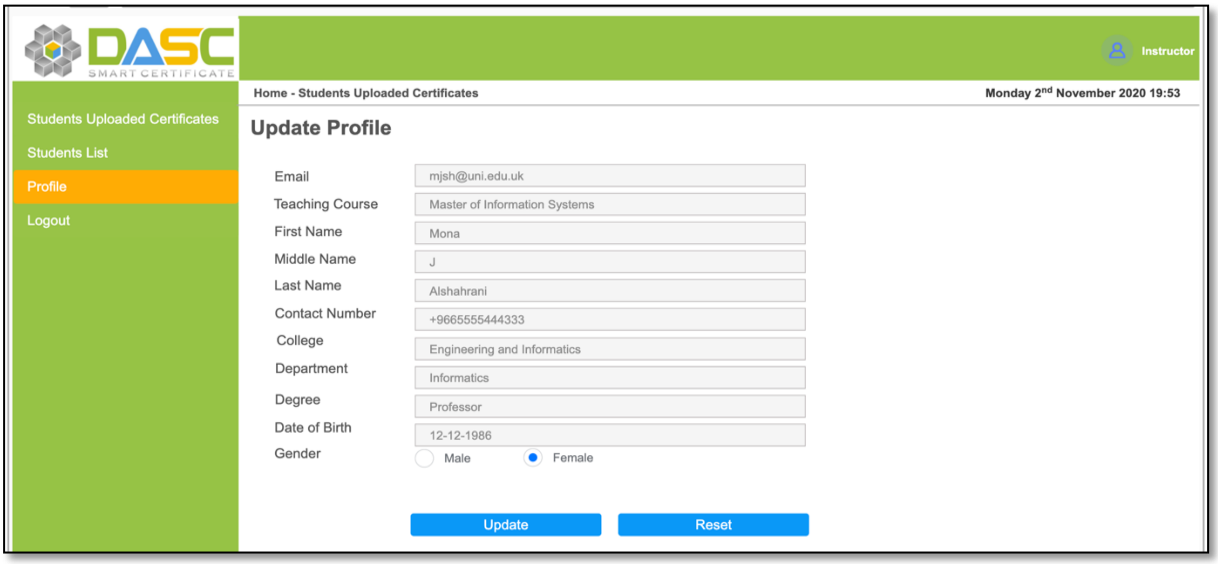

Figure 5.22 Instructor update profile screen

If an academic instructor wants to update their profile, they go to the 'Profile' button on their main page. This will allow the instructor to access the screen with all their account details. Figure 5.22 shows the screen that allows the instructor to update some of his/her personal information.

5.5 Summary

This chapter describes the DASC as a proposed solution and its components that support the purpose of this research by encouraging the intention to adopt the technology among prospective users. A detailed description of its functionalities, conceptual infrastructure, logical representations and graphical user interfaces (GUIs) has been provided. Moreover, in this chapter, the researcher aimed to analyse and evaluate a number of users' scenarios and cases that might occur when they interacted with the prototype DASC. Lastly, this chapter serves as a baseline for any future development of the system since this prototype has been tested and examined by real users in study 2 of this research (as explained in Chapter 6).

Chapter VI

6 2nd Study: Testing the DASC and Evaluating the Users' Intention to Adopt Blockchain

6.1 Overview

This chapter presents findings and discusses the results of the data analysis for the 2nd study in this research which is about testing the proposed DASC and investigating the users' perceptions about it. This study was conducted to test the proposed certification system DASC by the target users in the context of Saudi Arabia. This helps the research to test the user behaviour and acceptance toward blockchain-based system that would let them understand the features and functionalities of the system. The chapter begins with a description of the sample and data preparation and continues by providing and discussing the results of the tests on the hypotheses and the observation for the students obtained from an analysis of the survey data. The number of students enrolled for this study was initially 24, and there were 5 prospective employers. As shown on Figure 6.1, the actual number of students who finished and completed the subsequent survey was 17.

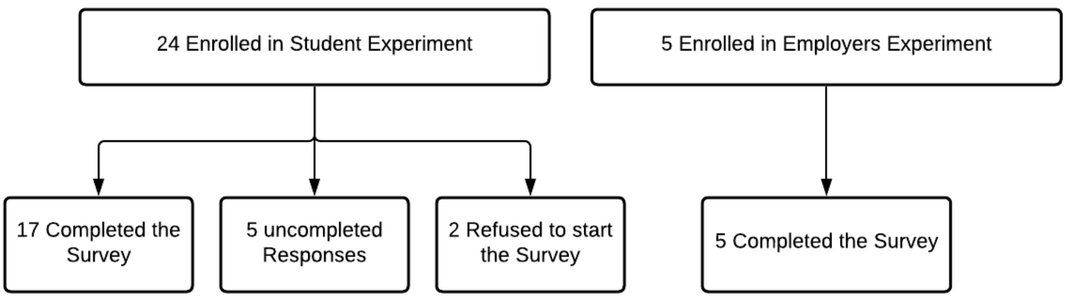

Figure 6.1: Distribution of the 2ndstudy's participants

Moreover, the result contained five uncompleted responses which were addressed by filling the missing parts with neutral answers to make sure the results would not be affected by using this strategy. These numbers of the participants in the study is due to the limitation of Covid-19 and the observation nature of this study was a barrier to have large number of students and employers. This part describes the overall demographic characteristics of participants in this study, which involved four dimensions: age, gender, educational level and field domain. The purpose of collecting demographic information was to provide an overview of the participants who responded to the study. Table 6.1 below presents a summary of the demographic data for the students' and prospective employers' samples.

Table 6.1: 2nd Study Demographic Information

Characteristics		**Student**		**Employer**	
		(n= 24)	%	(n= 5)	%
Age					
	18 - 25	22		0	
	26 - 35	1		1	
	36 - 45	1		2	
	46 - 60	0		1	
	+ 60	0		0	
Total		24	100	4	100
Gender					
	Female	12		1	
	Male	12		3	
	Prefer not to say	0		0	
Total		24	100	4	100
Education Level	High school	3		0	
	Undergrad	15		0	
	Bachelor's degree	5		2	
	Postgraduate or higher	1		2	
Total		24	100%	4	100
Field Domain					
	Science, Technology and Engineering	13		2	
	Business and Economics	1		2	
	Humanities and Art	1		0	
	Other	9		0	
Total		24	100%	4	100

6.2 Student Experiment: Descriptive Analysis and Interpretation

This section addresses the results and analysis of the students' data for the 2nd study. This involved analysing all the related criteria in the participants' responses after they had used the

DASC prototype. The survey consisted of five parts, where each part measured a specified construct covered by this study. Part One, refers to all the participants' demographic information. Part two measures the level of blockchain awareness followed by Part Three, that addresses the current issues of the existing system from the users' point of view. Part Four then discusses the proposed influential factors and the participants' perceptions about the designed solution in some detail. Lastly, Part Five outlines the participants' feedback about the DASC's graphical interfaces.

6.2.1 Part1: Demographic Information

The influence of each demographic characteristic was analysed to find out if any of them affected the students' intention to adopt blockchain for higher education.

Age

Figure 6.2 shows 90% of the participants were aged between 18 and 25. This result indicates that the survey sample had reached an appropriate target age range. The age ranges 26 to 35 and 36 to 45 both had an equal number of participants (5%). There were no participants in the older age ranges. This study aims to examine student perceptions about adopting blockchain technology for maintaining and verifying their academic accreditations. The age distribution in the sample meant the researcher was confident about satisfying the aim of this study and answering the research questions with an appropriate target sample.

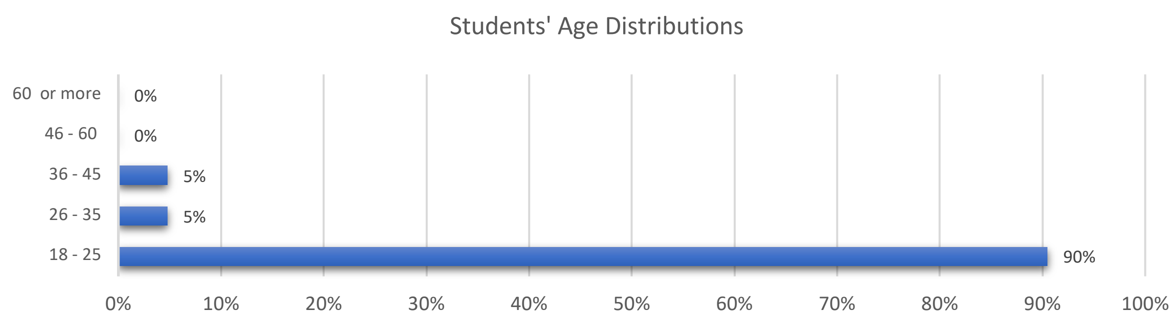

Figure 6.2: Study 2: Students' Age Distribution

Gender

Figure 6.3 shows that men comprised 58% of the whole sample. This preponderance of male participants balances study, as there were more female students who participated in Study 1 (see Chapter 5). Since the study now has a more even distribution of male and female student participants, it is easier to check the influence of gender on students' intention to adopt blockchain technology for certification.

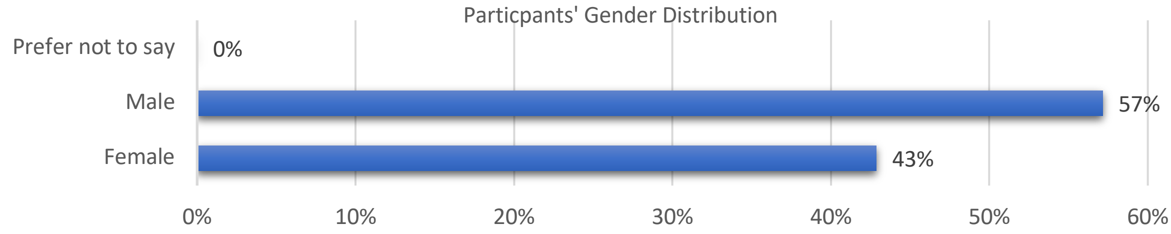

Figure 6.3: Study 2: Students' Gender Distribution

Educational Level

Figure 6.4 shows a high percentage of the participants had an undergraduate educational level (57%). Participants holding a bachelor's degree constituted 23% of the whole sample. The high school graduates or equivalent participants came third with 14%; and finally, around 5% of the participants were postgraduates.

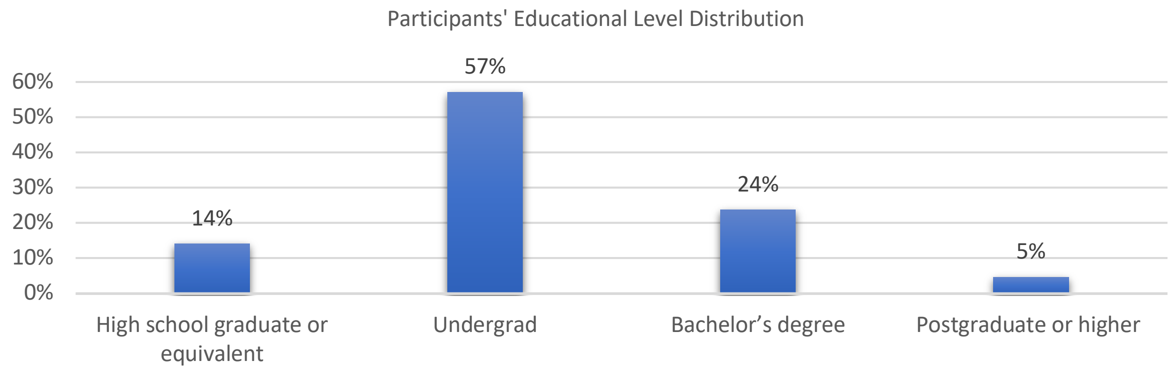

Figure 6.4: Study 2: Students' Level of Education Distribution

The result of the educational level distribution reflects that the sample was entirely suitable since the study is about involving students in higher education and undergraduates are the best target sample to involve. The second largest group of students was those with bachelor's degrees. Given that students volunteered to do a test with the DASC, this indicates an awareness on the part of this group of the advantages of generating and verifying academic qualifications electronically

Field Domain

Figure 6.5 shows that 50% of the participants were in Science, Technology and Engineering departments. Second largest group of participants around (40%) came from unspecified domains since they chose the ‘Other’ option. The Business and Economics, and Humanities and Art domains had an equal number of the participants.

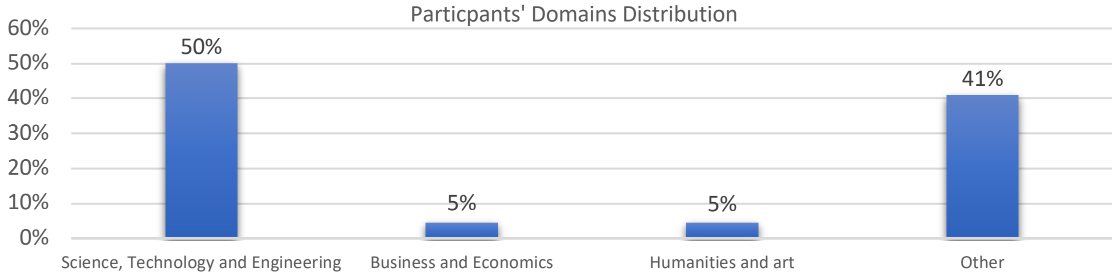

Figure 6.5: Study 2: Students’ Domains Distribution

The high number of students selecting the ‘Other’ option may have been due to their being undergraduates as in Saudi universities, students do not select their domain in their first year. Instead, they study a preparatory year and specify the domain they will go into at the end of this year, which also depends on the student’s GPA.

6.2.2 Part 2: Level of the Knowledge and Previous Experience about Blockchain Technology

In this section, the purpose was to investigate the participants’ backgrounds and the level of their previous experience of blockchain technology. Moreover, this section was designed to estimate the usage level of the participants to measure how this could affect the students’ intention to adopt a blockchain system for certification in higher education.

Knowledge: Firstly, the participants were asked to indicate their level of awareness about blockchain technology. The results in Figure 6.6 show that half the participants didn’t have any level of knowledge about the blockchain and only 30% reported a moderate level of awareness. This is result is not unexpected if the researcher refers to the sample’s young age (90% between 18-25) which might affect their knowledge of innovations such as blockchain technology. Also, that these students were unlikely to have any work experience (as described in the next section).

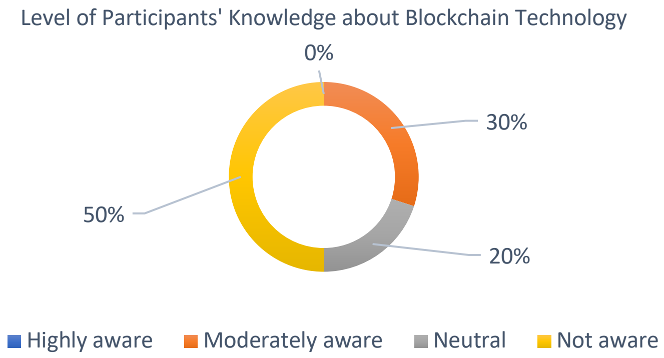

Figure 6.6. Study 2: Level of Students' knowledge about blockchain

Experience: The second aspect to be investigated in Part 2, was about the level of blockchain technology usage among the student participants. The aim was to measure the participants' experience with any aspect of the distributed technology, specifically blockchain. The results in Figure 6.7 showed that majority of the participants (90%) had not used blockchain in any way. The lack of experience could be as result of the young age of the participants as mentioned in the previous section.

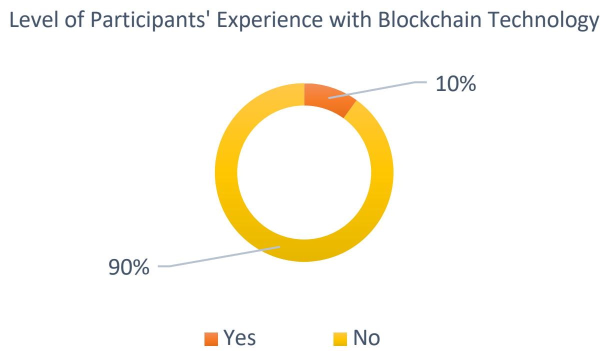

Figure 6.7. Study 2: Students' experience with blockchain technology

Another reason behind these results could be the blockchain as distributed technology is consider as new innovative technology to be used in higher education rather than being associated with cryptocurrencies. Therefore, using blockchain in the HE context is still not known amongst students especially in developing country as Saudi Arabia.

Skills and Training: The participants were asked about their opinion regarding any skills and training they had received about using blockchain technology in any way. 55% of them said they did not have adequate skills or training for any use of blockchain technology, 40% were not sure about the level of skills they had in order to deal with such systems, while only 5% indicated they had an acceptable level of skills and had received the proper training to handle blockchain-based systems. The participants were also asked whether they had received notification of any training by their institutes in the area of developing blockchain technology and the results are shown in Figure 6.8. The figure displays that almost 45% of the total participants had often received a training program about blockchain.

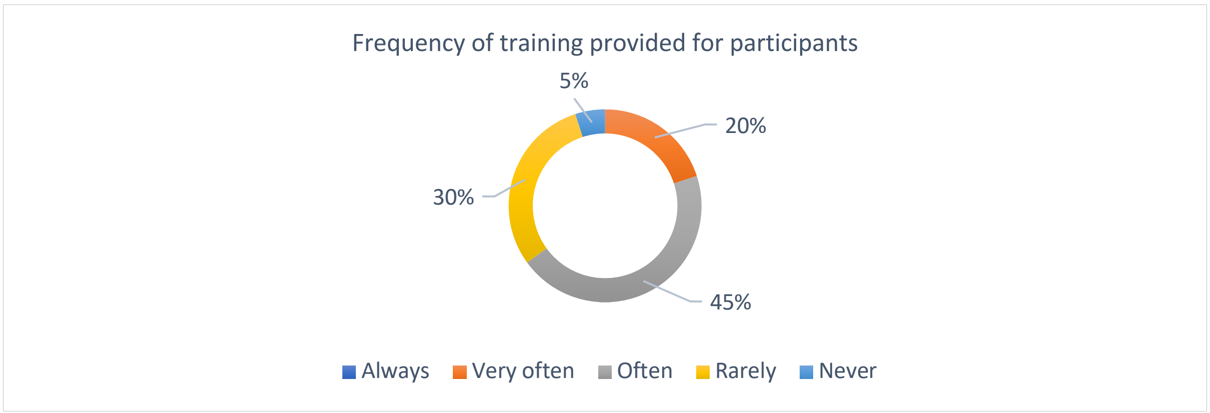

Figure 6.8: Study 2: Students opinions about frequently they had training

This indicates the role that academic institutes play in increasing awareness about this technology. However very few students attended such programmes, as was indicated when they were asked about their experience with blockchain technology.

Influential Factors*:* this section was designed to address the factors affecting the adoption of blockchain technology for higher education from the students' perspective. Figure 6.9 shows the options given to the participants, and from which they could choose more than one factor.

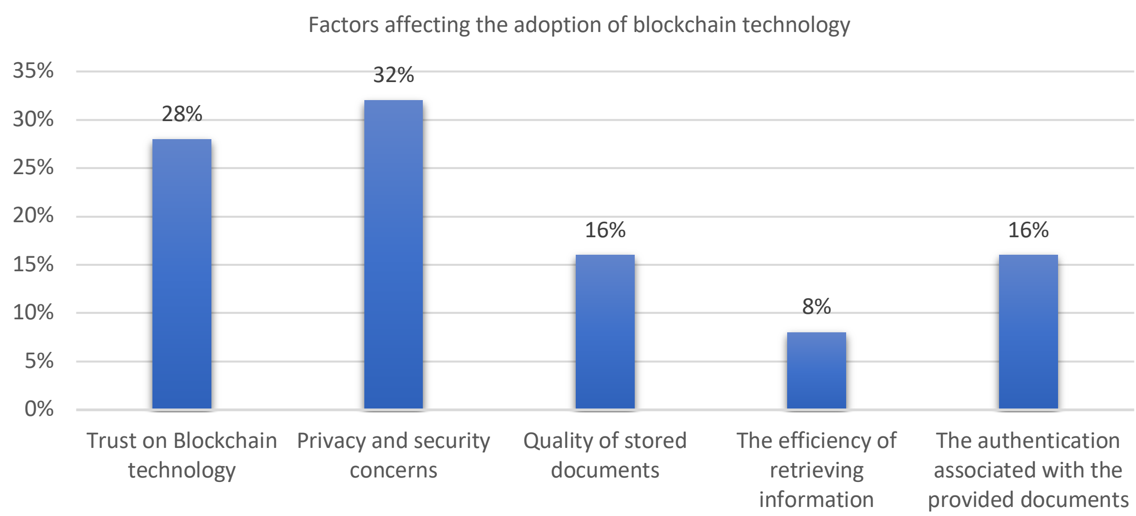

Figure 6.9: Study 2: Students' opinions about factors affecting blockchain technology adoption

Privacy and security related concerns featured as the most important factor perceived to affect the adoption of the blockchain for the certification process, as 32% chose it; 28% of the respondents chose trust in blockchain technology as the main factor and 16% opted for the quality of the stored documents with the same number choosing the authentication associated with the provided documents. The efficiency of retrieving information was chosen by the least respondents (8%). These percentages give an indication that many participants were aware of the challenges implied in the intention to adopt blockchain technology. Arguably, the result is a good indication that the students in the sample had some understanding about adopting blockchain.

6.2.3 Part 3: Existing System Issues

This section addresses the issues identified that currently exist with handling students' credentials in higher education institutes. It emphasises the current issues and how this research articulated them as motivations towards adopting blockchain technology and overcoming these problems. Moreover, the perceptions of the student participants about these issues after they tested the prototype DASC are measured. All the issues have been studied in the 1st stage of this research (see Chapter 4) and the findings detailed (Alshahrani et al., 2021).

The first statement to be measured was about whether the current version of the certificating system adequately reflected the student's skills and achievements. Figure 6.10 shows that an equal number of participants either agreed that the certification process did not do this accurately or were neutral (84% in total) while around 16% of the respondents disagreed.

Secondly, students were questioned about whether the current process of validating certificates by the employers was a time-consuming procedure. The results reflected that 37% of the sample agreed that under the current system this process took a long time. The fact that 42% of the students were neutral about this concern could be due to a misunderstanding or a lack of experience on the part of the student regarding this process. However, as 21% of the participants disagreed with this issue, it could be the case that students expect these procedures to take a long time.

Then, the questionnaire measured the perception of the participants regarding whether sharing their credentials with a prospective employer was a difficult task as a hard copy certificate is required as an official document. The results indicated that 43% of the sample agreed with this statement and this group could well have faced this issue. Meanwhile, 47% of the participants were neutral and around 10% disagreed with this as an issue in the current system. Again, the result might reflect lack of experience or being used to having to produce hard copies.

In the measurement about the participants' opinions about whether the current system prevents students accessing their achievements and certificates during their study, the majority of the respondents agreed (63%) and 15% were neutral. However, 21% disagreed with this statement and didn't see this as a problem with the current certification system. Then, the participants were asked about whether they considered dishonesty as one of the primary issues related to higher education certificates. Around 63% agreed this issue was one of the challenges affecting the current system; 26% of the participants were neutral and only 10% of the respondents disagreed this was an issue. Again, it is difficult to know whether the responses reflect the participants' experience of the current system or simply mirrors their expectations; although it is highly likely that any experiencing dishonesty issues either directly or indirectly (through hearing about it happening to a classmate) would have expressed concern.

One of the critical issues that current system faces is the lack of information about the procedures to follow to obtain the student's certificate. An equal number of students (37%) either thought this was a problem or were neutral and 26% of the respondents disagreed this was a problem in the current system. These results may have been due to the sample's youth which means they may not have gone through this process yet and have yet to understand the way it performs.

When the participants asked about their perceptions about whether there was too much paperwork needed to generate their educational certificates, 58% of them agreed, 16% were neutral and around 26% disagreed. Lastly, when the participants were asked about their perception about if the current process of issuing students certificates takes a lot of time and effort, the results showed that 48% of the respondents agreed with this statement; 37% were neutral and around 15% of the participants disagreed. Again, the results could be influenced by whether students had experienced the procedure as they were still at the beginning of their studies.

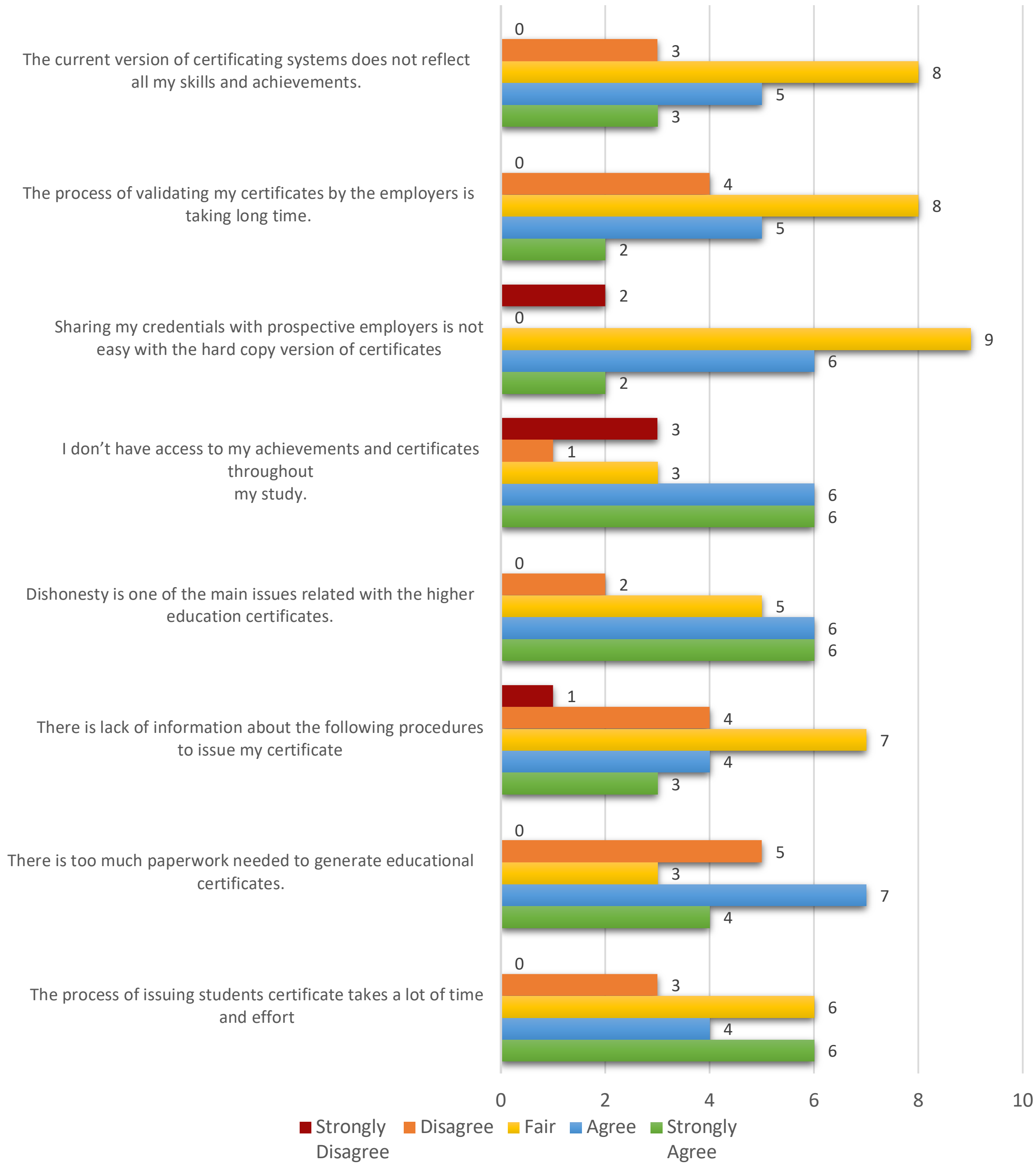

Figure 6.10: Study 2: Analysing the current issues with the existing systems for the students' sample

In conclusion, the same measurements that were used in the 1st study of this research were also used to investigate students' perceptions of the current certification system. Comparing these results together, the researchercan surmise that students generally believe that the issues occurring in the current system that would be overcome by adopting blockchain for this important process in the academic field.

6.2.4 Part 4: Factors affected the adoption of blockchain technology for higher education

This section of the study was designed to measure the impact of each factor in the proposed model of intention to adopt blockchain technology for the certification process in the higher education sector. As deeply discussed in Chapter 3, the proposed model includes four factors that affect the adoption process. In Chapter 3, the researcherlisted and mapped all the factors that will be investigated in this study, i.e., trust, security and privacy, social influence and efficiency. Moreover, all the sub-factors are listed in Chapter 3 to give a wider perspective about the impact of the factors. As in Study 1, each of these factors is measured by several items which utilise a 5-point Likert scale ('Strongly agree', 'Agree', "Fair", 'Disagree' and 'Strongly disagree').

Trust Factor (T)

This part of the survey addressed the trust factor after the participating students had tested the DASC. Three aspects were measured: functionality and transparency, knowledge and useability, and ease of access and sharing. The students participating were presented with a number of statements regarding the trust factor and all the other constructs (sub-factors) related to it.

- **Functionality and transparency (FT)**

The first measure of the trust factor was about the student participants' perception of the functionality and transparency of the proposed solution. Table 6.2 presents the statements included in the questionnaire after the participants had experienced the DASC. As shown below, functionality and transparency were measured with seven items in the subsequent survey.

Table 6.2: Study 2: The measures related to the DASC: FT

Factor	Item Code	Statement
FT	FT1	I can access all my credentials through the system
	FT2	In general, all the functions of the system are in the right place
	FT3	The system provides me with high level of trust by giving me control of my certificates
	FT4	I can easily share my certificates with prospective employers

FT5	It is easy to understand the operation for each task in the system
FT6	I can trust no one will change the posted certificate since it is relying on blockchain technology
FT7	The system lets me understand the concept of blockchain

The result for FT1 indicated that the majority of the participants (58%) agree with this statement about the DASC, whereas only 15% of the respondents were neutral about this statement. However, 26% of the participants disagreed with the statement. This could be interpreted as the quarter of the participating students did not follow the instructions that clearly describe how they can access their qualifications. Moreover, the students age and experiences could interpreted as they haven't interacted or uses a similar systems that are based on such technology.

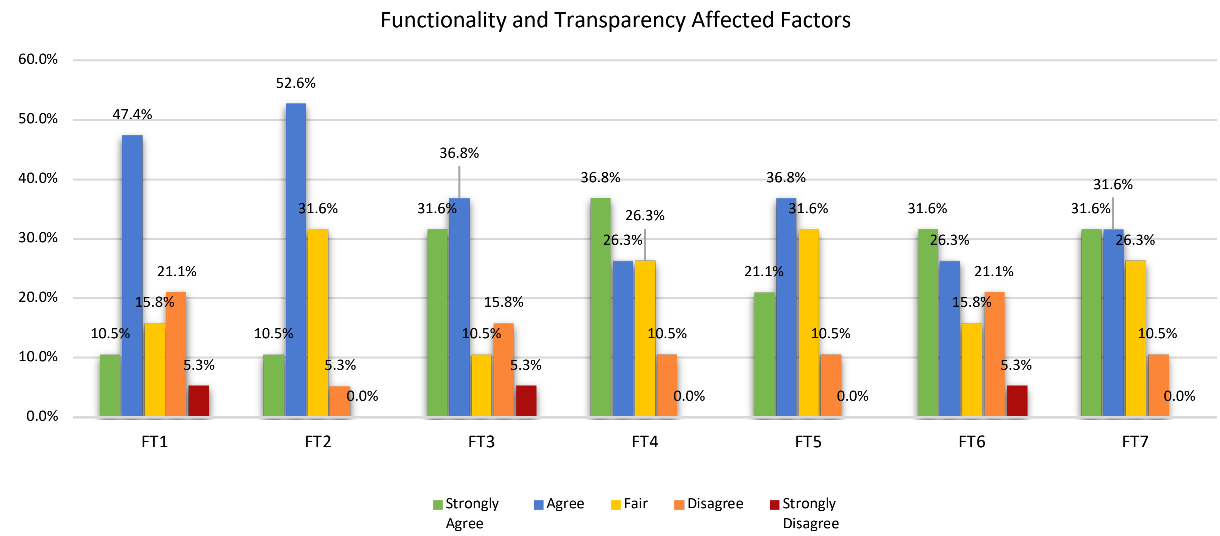

Figure 6.11:2nd Study FT measures for the students' sample

Regarding the suitability of the DASC functions (FT2) 63% of the participants agreed there was a proper assignment of the functions and transactions of the DASC. Moreover, the majority students (69%) agreed about that the prototyped system provides them with a high level of trust by giving me control of my certificates. However, around 20% of the participants disagreed with this feature about trusting such certification system (FT3). About the easiness of sharing certificates with prospective employers, most of the students as 63% agreed on this feature while only 10% were disagreed (FT4). Meanwhile, around 58% of the students agreed that it was easy to understand the operation behind each task while testing DASC (FT5). In the matter about trusting no one will change the posted certificate, more than 58% agreed on this feature that related to the nature of Blockchain technology (FT6). Lastly, majority of students as 64% agreed on the statement about if this experiment helped them to understand the concept of blockchain while around 26% were natural. However, only 10% of the participants disagreed on this statement (FT7).

- **Knowledge and Usability (KU)**

The second aspect of the trust factor to be measured was the participants' knowledge and their insights about the DASC's usability. Table 6.3 demonstrates the four measures used to investigate this factor. Firstly, participants were asked about their opinion regards the clarity of the system functionalities and 58% agreed they were and found the system's functionalities easy to navigate; 21% of the respondents were neutral and 11% disagreed (KU1). The results indicate that the majority of the users could observe the functionalities of the system and understand the purpose of different tasks provided by DASC within a short period of time.

Table 6.3: The measures related to DASC: KU

Factor	Item Code	Statement
KU	KU1	The DASC functionalities are clear and easy to navigate
	KU2	The DASC layout and colour scheme are very appropriate
	KU3	The DASC is understandable and easy to deal with
	KU4	I am very satisfied about the overall usability of the system

Then, two measures used to investigate the DASC layout and how users interact with it in easy and flexible way (KU2 and KU3). The results showed around 70% of the respondents agreed the DASC layout and colour scheme were appropriate and the DASC was easy to use; around 19% were neutral regarding the screen's usability and appearance. Although, 11% disagreed with these statements. Finally, 68% of the respondents were very satisfied with the overall usability of the DASC and 21% were neutral (KU4) and only 11% disagreed with the statement. The users' disagreement with this statement could be interpreted as the user's perception of the concept of blockchain and how it could be clearly shown among the provided DASC. Overall, the results reflect a good indication of the users' understanding of how to use the DASC.

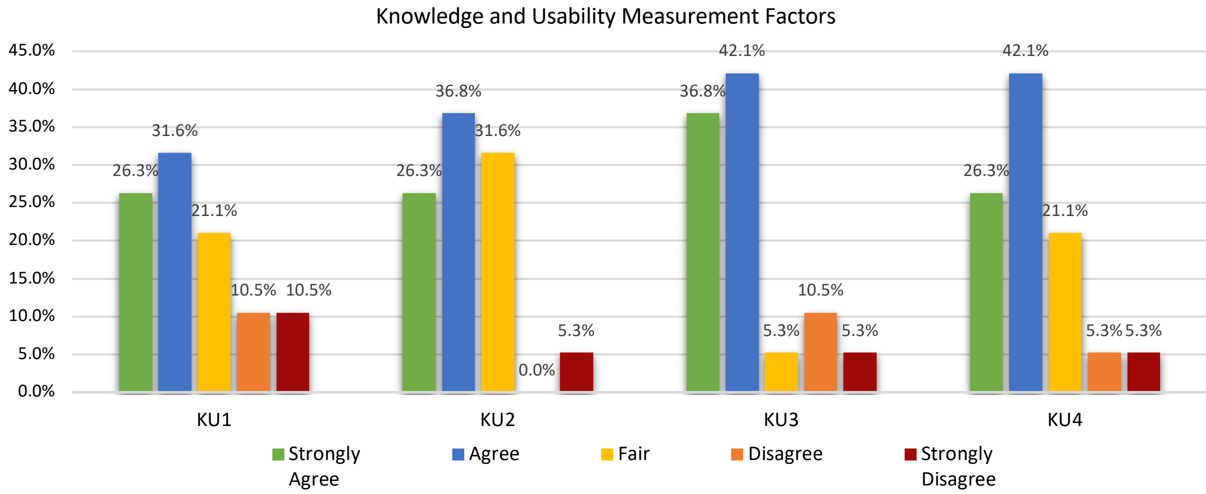

Figure 6.12: 2nd Study KU measures for the students' sample

- **Ease of Access and Sharing (EAS)**

This factor was the third aspect of the trust factor to be measured for the student's sample. It was about the participants' view regarding the ease and trustworthiness of accessing and sharing material on the DASC while they tested it. Firstly, when the respondents were asked if the system was easy to access, around 74% of the student agreed it was, 10% were neutral and 16% disagreed (EAS1).

Table 6.4: The measures related to DASC: Ease of Access and Sharing

Factor	Item Code	Statement
EAS	EAS1	I quickly learned how to access the system
	EAS2	Using the system reduced the time in controlling my credentials
	EAS3	Using the system took me less effort
	EAS4	The system is very useful, and the universities must be convinced to trust this technology and adopt it
	EAS5	I would use support from the IT representatives to be able to use the system

Then, participants were asked if the DASC reduced the time taken to control their credentials (EAS2). After testing the proposed system 79% agreed, 10% were neutral and 11% disagreed. When asked if using the DASC took them less effort (EAS3) the results indicated that most of the respondents (74%) agreed, 10% were neutral, but 16% of the sample disagreed. For the next item (EAS4), 74% agreed that the DASC was very useful, and the universities and academic institutes must be convinced to trust and adopt this technology, 21% of the participants were neutral and 6% disagreed with this measure. Lastly, 63% of the participants agreed that after testing the DASC they would use support from the IT representatives to be able to use the system, 21% were neutral, and 16% disagreed (EAS5). These results indicated that the majority thought the DASC system enabled easy access to and sharing of credentials, hoped other institutions would use it and were willing to seek support to use the system if necessary.

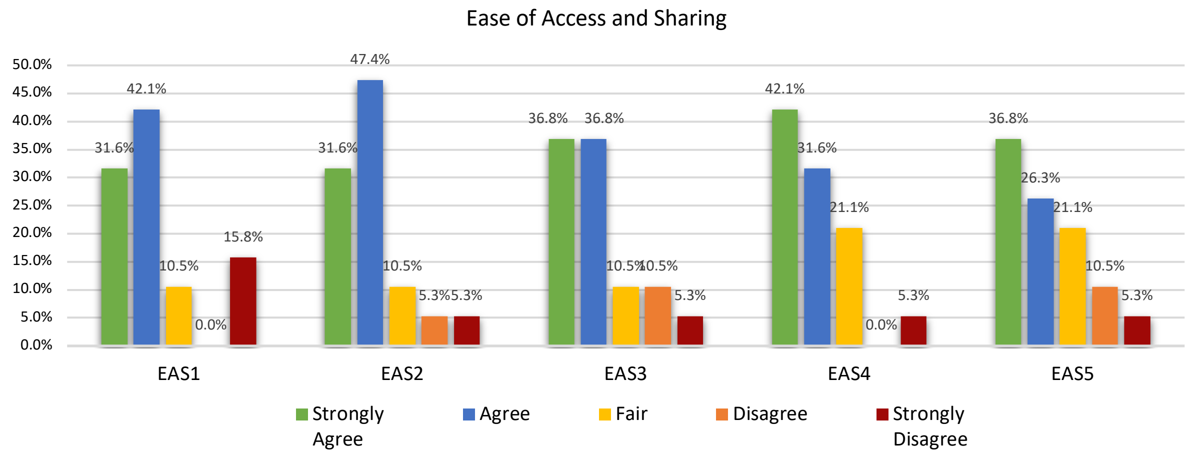

Figure 6.13: 2nd Study EAS measures for the students' sample

Security and Privacy Factor (SP)

- **Perceived security, privacy, immutability and reliability (PSP)**

Blockchain can offer users security, immutability and decentralised data storage. After using the DASC, students were asked if they could understand the security feature of blockchain-based systems and 53% agreed, around 30% were neutral and only 7% disagreed (PSP1). When asked if they understood the immutability feature of blockchain and believed no one would change the certificate after it was posted 71% agreed and 17% were neutral. On the other hand, 12% disagreed and didn't understand how this feature was applicable in the DASC (PSP2).

For item PSP3, the results reflect a high agreement among the respondents as 65% agreed the DASC provided high levels of security and privacy for smart certificates, 29% were neutral, and only 6% disagreed. When questioned whether the system enhanced the students' certificates' reliability and transparency (PSP3), the result indicated 65% of the participants agreed, 23% were neutral, and 12% of the respondents disagreed. The last item in this category (PSP5) sought the students' opinions about whether the DASC was very secure and maintained authentic certificates; and 77% agreed, 11% were neutral and 12% disagreed.

Table 6.5: Study 2: The measures related to the DASC: PSP

Factor	**Item Code**	**Statement**
PSP	PSP1	After using DASC, I can understand the security feature of blockchain based systems.
	PSP2	I understand the immutability feature of blockchain as I know no one will change the certificate after it posted.
	PSP3	This system is providing me with high levels of security and privacy for smart certificates.
	PSP4	This system enhances the students' certificates' reliability and transparency.
	PSP5	This system is very secure and maintains authentic certificates.

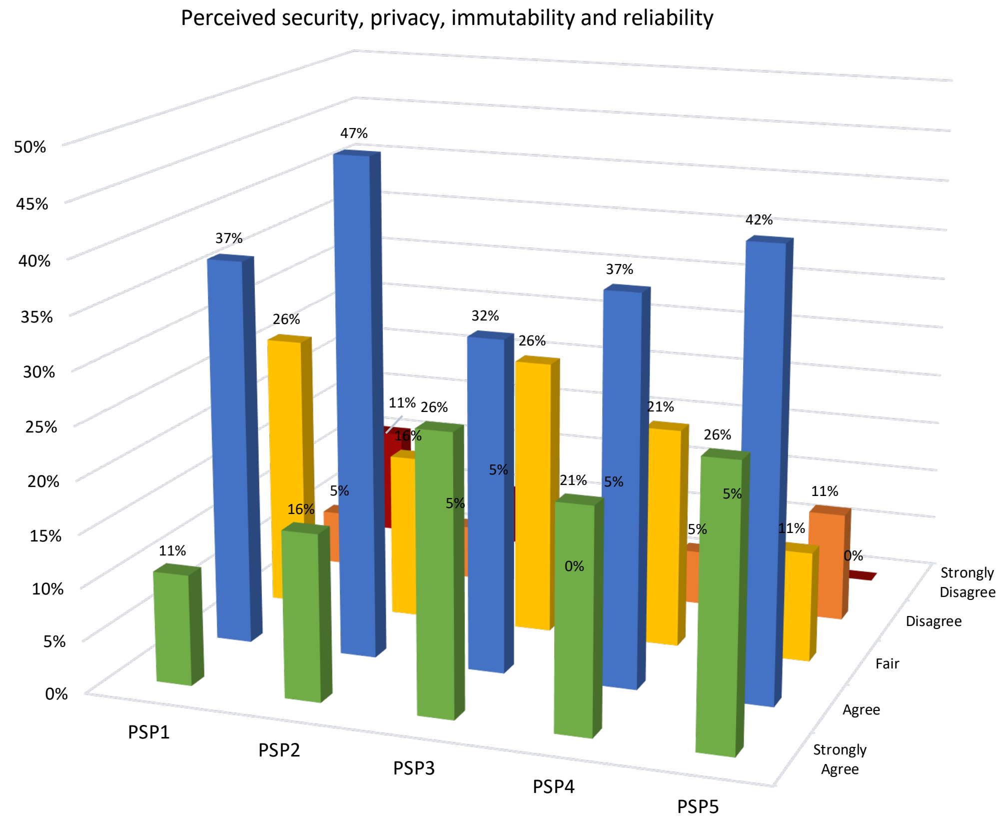

Figure 6.14. 2nd Study PSP measures for the students' sample

- **Perceived Risk (PR)**

This part of the questionnaire collected participants' perceptions about the risk of using the DASC after they had used the system. The results for PR1 show 36% felt their information was not secure and 11% were neutral. On the other hand, more than half disagreed. For PR2 65% agreed they felt confident accessing and sharing their credentials through the DASC on this. 11% were neutral, however, 24% disagreed.

Table 6.6: Study 2: The measures related to DASC: PR

Factor	Item Code	Statement
PR	PR1	After using the system, I don't feel my information is secure in this system.
	PR2	I feel very confident while accessing and sharing my credentials through DASC.
	PR3	I would use my smart certificate in DASC even if I have no idea about its security.
	PR4	After using the system, I can control who sees my credentials.

Around 42% agreed they would use smart certificates regardless of their awareness about its security, while 17% were neutral, and 41% of the respondents disagreed (PR3). One of the main advantages of using DASC is the ability to share the earned qualifications with any parties with the student's permission. For the final item (PR4) 53% agreed that they could control with whom they would share their credentials, 35% were neutral, but 12% disagreed and didn't recognize this feature about the system.

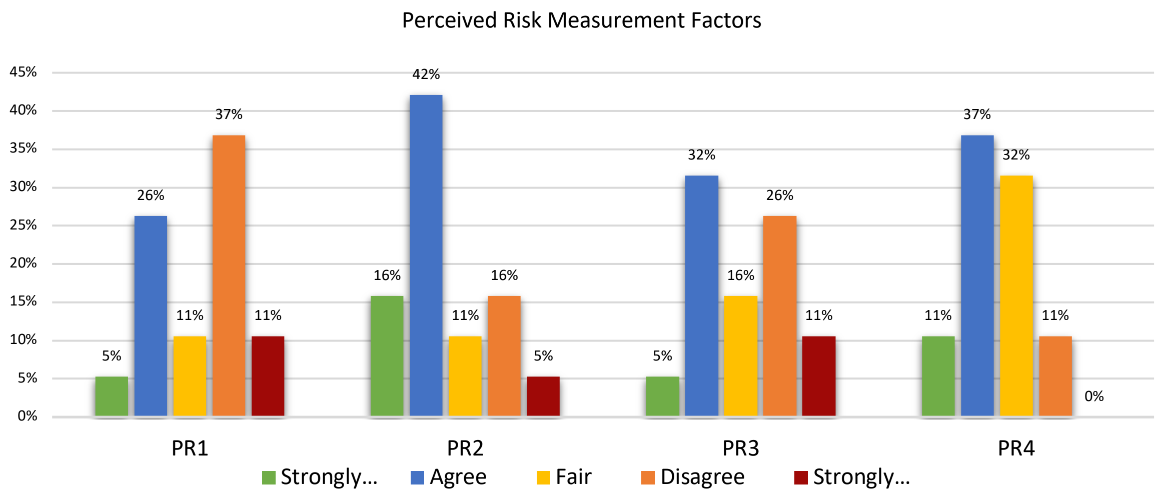

Figure 6.15:2nd Study PR measures for the students' sample

Social Influence Factor (SI)

This construct was measured to determine the student's perceptions about the impact of social influence on the intention to adopt blockchain for the certification process. SI was measured by four items as shown in Table 6.7. Figure 6.16 provides the overall result calculated from the students' survey data after testing the DASC. The first item (SI1) asked students if they felt that using a blockchain-based system created better career opportunities for them since they could control their profiles. The results reflect that 72% agreed that it did, 22% were neutral, and only 6% thought the DASC did not facilitate the process of finding a career.

Table 6.7: Study 2: The measures related to DASC: SI

Factor	Item Code	Statement
SI	SI1	I feel using this system creates better careers opportunities for students
	SI2	Using DASC, will encourage other educational institutions to want the same transparency level for their outcomes.
	SI3	I feel this system will encourage students to enhance their skills and earn more credentials.
	SI4	The reputation of blockchain technology in various fields, should encourage higher education institutions to adopt it.

The second item (SI2) was about evaluating the influence of using the DASC on other institutions' adoption of blockchain in order to have the same transparency level for their outcomes. Most of the participants (73%) agreed this would happen, only 11% were neutral and 16% disagreed.

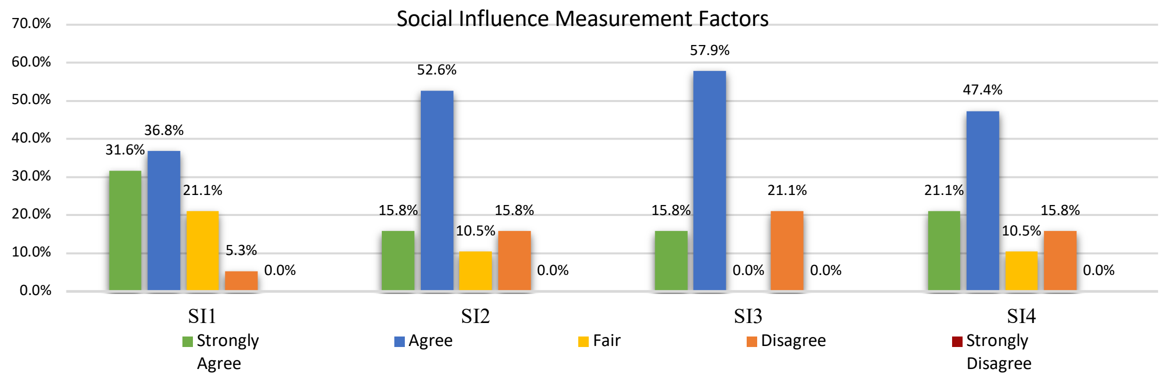

Figure 6.16:2nd Study SI measures for the students' sample

After that, the students were asked if they thought the DASC would encourage students to enhance their skills and earn more credentials (SI3). The majority of the respondents (78%) agreed, and only 22% disagreed, and did not see any effect of DASC on the students' level of achievements. The last item (SI4) was about whether the reputation of blockchain technology in various fields would encourage higher education institutions to adopt it, and 72% agreed it would, 11% were neutral and around 17% disagreed.

User Awareness (AW)

To measure the student's perception about the impact of user awareness on the intention to adopt blockchain, this part of the survey included four items (see Table 6.8). Firstly, the researcherasked the participants whether they were aware of all the properties and functionality provided by the DASC after they had tested it (AW1). Only 28% agreed they were fully aware of features of the DASC, 39% were neutral, and 33% disagreed. This was predictable, since the students had largely still not fully understood blockchain technology and the benefits for the certification process.

Table 6.8: The measures related to DASC: User Awareness

Factor	Item Code	Statement
AW	AW1	I am aware of all the properties and functionality provided by DASC.
	AW2	I need to learn a lot about blockchain before I will be able to effectively use the system.
	AW3	After using DASC, I have a good perception of the advantages of adopting blockchain for higher education institutes.
	AW4	After using DASC, I am aware about the challenges that prevent the adoption of blockchain for the certification process.

On the other hand, 78% of the whole sample agreed that they needed to learn a lot about blockchain before being able to effectively use the system and an equal number of students (11%) were neutral or disagreed (AW2). Moreover, the participants were asked if after they used DASC, they felt they had a good perception of the advantages of adopting blockchain for higher education institutes, 55% agreed they had, while 34% were neutral, and around 11% disagreed (AW3). This result can be explained with reference to the students' answers to the previous items in this section.

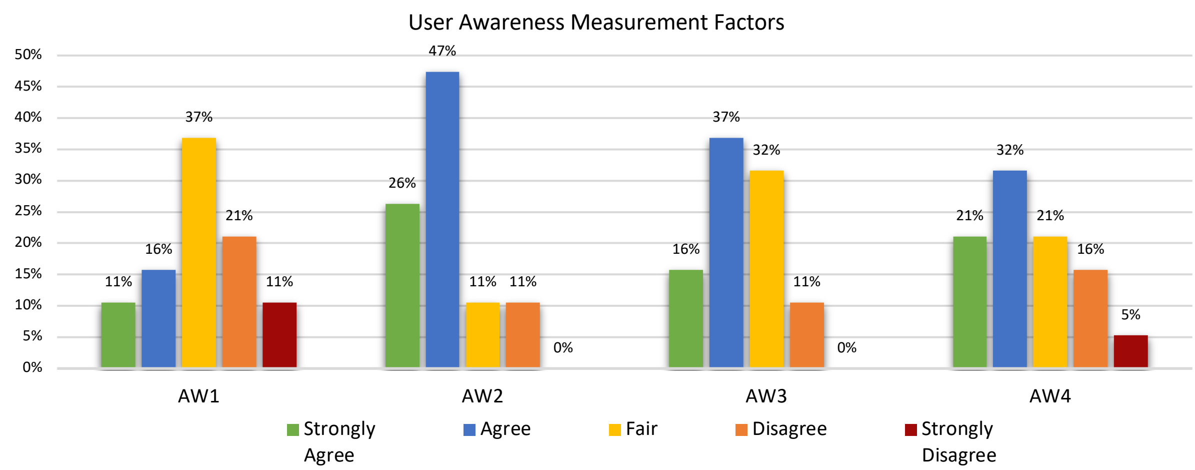

Figure 6.17: 2nd Study AW measurements for the students' sample

Finally, that last item (AW4) questioned participants about whether they were aware of the challenges that prevented the adoption of blockchain for the certification process. The results revealed that 56% of the participants agreed, 22% were neutral and 16% disagreed. Figure 6.17 shows the results for this factor.

Efficiency and Cost Factor (EC)

This factor was measured by investigating the students' perceptions regarding the efficiency of adopting blockchain technology for the certification process. This involved measuring the respondents' points of view about smart certificates and their efficiency, and the cost reduction benefits of adoption. The following section addresses the results for this factor.

- **Efficient smart certificate (ESC)**

All the items shown in Table 6.9 were designed to collect the participants' views about the smart certificates generated and maintained by blockchain technology. As shown in Figure 6.18, 58% of students agreed they were satisfied to have all their credentials in the DASC; 26% were neutral and 16% disagreed (ESC1). After that, the participants were asked whether they thought the DASC was more efficient and smarter than the existing system of generating certificates (ESC2). Most of the respondents (68%) agreed it was, 21% were neutral, and 11% disagreed. These results mean the study objectives are being met as the majority of the participants see the importance and efficiency provided by smart certificates and how could this help to enhance the certification process as well as graduate job application.

Table 6.9: The measures related to DASC: ESC

Factor	Item Code	Statement
ESC	ESC1	I am very satisfied with the idea of having all my credentials in a system such as DASC.
	ESC2	The process of generating the certificate is more efficient and smarter than the current process.
	ESC3	I can easily check if the provided certificate is authentic and provided by the authorized issuer.
	ESC4	I feel more confident during the experience of using a blockchain-based system since I have a record of all my certificates at any time.
	ESC5	I can easily share my educational credentials without any physical barriers.
	ESC6	The overall experience enhances the certification process for all the users involved.

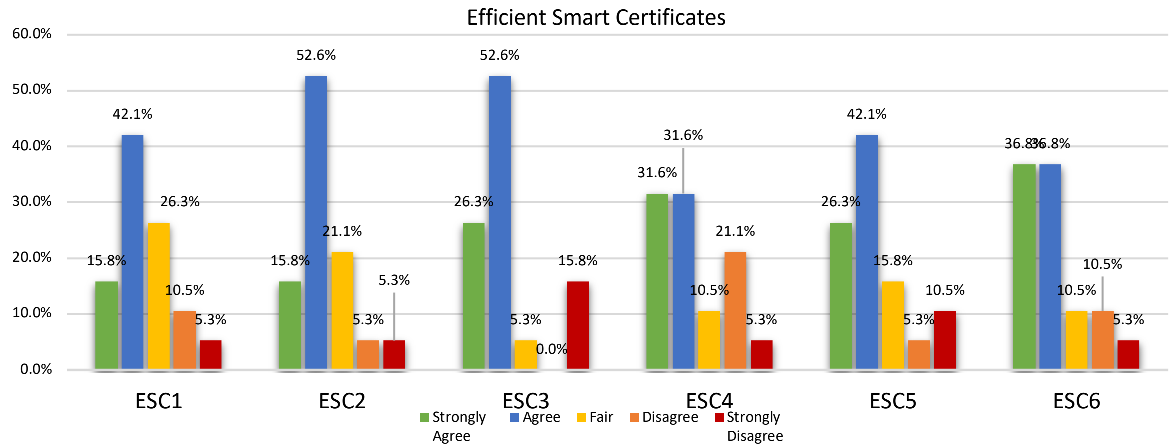

Figure 6.18:2nd Study ESC measures for the students' sample

Then, the survey asked the students about the DASC feature of generating certificates that are authenticated and provided by an authorized issuer, which is one of the main reasons to adopt blockchain for HE certification (ESC3). The results indicated that 79% agreed this was easy to check, 5% and 16% disagreed. Next, the participants were asked if the DASC enhanced their confidence during the experience of using a blockchain-based system since they could have all the records of certificates at any point in time (ESC4). The results showed that around 64% of the respondents agreed it did, 11% were neutral and 26% stated they disagreed. Regarding whether DASC enabled the students to easily share educational credentials without any physical barriers, 69% thought it did and 15% were neutral. However, 16% disagreed about the ease of sharing with the DASC (ESC5). Lastly, 74% agreed the overall certification process was enhanced, 11% were neutral, and 15% disagreed (ESC6).

- **Cost Reduction (CR)**

Item CR1 stated that the DASC reduced the cost associated with the process of generating the students' certificates. Around 69% of the participants agreed, 15% were neutral and 16% indicated they disagreed with this statement. Item CR2 stated that the DASC accelerated the time needed to issue the students' certificates; and 79% agreed, 10% were neutral and 11% disagreed. Item CR3 stated that using the DASC helped to reduce unnecessary costs associated with the transactions and centralized data storage, and around 64% of the participants agreed, 21% were neutral and around 15% disagreed. Finally, 74% agreed they would recommend this system to be adopted by all the national academic institutions, 15% were neutral and 11% disagreed (CR4).

Table 6.10: The measures related to DASC: CR

Factor	Item Code	Statement
CR	CR1	DASC reduces the cost associated with the process of generating the students' certificates.
	CR2	DASC accelerates the time needed to issue the students' certificates.
	CR3	Using DASC helps to reduce the unnecessary cost associated with the transactions and centralized data storage.
	CR4	I would recommend this system to be adopted by all the national academic institutions.

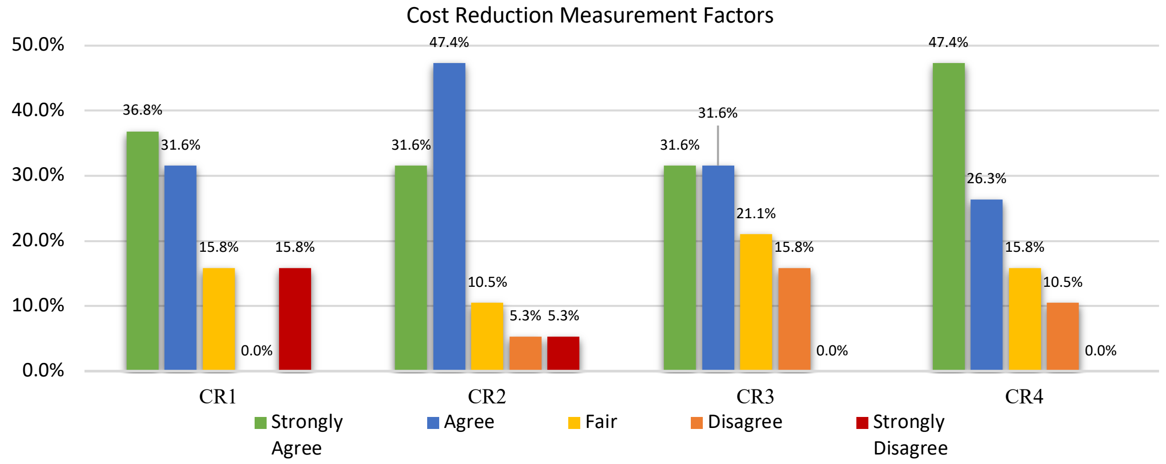

Figure 6.19: 2nd Study CR measures for the students' sample

6.2.5 Part 5: Graphical User Interface (GUI)

This part of the research instrument measured the participants' views regarding the system's layout, transactions and functionalities. Figure 6.20 represents the results of the students' experience with the DASC in terms of their satisfaction with the GUI. The overall feedback was as expected, and the users generally liked the DASC's appearance. The students also responded to separate statements regarding each functionality and screen during the experiment. As shown in Figure 6.20, the majority of the respondents found the screens and the functionalities excellent and in line with their expectations. In the design phase, this research devoted all the feedback from the 1st study and understand the characteristics of the research sample.

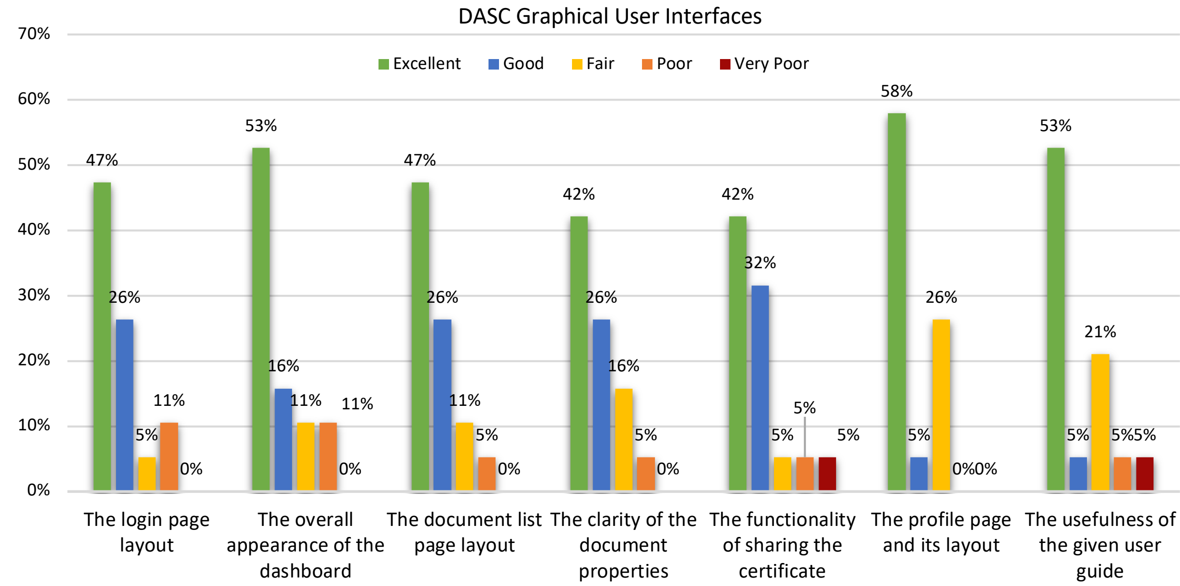

Figure 6.20: DASC GUI-related measurements for the student's sample

6.3 Inferential statistical analysis and assessment of hypotheses from the students' perspective

As in the 1st study, an in-depth detailed exploration of the data acquired from the students' sample was provided and analysed. All the suggested component items were reviewed and analysed separately to provide a comprehensive picture of the students' views, beliefs and behaviours after testing the DASC. This section presents the inferential analysis besides some of the descriptive analysis results that indicate the possible impact of the hypothesized parameters on the students' degree of intention to adopt blockchain technology. Furthermore, the relationships between the independent variables (factors) and dependent variable (intention to adopt blockchain) will also be calculated and examined. The results of these analyses will be used to assess if the stated hypotheses of this research were accepted or rejected; and also helped in producing the revised conceptual models shown in the upcoming section.

6.3.1 Trust (T)

Trust in new technology is a major factor in determining the users' acceptance of that technology. From the viewpoint of the students in this study, this construct was measured by three factors, namely: functionality and transparency, knowledge and usability, and ease of access and sharing.

Table 6.11: Study 2: Summary of the descriptive analysis of Trust from the students' perspective

Construct	N	No. of Items	Mean	S.D.	S. E.	Results interpretation
Trust (T)	**19**	**16**	**2.73**	**0.30**	**0.07**	Moderately Influential
FT	19	7	2.32	0.84	0.19	Influential
KU	19	4	3.76	1.01	0.23	Fairly Influential
EAS	19	5	2.12	1.01	0.23	Influential

Table 6.11 provides a summary of the descriptive analysis of all of trust-related factors with interpretations of the results. As mentioned before, this section is devoted to statically investigate the influence of trust-related factors and discuss all the findings. Two of the sub-factors were found to significantly influence the students' intention to trust the blockchain-based certification process. These were functionality and transparency (FT) and its ease of access and sharing (EAS). The following sections include the analysis for each trust sub-factor that was measured, along with a test of the proposed hypothesis related to each of them.

Table 6.12. Study 2: Normal Distribution results for Trust in the students' sample

Construct	No. of Items	Shapiro-Wilk	Skewness Statistic	Kurtosis Statistic
Intention To Adoption	**2**	**.861**	**.994**	**2.13**
Trust (T)	**16**	**.815**	**0.461**	**0.194**
FT	7	.414	0.367	-0.532
KU	4	.050	-0.734	0.578
EAS	5	.123	1.079	1.385

Functionality and Transparency (FT)

H1a: *Blockchain technology* ***functionality and transparency*** *positively influence user* ***trust*** *toward blockchain adoption for the certification process.*

As shown in the previous section, the descriptive analysis of the FT of blockchain as a factor had a positive influence towards influencing students to trust a blockchain-based system with composite score of (**M**= 2.32) for this factor which indicates very a positive influence on students' trust in blockchain technology. Consequently, the hypothesized relationship (**H1a**) between the FT of blockchain technology and trust in the technology is statistically valid according to the descriptive analysis.

After interpreting the composite score for this factor, the researcherinvestigated the correlation between two variables, namely, the FT of blockchain with trust in the blockchain from the participating students' perspective to validate the strength and direction of the relationship. Prior to the correlation test the researcherchecked the normality distribution for both variables and according to Shapiro-Wilk test the data was normally disturbed with values (.815 and .414) $p > 0.05$ as represented in Table 6.12. In this case, the normal distribution of data was verified and since the sample was small, the researcherselected Spearman's correlation coefficient to evaluate the relationship between Trust and FT. The result revealed a strong, positive correlation between these two variables (r_s= .89, n = 19, $p < .001$) and this correlation was found to be statistically significant. This indicates that a high level of understanding blockchain functionality and transparency was associated with a high level of trust in blockchain-based systems. Therefore, the research found the hypothesis (**H1a**) for the Functionality and Transparency factor was valid and supported.

Knowledge and Usability (KU)

H1b: *User* ***knowledge and familiarity*** *about blockchain positively influence user* ***trust*** *toward blockchain adoption for the certification process.*

After running the descriptive analysis for the KU sub-factor, the results showed that KU had a positive influence on students' intention to adopt a blockchain-based system. The composite score obtained was equal to 3.76 for this factor which indicated a moderate influence on students' trust in the blockchain technology, as shown in Table 6.11. These findings validate the hypothesized relationship (H1b) between the Knowledge and Usability of blockchain technology and trust in the technology which then needed to be statistically supported.

In order to validate the hypothesis, the researcherran a correlation analysis test to assess the relationship between these variables. First, the researcherchecked the normality distribution test and according to the values presented in Table 6.12, the data for these variables (Trust and KU) were not normally distributed as evaluated by Shapiro-Wilk results. Therefore, Spearman's correlation test was run to determine the strength and direction of the relationship. The variables trust and KU were significantly and strongly negatively correlated (r_s= -.67, n = 19, p > .001).

From the result, it is obvious that there is a negative association between students' knowledge and usability of blockchain which affects their trust in blockchain-based systems.

According to (Schober & Schwarte, 2018) negative correlation indicates two variables that tend to move in opposite directions. Consequently, the trust in blockchain technology decreases as the KU factor increases. Thus, the hypothesis (**H1b**) that suggests a positive relationship between Trust and KU is not valid.

Ease of Access and Sharing (EAS)

> ***H1c:*** *Easy **access and convenient sharing** of student credentials positively influence user **trust** toward blockchain adoption for the certification process.*

As mentioned in Chapter 3, the importance of the trust factor also involved investigating the perception of students regarding how easy it was to access and share their certificates while using DASC. As shown in Table 6.11, the descriptive analysis was conducted on this factor and the composite score **M**=2.12, was indicating that this factor had a positive influence on the students' trust in blockchain for the certification process. That support the assumed hypothesis regards the relationship between these two factors. Moreover, to analyse the relationship between Trust and EAS, a correlation test using Spearman's test was used to determine the degree of relationship. Prior to running the correlation coefficient test, the normal distribution was tested for the two variables. Table 6.12 indicates the two variables were normally distributed as evaluated by Shapiro-Wilk test, $p<.05$. Then, Spearman's correlation test investigated the strength and direction of the relationship, and the variables Trust and EAS were shown to be significantly and strongly positively correlated (r_s= .86, n = 19, $p < .001$). Thus, the assumed positive hypothesis (**H1c**) about the relationship between ease of access and sharing and the students' trust in blockchain was supported and valid.

Finally, the impact of trust and its related subfactors on the users' intention to adopt blockchain needed to be measured. To that end, the relationship between these two variables namely, Trust and students' intention to adopt blockchain for the certification process was investigated statistically to check the strength and the direction of this relationship. From the descriptive analysis of the trust factor (shown in Table 6.11), the composite score was 2.73 which indicated a moderate positive influence on the students' intention to adopt blockchain for the certification process. The review of the literature (see Chapter 3) supports the importance of the role that trust plays in the field of blockchain acceptance, as proposed by the hypothesized relationship (**H1**).

H1. *In the certification process in the higher education sector, an increase in the level of **trust** toward blockchain technology will increase users' **intention to adopt blockchain technology**, given that trust is considered a major determinant of user acceptance*.

Before the correlation between trust and intention to adopt blockchain was computed, the data's normal distribution among these variables was checked. The result of the Shapiro-Wilk test revealed both variables were normally distributed with ($p > 0.05$). Then, Spearman's correlation test was run to determine the relationship between trust and students' intention to adopt blockchain. The result showed a statistically significant positive relationship ($r_s = .169$, n = 19, $p > .001$). Even though the result does not imply a highly significant influence of trust on the intention to adopt blockchain, it still supported the assumed hypothesis and it showed as a valid relationship **(H1).**

Table 6.13. Validating the research Hypotheses of Trust Factor

Variables Relationship (Hypothesis)	Correlation Coefficient	Sig. (*p*)	Hypothesis Validation	Results interpretation
Trust → Blockchain Adoption	**.169**	**.489**	**No**	Low positive relationship
FT → Trust	$.89^{**}$	0	Yes	Strong positive relationship
KU→ Trust	$-.67^{**}$	.002	No	Strong negative relationship
EAS→ Trust	$.86^{**}$	0	Yes	Strong positive relationship

**Correlation is significant at the 0.01 level (2-tailed).

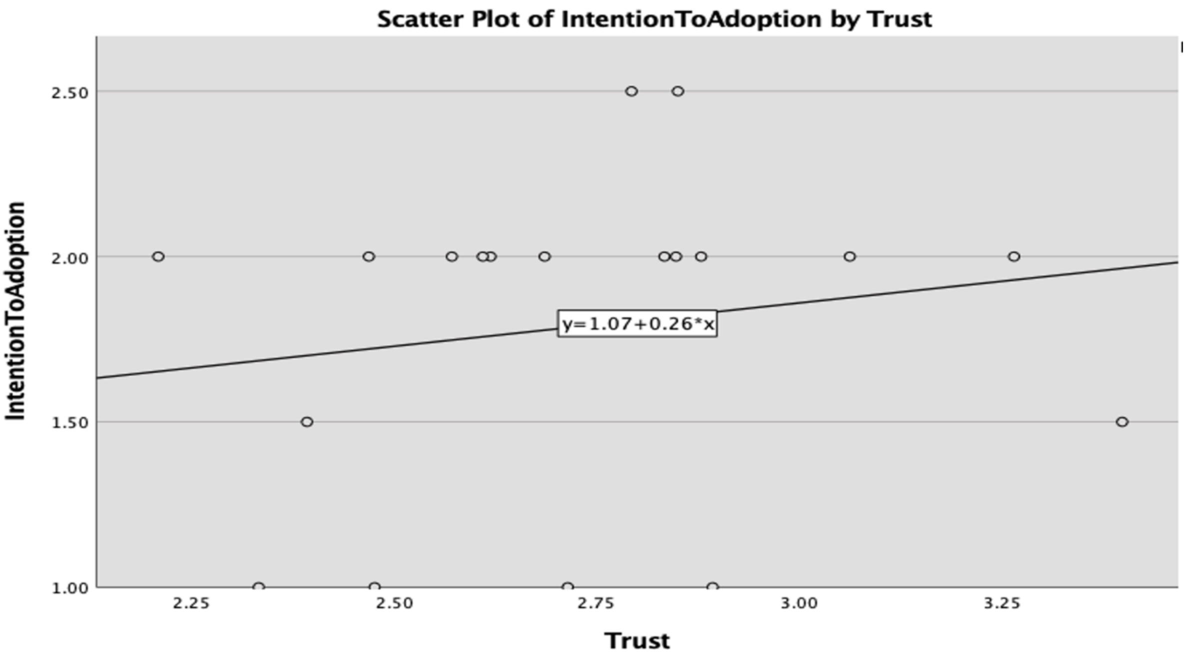

Figure 6.21, Representation of the relationship between T and Intention to Adopt Blockchain

Table 6.13 contains the overall results of the correlation coefficient tests applied to the factors related to trust to validate and check the validity of the hypothesized relationships mentioned above. To graphically represent the relationship between these variables, SPSS was used to demonstrate the Scarlett plot graph as shown in Figure 6.21. This figure shows there is a low positive relationship between these factors where a fit line has been used to represent an increase in trust in blockchain causes a slight increase in the intention to adopt it by students in the higher education sector. Finally, this section demonstrates that trust and its related factors have a positive influence from the students' perspectives in increasing their intention to adopt blockchain for the certification process.

6.3.2 Security and Privacy Factor (SP)

From the students' perspective, the SP involves two factors, namely, Perceived security, privacy, immutability and reliability (PSP) and Perceived Risk (PR). These factors have been already discussed (see Section 6.2.4).

Table 6.14: Summary of the descriptive analysis of SP factors from the students' perspective

Construct	N	No. of Items	Mean	S.D.	S. E.	Results interpretation
Security and Privacy (SP)	**19**	**9**	**2.68**	**.646**	**.148**	Moderately Influential
PSP	19	5	2.41	.905	.207	Moderately Influential
PR	19	4	2.96	.760	.174	Moderately Influential

Table 6.14 contains all the information related to the descriptive analysis of SP construct combined with the interpretation of the results. These findings show a positive influence of these factors on the students' intention to adopt a blockchain-based certification system. Additionally, the summary of all the normal distribution tests is presented in Table 6.15, which indicates whether the data were normally distributed or not. The following sections address the investigation into the factors related to SP to statistically demonstrate whether the relationships in the proposed hypotheses were supported.

Table 6.15, Normal distribution results for SP-related factors

Construct	No. of Items	Shapiro-Wilk	Skewness Statistic	Kurtosis Statistic
Intention To Adoption	**2**	**.861**	**.994**	**2.13**
Security and Privacy (SP)	**9**	**.946**	**.757**	**.318**

PSP	5	.948	.684	1.47
PR	4	.939	.856	1.69

Perceived security, privacy, immutability and reliability (PSP)

> ***H2a:*** *Perceiving security features of blockchain technology* ***(privacy, immutability, security and reliability)*** *positively influences users' understanding of the level of* ***security and privacy*** *provided by blockchain technology for the certification process.*

The PSP factor of blockchain technology used in this study was measured by a total of five items. To validate the hypothesized relationship for this factor, the findings of the descriptive and statistical analyses were measured. First, the relationship between PSP and the students' perceptions about the SP factor in blockchain. From the descriptive analysis performed on this factor the researcher found the composite score (**M**= 2.41) which implies a positive influence of PSP on the SP that would positively influence the students' intention to adopt blockchain. This demonstrates the validity of the proposed hypothesis regards PSP (**H2a**), but more statistical analysis and a correlation test were also conducted.

Prior to calculating the correlation coefficient test on these variables, the normal distribution was measured by the Shapiro-Wilk test and found the data on both variables were normally distributed as presented in Table 6.15. Therefore, the relationship between SP and PSP was evaluated by performing Spearman's correlation coefficient test. The result in Table 6.16 revealed that the relationship was strongly positive between these factors and there was a statistically significant correlation as (r_s= .830, n = 19, $p < .001$). Accordingly, the proposed hypothesized relationship (**H2c**) between SP and PSP is valid. This means that the more students have positive perceptions about these features of blockchain technology, the more they intend to adopt a blockchain-based system.

Perceived Risk (PR)

> ***H2c****: The* ***perception of low risk*** *associated with the use of blockchain technology positively influences users' understanding of the level of* ***security and privacy*** *provided by blockchain technology for the certification process.*

PR is composite of four items that were used for the purpose of measuring the relationship between PR and SP. As with the previous factors, three steps were performed before checking the validity of the proposed hypothesis regarding this factor, as stated above (**H2c**). Firstly, by interpreting the descriptive analysis results as presented in Table 6.14. The composite score was equal to 2.96 that is likely to reflect a positive influence of PR on the students' perceptions about SP. Then, the normal distribution among the data of these two variables was assessed by applying Shapiro-Wilk test as (p >.05) which showed the data were normally distributed. Lastly, the correlation test was conducted to gauge the statistical analysis and fulfil the validation process of the hypothesized relationship. Spearman's correlation test was chosen to examine the relationship, a found a strongly positive correlation which was statistically significant as (r_s= .652, n = 19, p > .001) as represented in Table 6.14. Consequently, the hypothesis (**H2c**) is valid and supported by this study.

After evaluating the relationships between the SP construct and its subfactors (PSP and PR), the impact of SP on the intention to adopt blockchain for the certification process from the students' point of view was conducted as a second investigation. The proposed relationship between SP and the students' intention to adopt blockchain for the certification process is represented in the following hypothesis:

> ***H2:*** *In the certification process in the higher education sector, an increase in understanding the level of* ***security and privacy*** *provided by blockchain technology will increase users'* ***intention to adopt blockchain technology****, given that this allows for better maintenance of student certificates.*

From the descriptive analysis results shown in Table 6.14, the composite score of SP (**M**=2.68) indicated a moderately positive influence on the students' intention to adopt blockchain for the certification process. Thus, the hypothesis above was supported but more verification with statistical analysis was required. To validate the normal distribution procedure among the data of these variables (SP and intention to adopt blockchain) the Shapiro-Wilk test as shown in Table 6.15 was applied and the findings verified the data were normally distributed as p > 0.05. In terms of statistical analysis, the correlation between the SP factor and students' intention to adopt a blockchain-based certification process was examined utilising Spearman's correlation coefficient test. A statistically significant, positive correlation was found between these two variables as (r_s= .197, n = 19, p > .001) (see Table 6.16). Accordingly, the research hypothesis related to this construct (**H2**) is valid.

Table 6.16. Validating the research Hypotheses by the connection of Correlation Results

Variables Relationship (Hypothesis)	Correlation Coefficient	Sig. (*p*)	Hypothesis Validation	Results interpretation
SP → Blockchain Adoption	**.197**	**.419**	**Yes**	Low positive relationship
PSP→ SP	.830**	0	Yes	Strong positive relationship
PR → SP	.652**	.002	Yes	Strong negative relationship

**Correlation is significant at the 0.01 level (2-tailed).

Figure 6.22 below is a graphical representation of the relationship between these variables (SP and intention to adopt blockchain), SPSS was used to construct the Scarlett plot graph. It is clear from this figure that there is a weak positive relationship between these variables. Additionally, the fit line indicates a very slight correlation between these variables where there is a low impact of the students' perception about blockchain security and privacy features on the students' intention to adopt blockchain for the certification process. Even though the results indicated the low impact of security and privacy concerns on the students' intention to adopt, it is still a huge concern when it comes to DLT, blockchain technology in particular.

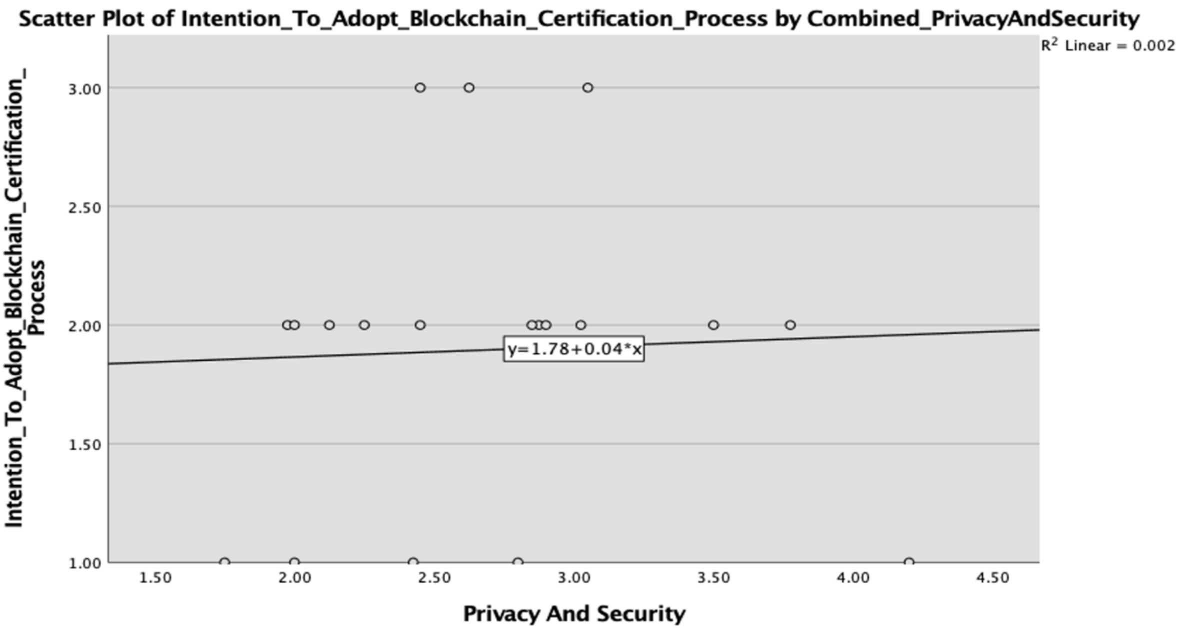

Figure 6.22. Representation of the relationship between SP and Intention to Adopt Blockchain

6.3.3 Social Influence Factor (SI)

Social influence (SI) in this study was measured by four items that were analysed to evaluate its impact on the adoption of blockchain for the certification process from the students' perspectives. As presented in section 6.2.4, all the descriptive analysis measures about this construct and its related factors were studied and discussed. Moreover, Table 6.17 contains the summary the of the descriptive analysis of SI composite score, standard deviation, standard error and interpretations of the results.

Table 6.17: Summary of the descriptive analysis of the SI factor from the students' perspective

Construct	N	No. of Items	Mean	S.D.	S. E.	Results interpretation
Social Influence (SI)	**19**	**8**	2.21	.817	**.187**	Influential

The normal distribution of the data among the variables for this construct was calculated and the results are presented in Table 6.18 below. Then, the relationship between the proposed variables were investigated to check the strength and direction of these relationships. Finally, the validity of the proposed hypothesized relationship could be revealed.

Table 6.18, Normal distribution results for the SI factor

Construct	No. of Items	Shapiro-Wilk	Skewness Statistic	Kurtosis Statistic
Intention To Adoption	2	.861	.994	2.13
Social Influence (SI)	4	.931	.497	-.330

The idea was to evaluate the relationship between the SI construct and the students' intention to adopt blockchain. In order to measure the validity of the proposed hypothesis below (**H3**):

H3: *In the certification process in the higher education sector, the level of positive* ***social influence*** *is positively associated with users'* ***intention to adopt blockchain technology***.

The result of the descriptive analysis showed that the SI had a positive impact on the students' intention to adopt, as shown in Table 6.17. The composite score of the SI measured factors was equal to 2.21 which indicated it was an influential factor for intention to adopt blockchain for certification. Consequently, the hypothesized relationship (**H3**) is valid according to the descriptive analysis.

After interpreting the composite score of this factor, the correlation between two variables, namely, the SI of blockchain with the students' intention to adopt blockchain was calculated to validate the proposed relationship. Moreover, applying the correlation test would help to identify the strength and direction of the relationship between SI and intention to adopt in the students' sample. Before conducting the correlation test procedures, the normal distribution of the data among the two variables was checked. As presented in Table 6.18, the data for the two variables as assessed by Shapiro-Wilk test were normally distributed with $p > 0.05$. The researcher found a positive influence and statistically significant relationship between SI and intention to adopt blockchain technology ($r_s = .329$, n = 19, $p > .001$) as represented in Table 6.19. Consequently, the hypothesised proposed relationship (**H3**) is valid and supported by the results of the descriptive and statical analysis.

Table 6.19. Validating the research Hypotheses by the connection of Correlation Results

Variables Relationship (Hypothesis)	Correlation Coefficient	Sig. (*p*)	Hypothesis Validation	Results interpretation
SI → Blockchain Adoption	**.329**	**.169**	**Yes**	Low positive relationship

SI was chosen as a factor for investigation in this study because of its importance in the field of technology adoption in education, and thus, for the context of this research. The adoption of the new and innovative technology is encouraged by the huge development seen in many educational institutes in Saudi Arabia. The findings of this study supported this fact, even though the results here reflected a weak impact for SI.

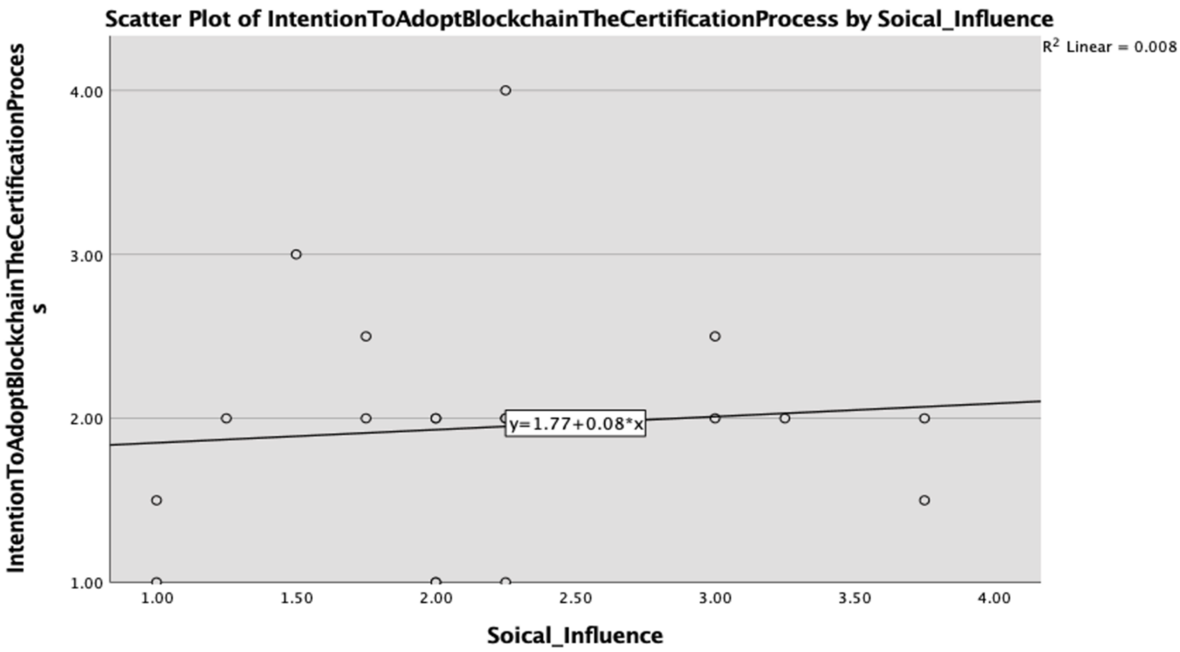

Figure 6.23. Representation of the relationship between SI and Intention to Adopt Blockchain

Figure 6.23 demonstrates the relationship between social influence and the students' intention to adopt blockchain for the certification process. It is obvious from the fit line in the scatter graph that the correlation is positive even thought it shows a slightly low impact. To conclude, social influence definitely has a positive impact towards the intention to adopt a blockchain-based certification system.

6.3.4 User Awareness (AW)

In this study the AW factor was measured by 4 items that helped to calculate the relationship between AW and the students' intention to adopt blockchain after they tested the DASC.

Table 6.20. Summary of the descriptive analysis of AW from the students' perspective

Construct	N	No. of Items	Mean	S.D.	S. E.	Results interpretation
User Awareness (AW)	19	4	2.53	.857	.198	Influential

Table 6.20 contains the summary of the descriptive analysis of the AW-related factors along with result interpretation; it shows that AW has a positive influence on students' intention of adopting blockchain certification systems. Also, Table 6.21 includes all the results of the normal distribution tests on the data for the variables measured in this section. Applying these tests helped to assess the validity of the proposed hypothesis (**H4**) stated below:

> ***H4**: **User's awareness** positively influences the users' **intention to adopt blockchain technology** for the certification process.*

From the descriptive analysis result, the composite score of AW was found to be 2.5 and was interpreted to indicate the positive influence of AW on the intention to adopt a blockchain-based certification system.

Table 6.21. Normal Distribution results for the AW factor

Construct	No. of Items	Shapiro-Wilk	Skewness Statistic	Kurtosis Statistic
Intention To Adoption	2	.861	.994	2.13
User Awareness (AW)	4	.958	.066	-.809

To support this finding, a correlation coefficient test was used for the purpose of evaluating the relationship. First, a test was conducted to verify if the data among the two variables were normally distributed. This was fulfilled by applying the Shapiro-Wilk test that showed the data for both variables were normally distributed $p > 0.05$ (see Table 6.21). Thus, for the aim of statistically validating that relationship, Spearman's correlation coefficient test was conducted to evaluate the hypothesized relationship as stated above. The result revealed that there was a positive and moderate correlation between AW and the students' intention to adopt a blockchain-based certification system which was statistically significant (r_s= .400, n = 19, p >.001). Table 6.22 provides the correlation test findings with the result interpretation. Thus, the proposed hypothesized relationship in (**H4**) is valid and shows a positive relationship between AW and students' intention to adopt blockchain.

Table 6.22. Validating the research Hypotheses by the connection of Correlation Results

Variables Relationship (Hypothesis)	Correlation Coefficient	Sig. (p)	Hypothesis Validation	Results Interpretation
AW → Blockchain Adoption	**.400**	**.096**	**Yes**	Moderate positive relationship

This means that when the students have a high level of awareness about blockchain, this increases the level of their intention to adopt blockchain. As presented in Figure 6.24, the relationship between user awareness and intention to adopt blockchain was symbolized as a fit line where an increase in awareness would impact moderately and increase the students' intention to adopt blockchain.

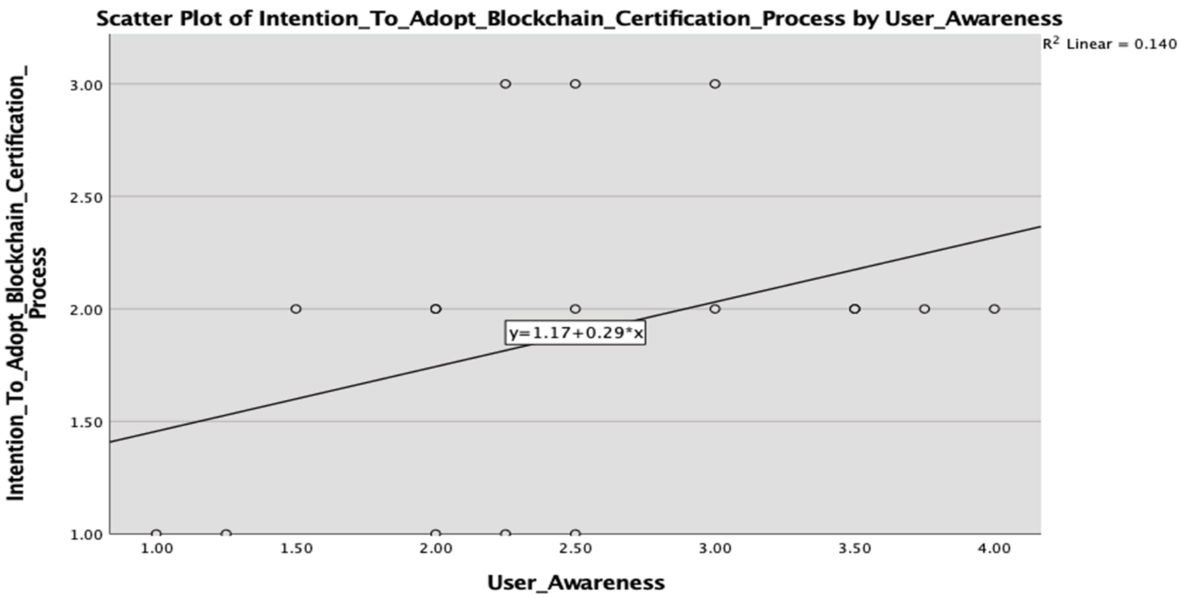

Figure 6.24. Representation of the relationship between AW and Intention to Adopt Blockchain

6.3.5 Efficiency (EF)

In this research this factor consisted of two major constructs namely, the efficient smart certificate and cost reduction. Two analyses were performed on the data which were the descriptive and inferential analyses. Table 6.23 includes the summary of the descriptive analysis of all the efficiency-related factors with interpretations of the results. It is clear from the descriptive analysis that efficiency and its related factors have a positive influence on the students' intention to adopt blockchain in the higher education sector.

Table 6.23: Summary of the descriptive analysis of EF from the students' perspective

Construct	N	No. of Items	Mean	S.D.	S. E.	Results interpretation
Efficiency (EF)	**19**	**10**	**2.21**	**1.01**	**.232**	Influential
ESC	19	6	2.30	1.04	.239	Influential
CR	19	4	2.11	1.05	.237	Influential

Meanwhile, Table 6.24 comprises all the results of the normal distribution tests applied to the data to determine the suitable correlation coefficient test to be performed. These tests assisted the investigation of the validity of each hypothesis about the relationships between the measured factors in order to evaluate the intention of adopting blockchain.

Table 6.24. Normal Distribution results for EF

Construct	No. of Items	Shapiro-Wilk	Skewness Statistic	Kurtosis Statistic
Intention To Adoption	**2**	**.861**	**.994**	**2.13**
Efficiency (EF)	**10**	**.920**	**.966**	**.708**
ECS	6	.911	1.05	1.01
CR	4	.877	.830	.144

Efficient smart certificate (ESC)

> ***H5a:*** *The* ***efficient smart certificates*** *enabled by blockchain technology positively influence the* ***efficiency*** *of the certificating process.*

This factor was measured by six items that ascertained the students' attitudes regarding the efficient smart certificates that are controlled by blockchain. The descriptive analysis results showed the composite score **M**=2.30 that indicated the students' views about smart certificates had an influence on their perceptions of blockchain efficiency. To support the descriptive analysis result I was necessary to statically compute the correlation of ESC and EF to test the hypothesized relationship (**H5a**). Prior to applying the correlation test, the normal distribution among the data for the two variables was checked. As shown in Table 6.24, the ESC and EF were normally distributed as assessed by the Shapiro-Wilk test as their values exceeded 0.05. Since the data were normally distributed but it was considered as small sample, the correlation was checked by conducting Spearman's correlation coefficient test. The results revealed a positive and strong correlation between CR and EC which was very statistically significant (r_s= .98, n = 19, $p < .001$). This indicated the students' opinions regarding efficient smart certificates had a strong influence on the way they recognized efficiency in blockchain technology. This was as expected from the students in this age range, they were enthusiastic about the concept of smart certificates and interacted with it more than other aspects of blockchain technology. Thus, the proposed hypothesis (**H5a**) is valid and supported by the findings of this study.

Cost reduction (CR)

> ***H5b: Cost reduction*** *provided by blockchain technology positively influences the* ***efficiency*** *of the certificating process.*

The cost reduction factor (CR) consisted of four items that were measured and analysed to evaluate the influence of CR on the efficiency of the blockchain certification process from the students' point of view. From the descriptive analysis conducted on CR, a composite score equal to 2.11 was found, indicating a positive influence of CR on the efficiency of blockchain (see Table 6.23). Then, the normal distribution test was conducted and results showed the data for the two variables were normally distributed among the given sample, as assessed by Shapiro-Wilk test with values p>0.05. To statistically evaluate the relationship between EF and CR, a Spearman's correlation test was run. The researcher found a positive influence and statistically significant relationship between CR and EF (r_s= .96, n = 19, $p < .001$). Consequently, the hypothesis proposed about this relationship (**H5b**) is valid and supported by the results of the descriptive and statistical analysis.

After assessing the relationships between efficiency (EF) and its subfactors (ESC and CR), the impact of EF on the intention to adopt the blockchain from the students' point of view was measured. The proposed relationship between EF and the students' intention to adopt blockchain for the certification process was represented in the following hypothesis:

> ***H5****: In the certification process in the higher education sector, an increase in the level of* ***efficiency*** *and reduction in the associated cost of blockchain technology will increase users'* ***intention to adopt blockchain technology*** *for the certification process.*

From the descriptive analysis performed at the beginning of this section, Table 6.23, shows the composite score of EF as (**M**=2.2)1 that reflects a moderate level of influence of this factor on the users' intention to adopt blockchain. As stated previously in Chapter 3 this supports the relationship assumed in this study (**H5**). To provide an additional support to the findings of the descriptive analysis, the relationship between these two variables was tested. According to the results of Shapiro-Wilk test, the data for EF and Intention to Adopt were normally distributed and the Spearman's correlation coefficient was subsequently performed to determine the strength and direction of this relationship. The result revealed a weak, positive correlation between these two variables (r_s= .089, n = 19, p > .001). Thus, the proposed hypothesis (**H5**) is valid in this study.

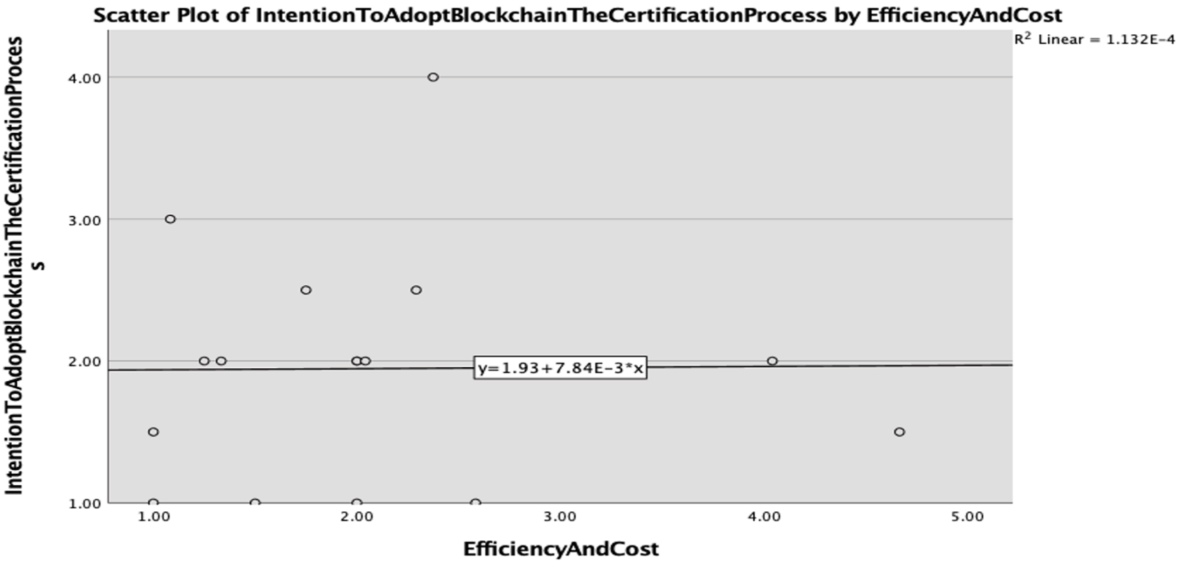

Figure 6.25. Representation of the relationship between EF and Intention to Adopt Blockchain

Figure 6.25 below is a graphical representation of the relationship between these variables, SPSS was used to demonstrate the Scarlett plot graph. It is clear from this figure that there is a weak positive relationship between EF and intention to adopt blockchain. Moreover, the fit line demonstrates a very slight correlation between these variables where there is a small impact of EF on the students' intention to adopt blockchain for the certification process.

Table 6.25. Validating the research Hypotheses by the connection of Correlation Results

Variables Relationship (Hypothesis)	Correlation Coefficient	Sig. (*p*)	Hypothesis Validation	Results interpretation
EF → Blockchain Adoption	**.089**	**.72**	**Yes**	Low positive relationship
ESC→ EF	.98	.00	Yes	Strong positive relationship
CR → EF	.96	.00	Yes	Strong negative relationship

Finally, Table 6.25 contains the summary of the overall results of the correlation coefficient tests applied to efficiency (EF) and the related factors (ESC and CR) to check the validity of their hypothesized relationships that have been discussed above. It is clear from these findings that the students' perceptions about the ESC and CR had a very high influence on their perception of the efficiency of blockchain technology for the certification process.

6.4 Employer Experiment Descriptive Analysis and Interpretation

This section addresses the results and data analysis of the part of the study which investigated prospective employers. All the related criteria in the participants' responses were analysed after they had used the DASC prototype. The prospective employers play an important role in this research, as mentioned before, as they are the main drivers for motivating educational institutes to adopt blockchain technology for the certification process. The number of employers participating in this study was 5, They all came from different sectors i.e., the educational, financial, business, engineering and economic sectors; and had solid reputations in the Saudi market. The focus in this part was to compare the collected results from the first study with the results obtained in this study to measure how the employer's points of view changed after testing the DASC.

6.4.1 Part1: Demographic Information

The first section of this study was designed to collect the demographic information which was analysed to find out any influences from these characteristics on the level of the factors that could affect the intention to adopt blockchain in the higher education field. The respondents were requested to answer several questions in order to collect demographic data about them including their gender, age, education level and field domains.

Age

The first question was asked to ascertain the employers' age distribution. Figure 6.26 shows that 60% of the respondents were between 36 and 45 years; followed by equal numbers (20%) aged 46 to 60 and 26 to 35 respectively. The age distribution was as expected from the study since these ages (26-60) are usually when employers are in position to be involved in activities related to human resources.

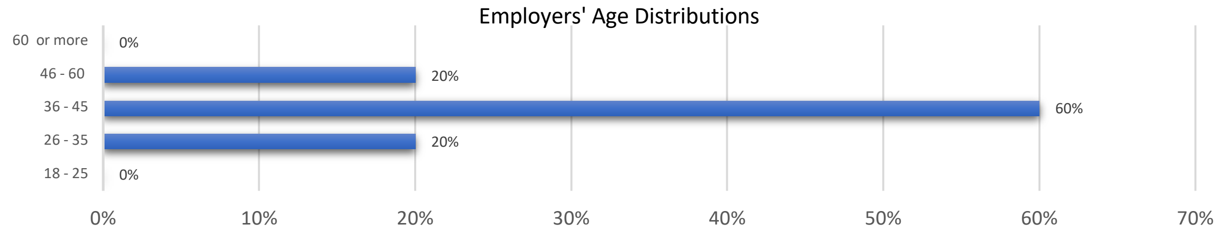

Figure 6.26: Study 2: Employer's sample age distribution

Gender

This study intended to involve more female participants especially at the decision-making level to enrich the studies involved more female participants in the context of Saudi Arabia. Thus, the second question in the demographic section of the questionnaire asked about the gender of the participating employers. The result of the gender distribution is shown in Figure 6.27 which indicates 60% of the respondent were male and 40% were female; which is still represents a good number of women in leading positions, specifically in the context of Saudi Arabia. The almost equal number of males and females' participants add a value to this study due to the lack of female participants in most studies in Saudi Arabia.

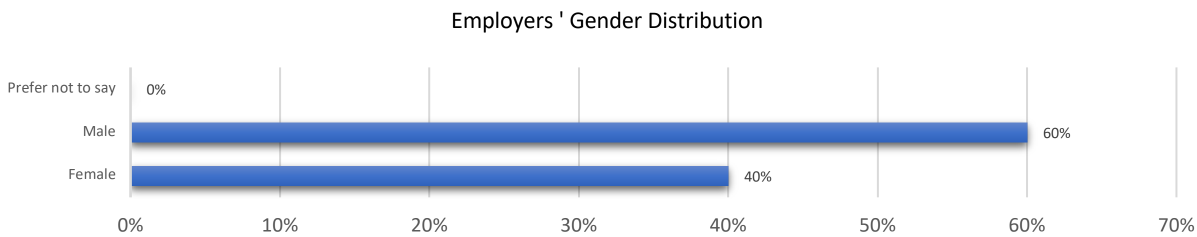

Figure 6.27: Study 2: Employer's sample - gender distribution

Educational Level

As shown in Figure 6.28, majority of the participating employers were postgraduates or higher (60%) which means they held Masters or PhD degrees. Meanwhile, around 40% of them held a bachelor degree, with no participating employer below this level. The overall educational level of the employers was as expected and reasonable for the size of the sample; and appropriate, since the study targets employers who have the knowledge and ability to use new technological innovations such as blockchain.

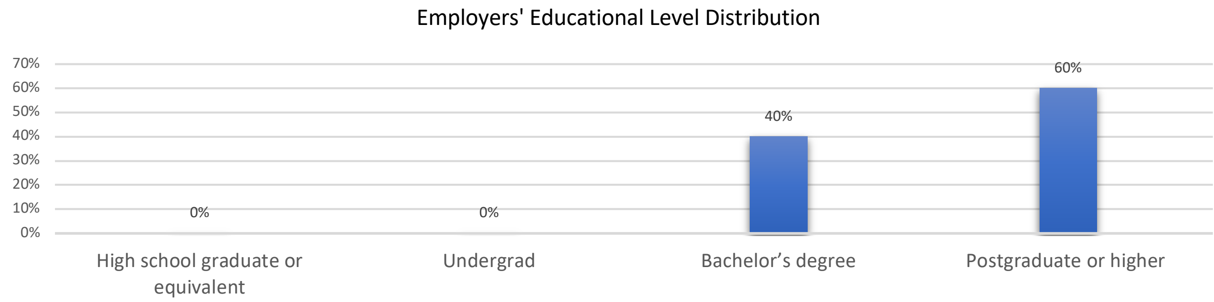

Figure 6.28: Study 2: Employer's sample- educational level distribution

Field Domain

The last question seeking demographic information part was about the employers’ speciality domains. It is clear from Figure 6.29 that most of the participating employers (60%) were from science, technology or engineering domains. Meanwhile, 40% were from the business and economics domains. The research aimed to target employers in relevant fields to realise the aim of this research and investigate the desire to adopt blockchain technology. Thus, having the employer participants in these two domains could be helpful to fulfil the research aims.

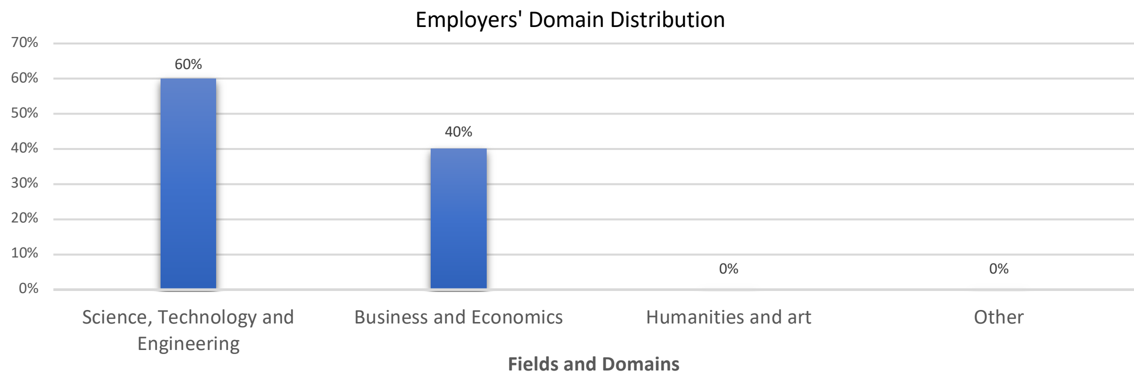

Figure 6.29: Study 2: Employers’ sample - domain distribution

6.4.2 Part 2: Level of the Knowledge and Previous Experience of Blockchain Technology

In this section, the purpose was to investigate the employers’ backgrounds and their levels of previous experience with blockchain technology. The participants’ experiences are considered as a key measure to evaluate prospective employers’ willingness to use the DASC; and for this phase of the research, the participants had already encountered the system. Furthermore, this section was designed to estimate the level of the participants’ use of blockchain to measure how this factor could affect their intention to adopt a blockchain-based certification system. Also, the participants were asked about the skills and training they had received in order to increase their knowledge and awareness regarding blockchain technology.

***Knowledge**:* The first item in this section was about the level of familiarity and awareness among the participating employers. As shown in Figure 6.30, the results indicated different levels of awareness amongst the employers; and the majority reported being slightly aware about blockchain. Meanwhile, 20% of the participants indicated they were highly aware, the same percentage were moderately aware, and a further 20% implied they had no awareness of blockchain technology. The results show a good diversity among the prospective employers in terms of their knowledge levels about blockchain. It was assumed that participants would be able to judge their awareness level from other experiences of embracing new technical solutions in their organisations.

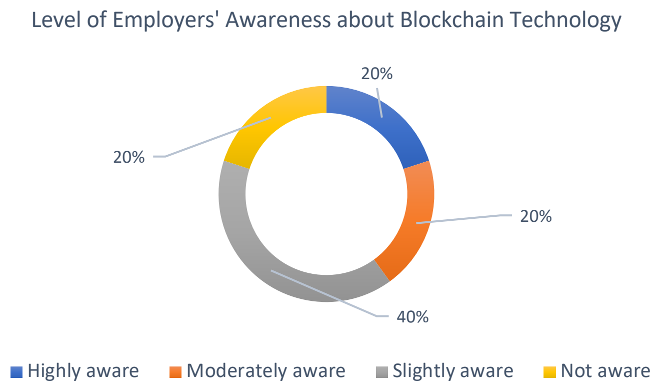

Figure 6.30:Study 2: Level of Employers' knowledge about blockchain

***Experience**:* The second item addressed experiences with developing or using systems based on blockchain technology. Figure 6.31 shows that 80% of the respondents had some level of experience with blockchain technology. According to the results obtained in the previous question about the awareness, it could be assumed that the level of these experiences would vary among the participants, would range from high to low and could involve developing, programming or just having a slight interaction with blockchain-based systems.

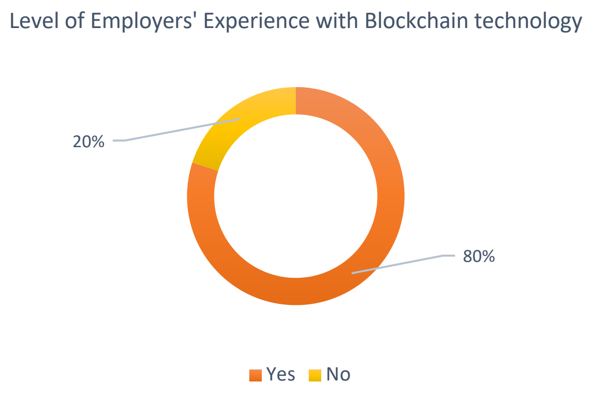

Figure 6.31: Study 2: Level of Employers' experience about blockchain

Skills and Training: The third item in this section collected data regarding the participating employers' skills in the field of distributed technology; and ascertained if they felt they had received adequate training to use blockchain technology in any way. As shown in Figure 6.32, the participants responded to a question about how often they attended workshops/seminars about DLT, in particular blockchain technology and the results indicated that all the participating employers attended some sort of workshop on this subject. On the other hand, the participants were asked to evaluate their skills and training levels and if they considered them sufficient to be able to handle systems such as DASC. The results shows that 60% of the respondents answered 'maybe' while 40% were certain their skills were sufficient and reported they had received training either from their organisations or as self-development. This indicated the high level of organisations' efforts to keep up to date with the current technical innovations and provide sufficient training to increase awareness about this technology. Consequently, the idea of adopting such technology will be highly recommended among educated and aware employees and staff.

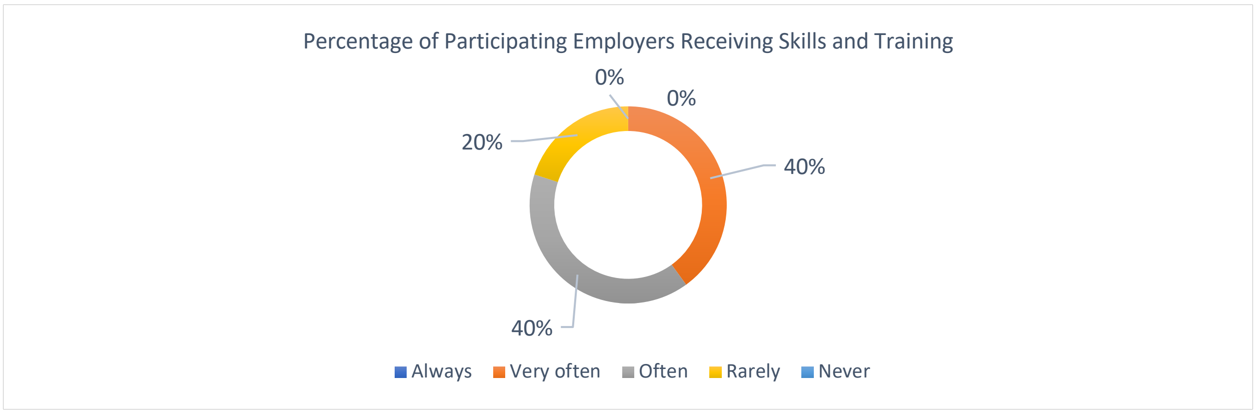

Figure 6.32: Percentage of how often employers had received training

Influential Factors*:* the last item in this section addressed the factors affecting the adoption of blockchain technology from the perspective of the participating employers. Figure 6.33 represents the suggested factors given to the participants to choose from, whereby they could choose more than one factor. The results indicated that most of the participating employers (60%) agreed on three factors: namely, privacy and security related concerns, trust in blockchain and the authentication associated with the provided documents. Followed by 40% of the respondents who selected efficiency of retrieving documents as factor that would impact their decision about adopting a blockchain-based system.

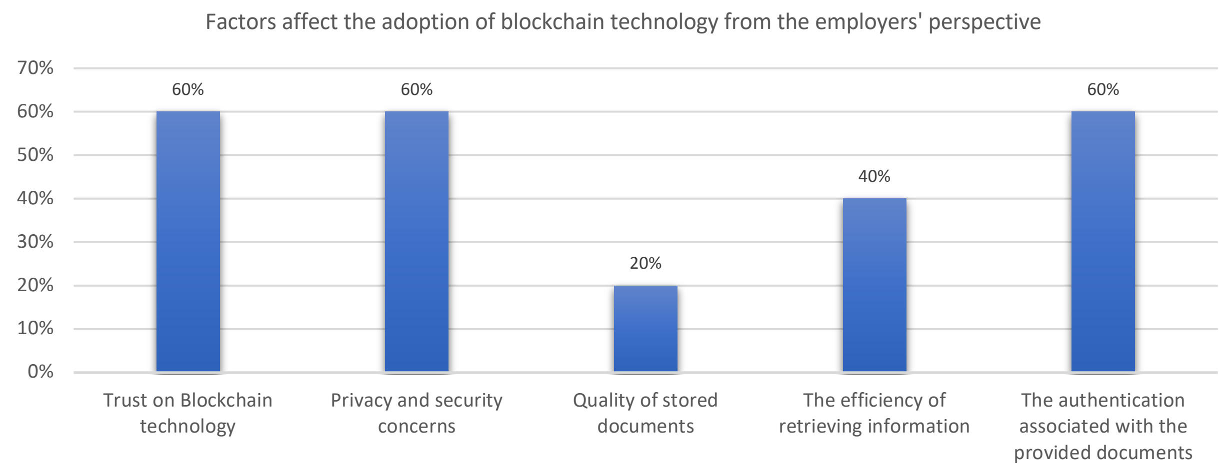

Figure 6.33: Factors affect the adoption of Blockchain technology from the Employers' Perspective

Lastly, the quality of the stored document was chosen by only 20%. To sum up, the demographic characteristics of the sample suggest that it is appropriate for the study. This is both in terms of the spread of age and gender in the sample and the level of likely understanding of the how the technology works and their subsequent ability to make informed judgements of its suitability for the certification process.

6.4.3 Part 3: Existing System Issues

The purpose of this section was to evaluate how the current certification process in the HE sector was viewed by the prospective employers. The participants were given seven issues with a scale from 'strongly agree' to 'strongly disagree' to choose from. The goal of this section was to estimate the effect of each of these issues on user satisfaction with the current system. These issues have already been investigated with student participants in both of the conducted studies, while the employers' point of view is only measured in this 2nd Study.

Figure 6.34 shows the results obtained from this part of the study. The first item asked whether the employers considered the current process of issuing student/candidate certificates considered as time-consuming and requiring a lot of effort. The majority of the respondents (60%) agreed it was and would impact on candidates applying for work. The rest of the respondents (40%) were neutral or didn't know about the issuing process from an academic perspective. No employers disagreed. The second item measured whether the participating employers viewed the current system as requiring a lot of paperwork to validate certificates provided by the candidates. The results showed 80% agreed, while only 20% were neutral. The participants were then asked whether the current process of validating candidates' certificates was time-consuming as it required dealing with different organizations with varying protocols to validate the credentials. The result indicated 40% agreed, 40% were neutral and only 20% disagreed.

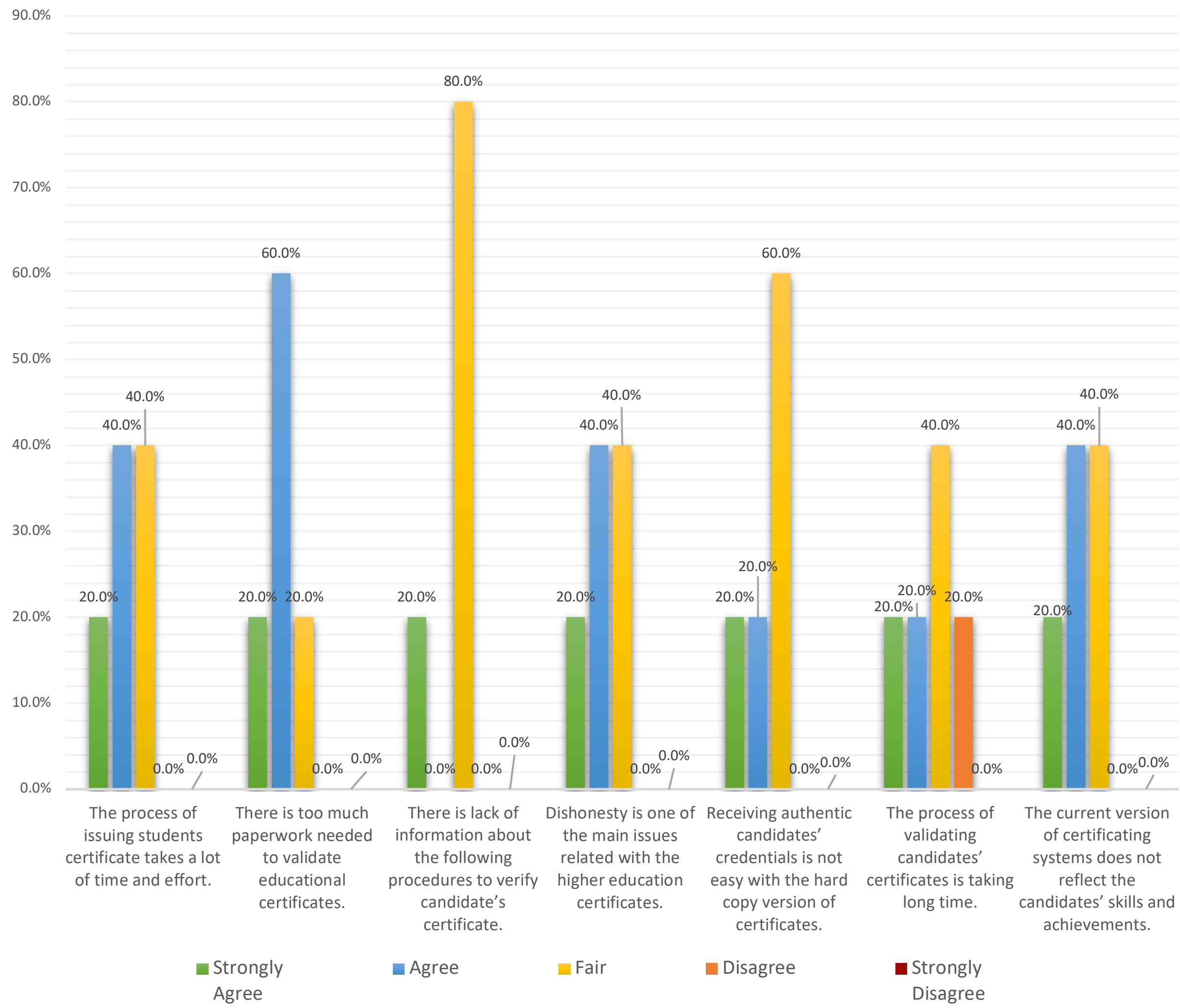

Figure 6.34: Issues related with the existing certification system from Employer's point of view

The employers were also asked about whether they had experienced a lack of information about following procedures to verify candidates' certificates. Agreement was very low as only 20% agreed, and 80% were neutral. This means that the participating employees were familiar with the procedures of verifying any provided qualifications even though they were not satisfied about the time and effort required.

As mentioned in the literature review, dishonesty is one of the main issues related to certification in higher education. Consequently, measuring the employers' perceptions regarding this issue is essential when examining their views about the current certification system. The result reflected that 60% agreed that dishonesty was one of the main issues needing a solution in higher education. Meanwhile 40% of the respondents were neutral with no one disagreeing about this issue. The adoption of blockchain would serve as a solution to eliminate possible tampering and dishonesty with any qualifications issued by the higher education institutes due to the transparency and immutability features in DLT.

Then, the questionnaire measured the perception of the participants regarding the ease of receiving authentic candidates' credentials as a hard copy. The results indicate only 40% agreed this issue was problematic, 60% were neutral with no disagreement. To interpret this result, most Human Resources departments in different Saudi organizations still believe in having a hard copy of the files with some having difficulty in accepting a digital version of candidates' qualifications. With the era of digital transformation, this issue will be eliminated as the most transactions with official documents will use digital copies.

The last measure on this section was about whether the participating employers considered the current version of certificates did not reflect the candidates' skills and achievements. Dissatisfaction with the current system would mean that a type of certification that mirrored students' actual qualifications was needed. The results showed no disagreement that this issue was problematic in the current system as 60% agreed and 40% were neutral.

To conclude, this part of the study focused on collecting the employers' points of view about issues in current system regarding the certification of students. The main issues were about the procedure being time-consuming, requiring a lot of paperwork, and issues of dishonesty. All these issues are critical motives affecting intention to adopt blockchain for the certification process with all the advantages of the features and capabilities provided by the nature of DLT.

6.4.4 Part 4: Factors affecting the adoption of blockchain technology in higher education

This section from the study was designed to measure the impact of each factor in the proposed model on intention to adopt blockchain technology for the certification process in higher education from the employers' perspective. As already discussed in Chapter 3, the proposed model includes the main factors identified as affecting the adoption process, namely: trust, security and privacy, social influence, user awareness and efficiency. Moreover, all the sub factors are addressed to give a comprehensive picture of these influential factors and how the employer sample reacted to each item related to them. In this study the number of the employers participating was five, they represented organizations from different industry domains that would potentially be recruiting graduates.

Trust Factor (T)

After they had tested the DASC, the employers were given several statements regarding the trust factor and all the other constructs related to it. As mentioned in Chapter 3, in the research model, the trust factor was allocated three measures: functionality and transparency, knowledge and useability, and applicants' certificate authenticity.

- **Functionality and Transparency (FT)**

The first measure of the trust factor involved the participants' perceptions of the functionality and transparency of the proposed solution. At this stage, the participants had already tested the DASC and had information about the core functionalities of smart certificates. Table 6.26 presents the statements included in the subsequent survey where functionality and transparency were measured with six items. Figure 6.35 below shows the results for this factor. First, the participants were asked if they believed the transparency feature the encountered while testing the system made the proposed solution a suitable option for managing educational certificates (FT1). The result revealed that 60% agreed it would, 20% were neutral and 20% disagreed with this statement. Then, they were asked about if they thought the system would be able to handle different forms of academic credentials, transcripts, and students' certificates (FT2) and if they recognized that the DASC provided a high level of trust by eliminating applicants' dishonesty (FT3). There was 60% agreement and 40% neutrality for both items.

Table 6.26.Study 2: Statements related to FT

Factor	Item Code	Statement
FT	FT1	The system transparency making it a suitable option for managing educational certificates.
	FT2	The system can handle all forms of academic credentials, transcripts, and students' certificates.
	FT3	The system provides high level of trust to the prospective employers by eliminating any dishonesty.
	FT4	The system enables students to share their official documents directly with me once requested.
	FT5	The system emphasises the actual learning outcomes and alumni skills and accomplishments.
	FT6	Blockchain technology's immutable feature gives me full trust **[in]** the provided certificates.

The majority of the participants (80%) agreed and 20% were neutral regarding whether the system eased the sharing process between the applicants and the prospective employers (FT4). With the same results for FT5, when participants considered whether the DASC emphasised the actual skills and accomplishments of the applicants. Finally, the participants were asked whether blockchain technology's immutable feature influenced them to trust the provided certificates the results showed that 20% strongly agreed and 60% agreed. Meanwhile, 20% were neutral about this statement with no disagreement. The results indicated the majority of the employers had a high level of trust in DASC functionalities and transparency.

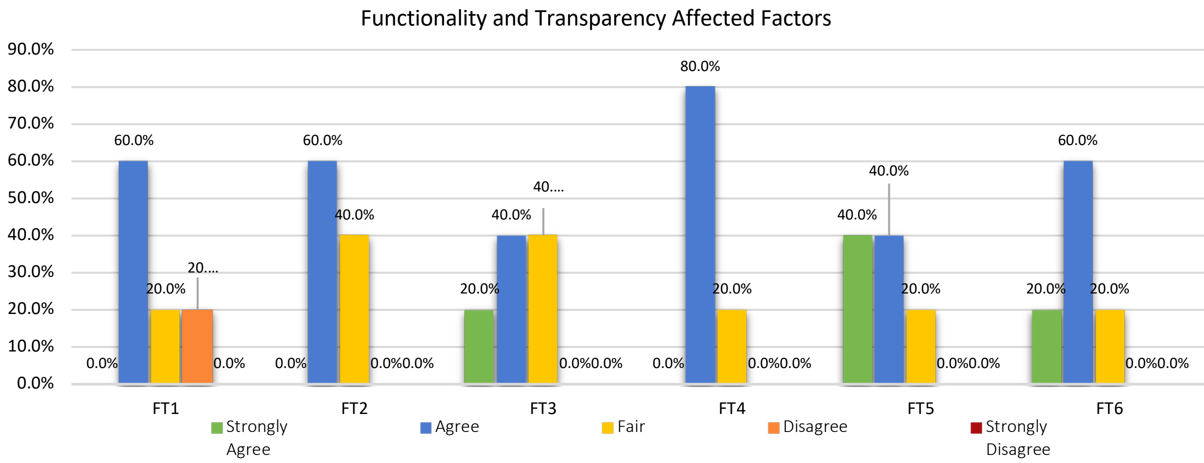

Figure 6.35. 2nd Study FT measures in the employers' sample

- **Knowledge and Usability (KU)**

The second aspect of the trust factor was about the participants' knowledge of the DASC and its usability. Table 6.27 demonstrates the four measures used to investigate this factor and Figure 6.36 below shows the results. The majority of employers (60%) agreed that the DASC's main transactions were clear and easy to navigate; while 40% were neutral, with no disagreements (KU1). Then, participants were asked about their opinion of the appropriateness of the DASC layout and colour scheme. The result reflected that 40% agreed and 60% were neutral about these aspects of the DASC. However, regarding the DASC's ease of use 80% of the respondents agreed that they understood it and could operate it and 20% were neutral.

Table 6.27.Study 2: Statements related to KU

Factor	Item Code	Statement
KU	KU1	The DASC functionalities are clear and easy to navigate
	KU2	The DASC layout and colour scheme are very appropriate
	KU3	The DASC is understandable and easy to deal with
	KU4	I am very satisfied about the overall usability of the system

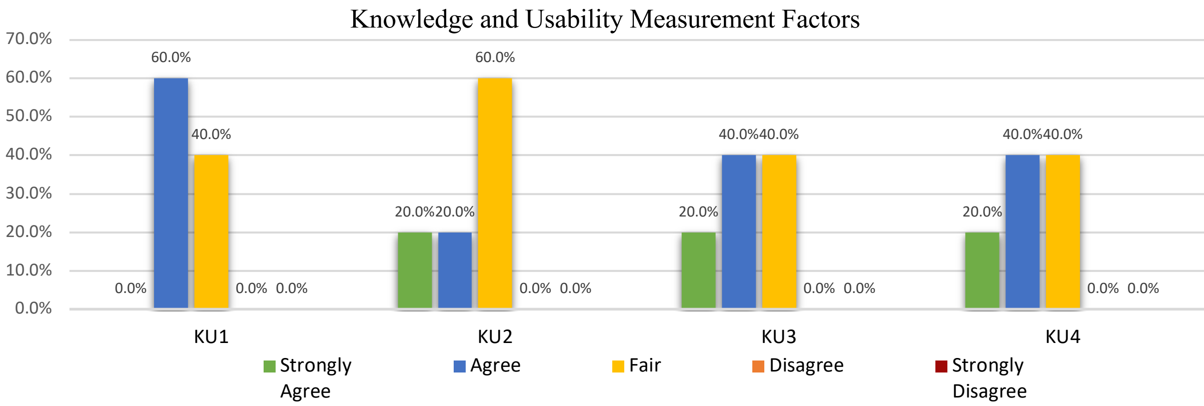

Figure 6.36. 2nd Study KU measures in the employers' sample

Lastly, for KU4, 60% of the participants were very satisfied about the overall usability of the DASC, 40% were neutral and no one was dissatisfied. These answers showed that employers were largely satisfied about the usability of the DASC.

- **Applicants' Credentials Authenticity (CA)**

This third sub-factor was designed to evaluate prospective employers' perceptions about the DASC in relation to the authenticity of the applicant's credentials. Five statements measured the employers' trust in the authenticity of credentials, as shown in Table 6.28.

Table 6.28.Study 2: Statements related to CA

Factor	Item Code	Statement
CA	CA1	After using DASC I believe it is beneficial in higher education and will be expanded to enhance the employment process
	CA2	The system helps in accelerating the process to prospective employees and guarantee they are qualified candidates

	CA3	I believe that adopting DASC in higher education enables students' credentials to reach international organisations
	CA4	Using the system allows the organization to check the authenticity of the applicant's credentials
	CA5	After using the system, I believe it encourages the applicants to improve their skills and achievements to match the employers' expectations

For CA1, 60% of the participants agreed the DASC was beneficial in HE and would be expanded to enhance the employment process while 40% were neutral. The majority of participants (60%) agreed that the DASC helped to accelerate the process for prospective employees and guaranteed the applicants were qualified candidates, and 40% were neutral (CA2). When asked whether, after testing the DASC, they thought it could enable students' credentials to reach international organisations (CA3), 60% and 20% were neutral, however 20% disagreed about the effect of the DASC in this matter. For CA4, 80% agreed that using the DASC would allow an organization to check the authenticity of the applicant's credentials and 20% were neutral. Lastly the employers were asked if they agreed that the DASC would be an encouragement for the applicants to improve their skills and achievements to match employers' expectations. The results indicated that 60% agreed and 40% were neutral. Figure 6.37 below shows the results for this factor.

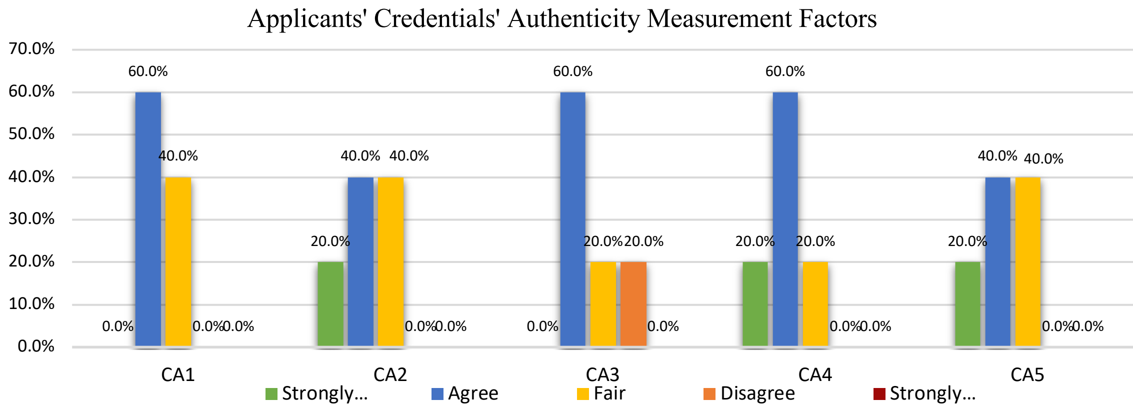

Figure 6.37. 2nd Study CA measures for the employer's sample

Security and Privacy Factor (SP)

As mentioned before in Chapter 3, it is very important to investigate the impact of security and privacy in adopting blockchain for higher education systems since these two factors are much discussed in the literature about this technology. This factor was measured by two sub-factors which included the main issues surrounding SP.

- **Perceived security, privacy, immutability and reliability (PSP)**

This sub-factor focused on security, privacy, immutability and reliability as the main features of blockchain technology and addressed the relevant key issues. As presented in Table 6.29, five items measured this sub-factor and all the results are illustrated in Figure 6.38. The majority of the respondents (60%) agreed that they understood the security feature of blockchain based systems and 40% were neutral (PSP1).

Table 6.29. Study 2: Statements related to PSP

Factor	Item Code	Statement
PSP	PSP1	After using DASC, I can understand the security feature of blockchain based systems.
	PSP2	I understand the immutability feature of blockchain as I know no one will change the certificate after it is posted.
	PSP3	This system provides me with high levels of security and privacy for Smart certificates.
	PSP4	This system enhances the applicants' certificate's reliability and transparency.
	PSP5	This system is very secure and maintains authentic certificates.

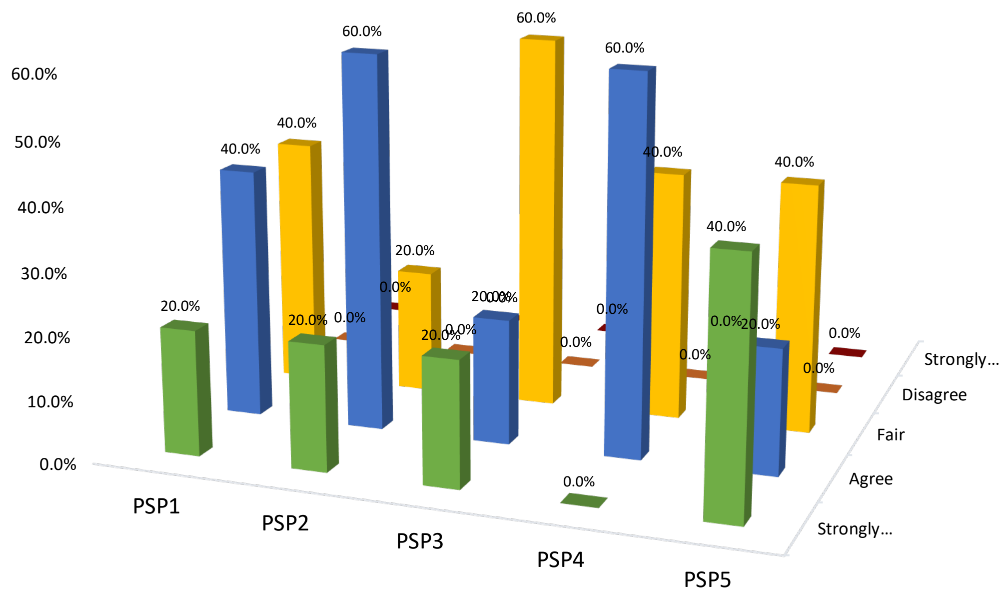

Figure 6.38. 2nd study: PSP measures in the employers' sample

When asked about whether they recognised that the immutability feature of blockchain eliminated the possibility of changing certificates after they were posted (PSP2) 80% agreed and 20% were neutral. However, just 40% of the employers' sample agreed that the smart certificates provided by the system maintained a high level of security and privacy, while, 60%

were neutral with no disagreement (PSP3). On the other hand, 60% agreed on that the DASC enhanced the applicants' certificates' reliability and transparency and 40% were neutral (PSP4). Lastly, the employers reacted similarly to the statement about whether they considered this system as very secure and able to maintain authentic certificates (60% agree 40% neutral for PSP5).

- **Perceived Risk**

After using the system, participating employers' perceptions about the risk of using the DASC were collected. The majority of the respondents (80%) were confident while using DASC to verify the applicants' credentials; however, 20% were not confident about this matter (PR1).

Table 6.30.Study 2: Statements related to PR in the employers' sample

Factor	Item Code	Statement
PR	PR1	I do not feel confident while using and verifying my applicants' credentials through this system.
	PR2	Using DASC would not risk my privacy or security as an organisation and prospective employer.
	PR3	This system helps in reduce any fraud and dishonesty regarding the applicant's credentials.
	PR4	DASC increases transparency and quality of applicants' certificates.

When employers were asked whether DASC would not pose any risks to their privacy or security as an organisation, 60% agreed it would not and 40% were neutral (PR2). Similarly, 60% agreed that the DACR would help in reducing any fraud and dishonesty regarding the applicant's credentials, while, 40% were neutral regarding this major risk (PR3).

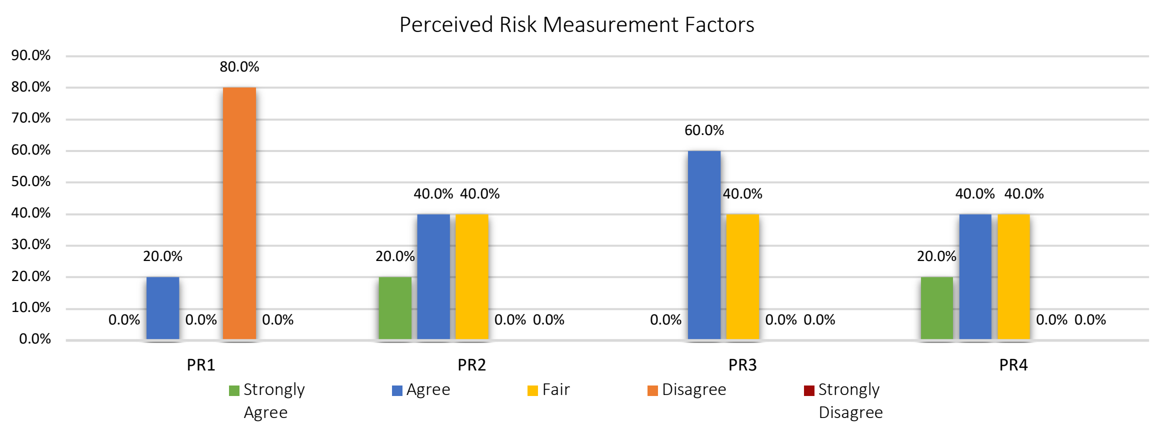

Figure 6.39. 2nd study: PR measures for the employers' sample

Finally, after testing the DASC, the employers were asked whether it would increase the transparency and quality of applicants' certificates; 60% agreed it would and 40% were neutral (PR4). These results were understandable in the light of the results obtained for the awareness factor, as this would affect the employers' perceptions about the perceived risks.

Social Influence Factor (SI)

This construct was measured to determine the prospective employer's perceptions about the impact of social influence on intention to adopt blockchain for the certification process. SI was measured by four items, as shown in Table 6.31.

Table 6.31. Statements related to Social Influence (SI)

Factor	Item Code	Statement
SI	SI1	Using this system among higher education institutes creates better careers opportunities for students
	SI2	Using DASC, will encourage more educational institutes to obtain the same transparency level for their outcomes.
	SI3	This system will encourage students to enhance their skills and earn more credentials.
	SI4	Blockchain technology's reputation in various fields, should encourage higher education institutes to adopt it.

After testing the DASC, the employers were asked whether it could help applicants to create better careers opportunities, 60% agreed it would and 40% were neutral (SI1). The majority of the participants (80%) agreed that using the DASC encourages other educational institutes to adopt blockchain to have the same transparency level in their outcomes; 20% were neutral with no disagreement (SI2). Moreover, the same percentage of the participants agreed that the DASC would encourage students to enhance their skills and earn more credentials (SI3).

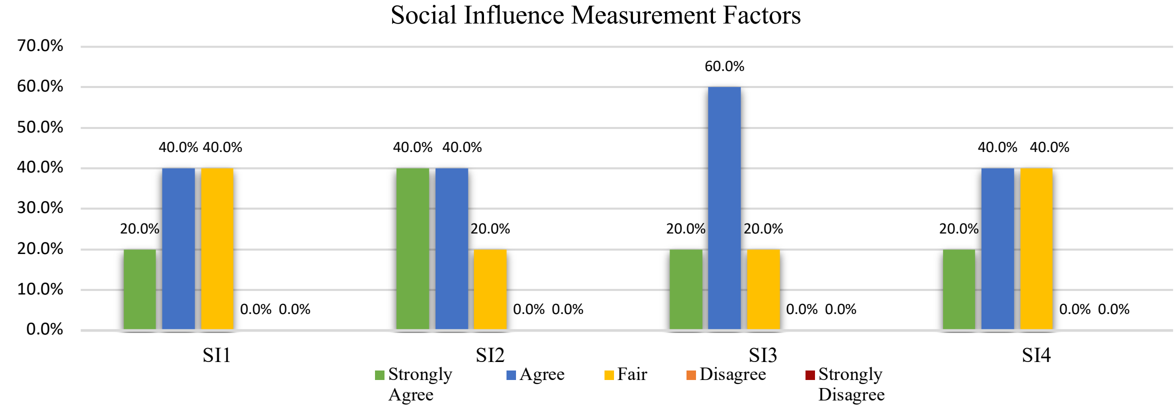

Figure 6.40. 2nd study Social Influence measures in the employers' sample

Lastly, after their experience with the DASC, participants were asked whether blockchain technology's reputation in various fields, would encourage higher education institutes to adopt it (SI4). The results showed that 60% agreed and 40% were neutral. The results for this factor, as displayed in Figure 6.40, demonstrate mostly agreement from the employers', which is evidence of the impact of social influence on the intention to adopt blockchain technology.

User Awareness (AW)

After experiencing the DASC, the employers' perception about the impact of user awareness on the adoption of blockchain, was measured by four items which are represented in Table 6.32.

Table 6.32.Study 2: Statements related to AW in the employers' sample

Factor	Item Code	Statement
AW	AW1	I am aware of all the properties and functionality provided by DASC.
	AW2	After using the system, I know what I need to learn about blockchain before I will be able to effectively use the system.
	AW3	After using DASC, I have a good perception of the advantages of adopting blockchain in higher education institutes.
	AW4	After using DASC, I am aware about the challenges that prevent adopting blockchain to verify certificates.

First, the participants were asked whether they were aware of all the properties and functionality the DASC provided; 40% agreed they did and 60% were neutral (AW1). Then, the employers were asked whether they were aware of what knowledge they needed to acquire about blockchain to be able to effectively use the system (AW2).

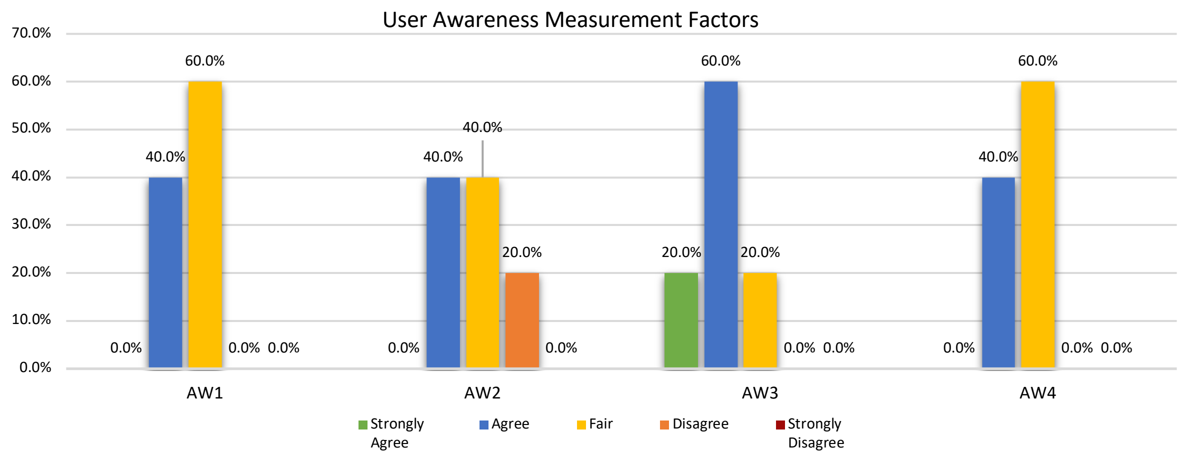

Figure 6.41. 2nd study User Awareness measures in the employers' sample

Almost half (40%) indicated they were neutral, meaning they were not sure, 40% agreed, but 20% disagreed, meaning they were unsure about what knowledge they needed. Nevertheless, 80% agreed they had a good perception of the advantages of adopting blockchain for the certification process in HE while only 20% were neutral (AW3). Finally, for AW4, 40% agreed they were aware of the challenges that prevented the adoption of blockchain to verify certificates and 60% were neutral. These results were expected, because employers in Saudi Arabia are still in the early stages of adopting this technology, thus awareness is still quite low. Figure 6.41 below shows the results for this factor.

Efficiency and Cost Factor (EC)

This factor measured the employers' perceptions regarding the efficiency of smart certificates and cost reduction that could be gained by adopting blockchain technology for the certification process.

- **Efficient smart certificate**

The employers' perceptions about the efficiency of the proposed smart certificates were measured by six items after they had experienced the DASC, as shown in Table 6.33. For ESC1, 80% agreed they were very satisfied with the idea of having all the students' credentials in a system like the DASC, 20% were neutral and no employers disagreed. The percentages were the same for ESC2, with the majority believing that the process of verifying certificates was more efficient and smarter with the DASC than with the current process. Moreover, the majority of the participating employers (80%) also agreed that checking authenticity and authorization of the provided certificate was easy, while, 20% were neutral (ESC3)

Table 6.33. Study 2: Statements related to ESC in the employers' sample

Factor	Item Code	Statement
ESC	ESC1	I am very satisfied with the idea of having all the student's credentials in a system such DASC.
	ESC2	The process of verifying the certificate is more efficient and smarter than the current process.
	ESC3	I can easily check if the provided certificate is authentic and provided by the authorized issuer.
	ESC4	The system enables several features that measure and evaluate the students' performance.
	ESC5	The system offers an efficient shareable system among prospective employers.

ESC6	The overall experience is showing an enhancement in the certificating process for all the users involved.

The participants were also asked if the system enabled several features that measured and evaluated the students' performance (ESC4) and 60% agreed it did and 40% were neutral. Also, the same percentages were obtained regarding whether employers agreed the DASC was an efficient sharable system among prospective employers (ESC5). Lastly, 60% agreed and 40% were neutral that their overall experience with the DASC had demonstrated an enhancement in the certification process for all users (ESC6). These results are shown in Figure 6.42 and indicated that the prospective employers were generally satisfied with the DASC and understood how beneficial it would be for the employment process.

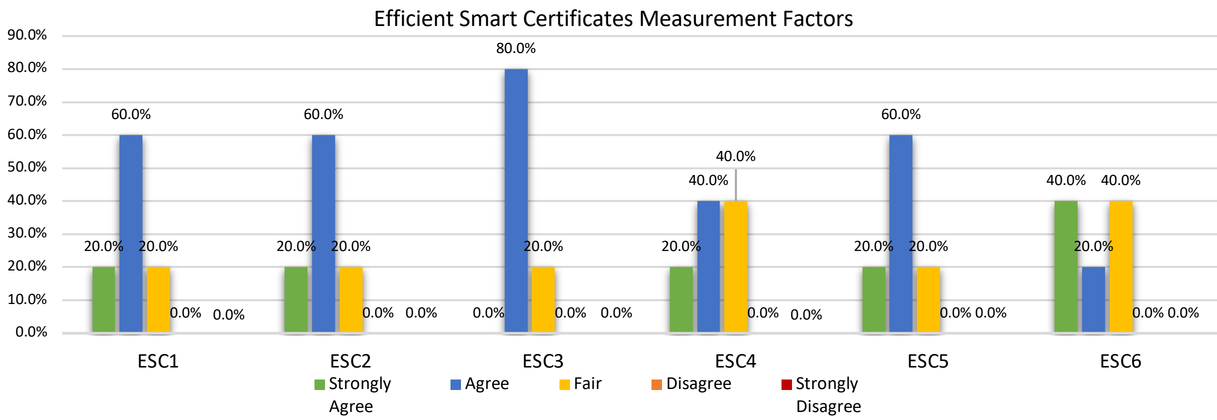

Figure 6.42. 2nd study ESC measures in the employers; sample

– **Cost Reduction (CR)**

This factor was related to the reduction in cost and time that would be provide by the proposed system and enabled evaluation of the efficiency factor. It was measured by four items, as presented in Table 6.34, and the results are illustrated in Figure 6.43. For item CR1, 60% agreed that the DASC reduced the cost associated with the process of generating the students' certificates while 40% were neutral. Also, 80% agreed that the DASC accelerated the time needed to verify the applicants' certificates and 20% were neutral (CR2). Then, the participants were asked whether using the DASC would help reduce the unnecessary cost associated with transactions and centralized data storage (CR3).

Table 6.34.Study 2: Statements related to CR in the employers' sample

Factor	Item Code	Statement
CR	CR1	DASC reduces the cost associated with the process of generating the students' certificates.
	CR2	DASC accelerates the time needed to verify the applicants' certificates.
	CR3	Using DASC helps to reduce the unnecessary cost associated with the transactions and centralized data storage.
	CR4	The system is a cost-efficient approach for organisations and prospective employers.

The results (see Figure 6.43) indicated 80% agreed and 20% were neutral with no disagreements. Lastly, employers were asked whether they considered the DASC as cost-efficient approach, and 80% agreed and 20% were neutral.

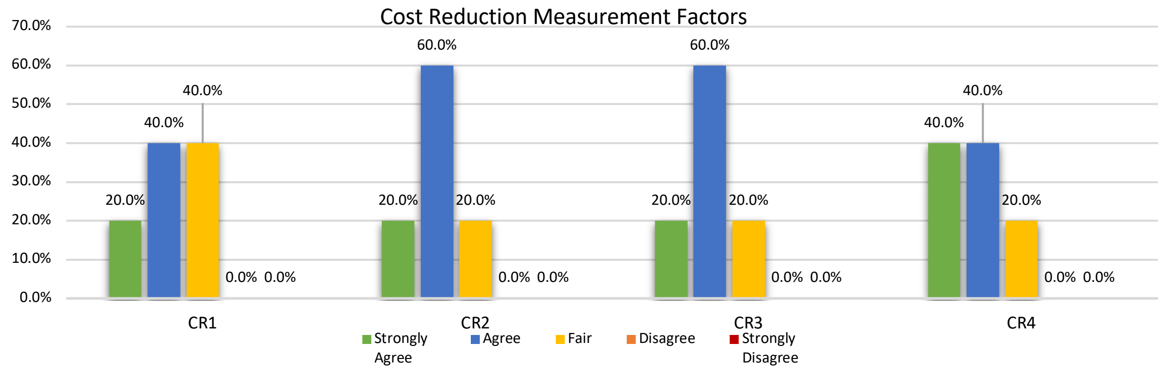

Figure 6.43. 2nd Study CR measures in employers' sample

6.4.5 Part 5: Graphical User Interface GUI

The last section of this study was designed to investigate the DASC user interface, as it is very important for any future implementation of an actual certification system. Figure 6.44, shows the results for all the items presented in the subsequent survey after the users had experienced the DASC. The overall feedback was as expected whereby the employers' were generally positive about functionality of aspects of the DASC they had encountered during the experiment; and majority of the respondents found these 'excellent', 'good' or 'fair' and only the 'advanced search' function was rated as 'poor' by 20% of the sample. In the designing this phase, the feedback from the 1st study was used understand the characteristics of the research sample. Thus, feedback from the 2nd study was about the prototype DASC in order to ascertained what was expected from it by prospective employers for any future implementation of a blockchain-based certification system for HE.

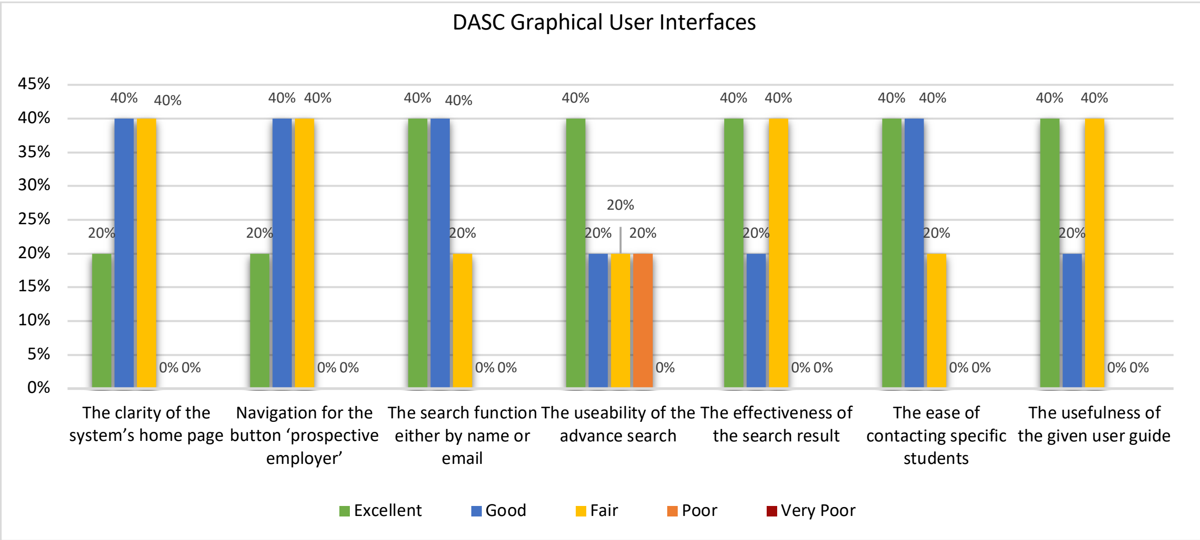

Figure 6.44. DASC GUI -related measurements from the employers' sample

6.5 Inferential statistical analysis and hypotheses assessment from the employers' perspective

As has been done for the student's sample (see section 6.3), this section addresses the descriptive analysis which indicates the possible impact of the hypothesized parameters on the employers' degree of adoption intention towards blockchain technology for the certification process. This section thus shows results for the proposed hypothesised relationships, as presented in Chapter 3. To examine the links between the study model constructs, the correlation coefficient for each hypothesized association was obtained. The findings from these tests helped to demonstrate whether the research hypotheses were supported or unsupported. The results for each factor are summarized and illustrated later in the revised research model.

6.5.1 Trust (T)

Trust was investigated in this study by exploring employers' reactions, after they had tested a prototype DASC, to three factors that could impact on their intention to adopt a blockchain certification system. These three factors were the system's perceived functionality and transparency, knowledge and usability and the perceived authenticity of the applicants' credentials.

Table 6.35 contains all the descriptive analysis for the trust construct along with its related factors. In general, all the factors related to the employers' trust showed a strong positive influence on their intention to adopt a blockchain-based certification system.

Table 6.35. Summary of the descriptive analysis of Trust factors from the employers' perspective

Construct	N	No. of Items	Mean	S.D.	S. E.	Results interpretation
Trust (T)	**5**	**16**	**2.24**	**.60**	**.269**	Influential
FT	5	6	2.22	.60	.269	Influential
KU	5	4	2.30	.74	.329	Influential
CA	5	5	2.20	.62	.275	Influential

Moreover, the normal distribution for trust and its related factors was calculated, as shown in Table 6.36. These results and findings were interpreted to assess the proposed hypothesised relationships for this construct.

Table 6.36. Normal Distribution results for T-related factors

Construct	No. of Items	Shapiro-Wilk	Skewness Statistic	Kurtosis Statistic
Intention To Adopt	**2**	**.881**	**-.512**	**-.612**
Trust (T)	**16**	**.848**	**.536**	**-2.785**
FT	7	.920	.431	-2.146
KU	4	.907	-.518	-.797
CA	5	.960	0.085	-.659

The following sections include the analysis for each sub-factor that was measured under the trust construct, along with tests on the proposed hypotheses related to each of them.

Functionality and Transparency (FT)

> ***H1a:*** *Blockchain technology* ***functionality and transparency*** *positively influence user* ***trust*** *toward blockchain adoption for the certification process.*

The descriptive analysis of the FT of blockchain revealed a composite score of (**M**= 2.22) for this factor, which indicates a very positive influence on the employers' trust in blockchain technology. Thus, the proposed hypothesis for this factor is accepted and supported by the descriptive analysis results. The normal distribution of the data among the two variables: Trust and FT as calculated by the Shapiro-Wilk test showed the data was normally distributed for the employers' sample (p > 0.05) as stated in Table 6.36. The correlation between the two variables, namely, FT and Trust, was investigated to assess the strength and direction of the relationship between them. Since the sample was small for this study, Spearman's correlation coefficient was utilised to evaluate this relationship. The result reveals a strong, positive correlation between these two variables (r_s=.900, n=5, p <0.05) which was statistically significant. Therefore, the research found that hypothesis (**H1a**) for the FT factor is valid and supported by this research.

Knowledge and Usability (KU)

> ***<u>H1b:</u>*** *User **knowledge and familiarity** about blockchain positively influence user **trust** in blockchain adoption for the certification process.*

This factor reflected the employers' evaluation about their levels of KU regarding the tested DASC prototype. From the descriptive analysis results presented in Table 6.36, this factor had a positive influence on the employers' trust in blockchain-based certification system as the composite value of KU was equal to 2.30. To support this value in assessing the proposed hypothesis regards this factor, the correlation of the two variables KU and Trust was calculated, to find the strength and direction of their relationship. Before conducting the coefficient correlation test, the distribution of the data for these variables was measured. The normality test indicated that data was normally distributed as assessed by Shapiro-Wilk's test, (p > 0.05) and shown in Table 6.36. Then, the correlation was calculated by Spearman's coefficient test and the results showed a statistically significant and strong positive relationship between KU and Trust (r_s= .872, n = 5, p < 0.05). Therefore, the results indicated a high level of KU in relation to trust in a blockchain-based certification system and supported the intention to adopt it. Thus, the assumed positive hypothesis (**H1b**) about the relationship between knowledge and usability feature and the employers' trust in relation to their intention to adopt blockchain is supported and accepted.

Applicants' Credentials' Authenticity (CA)

> ***<u>H1d:</u>*** ***Trust in applicants' accreditations*** *positively influences employers'* ***decisions*** *toward blockchain adoption for the certification process.*

The results from the descriptive analysis revealed the composite value of CA was (**M**=2.20), indicating a very positive influence on the employers' trust in blockchain technology and their intention to adopt it for the certification process. Thus, the proposed hypothesised relationship about CA and trust in the blockchain technology was supported by the descriptive analysis results. Moreover, the researcher investigated the correlation between CA and Trust to add more evidence and findings to the support the hypothesis. Table 6.36 indicates the two variables, namely, CA and Trust were normally distributed as calculated by the Shapiro-Wilk test, $p<0.05$. Spearman's correlation coefficient was used to determine the strength and direction of this relationship. The result revealed a statistically significant, positive and strong correlation between CA and Trust, as follows ($r_s = .821$, $n = 5$, $p < 0.05$). Thus, the proposed hypothesised relationship about CA and Trust (**H1d**) is supported and accepted in this study.

Table 6.37 below contains all the correlation coefficient test results along with the interpretation of results to analyse the proposed hypotheses related to the Trust factor in this study from the employers' perspective. Finally, the impact of trust and its related subfactors on the users' intention to adopt blockchain was measured. Thus, the relationship between trust and the employers' intention to adopt blockchain for the certification process was measured.

Table 6.37. Validating of the research hypotheses of the Trust factor

Variables Relationship (Hypothesis)	Correlation Coefficient	Sig. (*p*)	Hypothesis Validation	Results interpretation
Trust → Blockchain Adoption	**.289**	**.319**	**Yes**	Low positive relationship
FT → Trust	.900*	.037	Yes	Strong positive relationship
KU→ Trust	.872	.027	Yes	Strong positive relationship
CA→ Trust	.821**	.044	Yes	Strong positive relationship

* Correlation is significant at the 0.05 level (2-tailed).
** Correlation is significant at the 0.05 level (1-tailed).

As shown in Table 6.35 the descriptive analysis of the trust factor presents the composite score as 2.24, which indicates a strong positive influence on the prospective employers' intention to adopt blockchain for the certification process. This finding supports the hypothesized relationship (**H1**) regarding the impact of the trust factor on the intention to adopt blockchain which is stated as:

> ***H1.*** *In the certification process in the higher education sector, an increase in the level of* ***trust*** *toward blockchain technology will increase users'* ***intention to adopt blockchain technology****, given that trust is considered a major determinant of user acceptance.*

Moreover, a correlation coefficient test was performed to check the strength and direction of this relationship. The data for the two variables, Trust and intention to adopt blockchain, were found to be normally distributed by the Shapiro-Wilk test, where $p<0.05$. Then, Spearman's correlation test was utilised to evaluate the relationship between these variables. The result from the correlation test revealed a positive relationship between employers' trust in blockchain and their intention to adopt it as (r_s= .289, n = 5, p > .05); although this relationship can be considered weak. Thus, the findings from the descriptive analysis of this factor as well as the correlation result supported the hypothesized positive relationship (**H1**).

Figure 6.45 below shows that an increase in the level of the employers' trust, results in increasing their intention to adopt blockchain technology. This shows the slight positive relationship between these two variables. Even though the results showed that trust had a low influence on employers after they tested the DASC, the combined inference from all the collected results demonstrated that trust had a positive impact, as proposed by the researcher in this study.

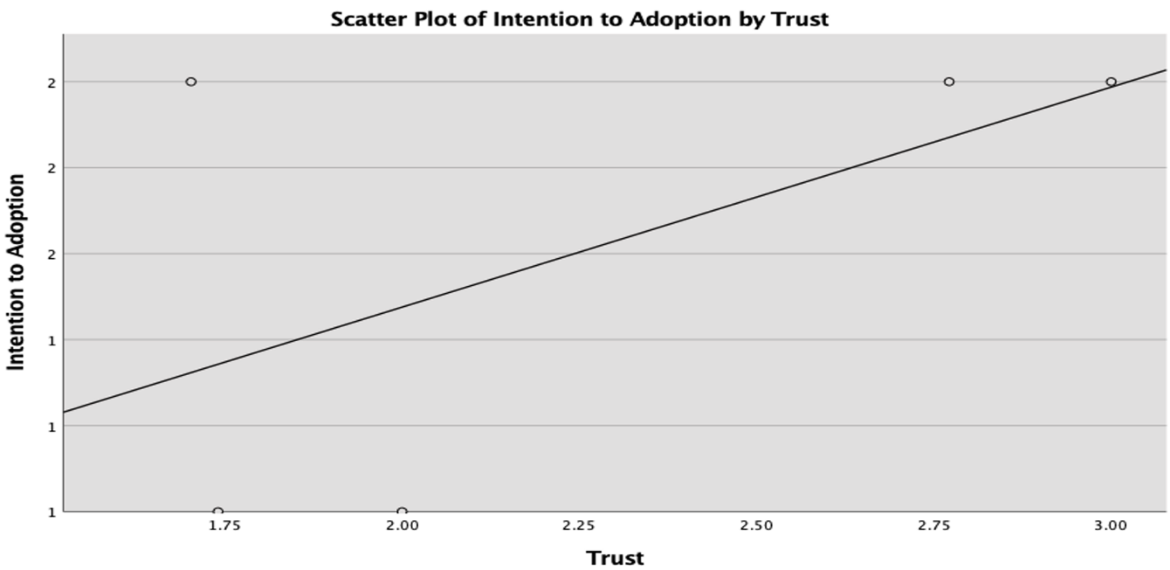

Figure 6.45. Representation of the relationship between T and Intention to Adopt Blockchain

6.5.2 Security and Privacy (SP)

This section is about measuring the security and privacy matters related to blockchain from the employers' point of view after testing the DASC. This construct involves two factors, namely, Perceived security, privacy, immutability and reliability (PSP) and Perceived Risk (PR). Table 6.38 contains all the information related to the descriptive analysis of SP combined with the interpretation of the results. These findings show there was a positive influence of these factors on the employers' intention to adopt a blockchain-based certification system.

Table 6.38. Summary of the descriptive analysis of SP factors from the employers' perspective

Construct	N	No. of Items	Mean	S.D.	S. E.	Results interpretation
SP	**5**	**9**	**2.37**	**.508**	**.227**	Influential
PSP	5	5	2.20	.734	.328	Influential
PR	5	4	2.55	.410	.183	Influential

Additionally, a summary of all the normal distribution tests is presented in Table 6.39, which indicates whether the data were normally distributed or not among the employers' sample. The following sections address the investigation on the factors related to SP to statistically validate the proposed hypotheses among their relationships.

Table 6.39. Normal Distribution results for SP-related factors

Construct	No. of Items	Shapiro-Wilk	Skewness Statistic	Kurtosis Statistic
Intention To Adopt	**2**	**.881**	**-.512**	**-.612**
SP	**9**	**.950**	**-.691**	**1.621**
PSP	5	.957	-.353	-1.292
PR	4	.914	-.518	-1.691

Perceived security, privacy, immutability and reliability (PSP)

> ***H2a:*** *Perceiving security features of blockchain technology* ***(privacy, immutability, security and reliability)*** *positively influences users' understanding of the level of* ***security and privacy*** *provided by blockchain technology in the certification process.*

The PSP factor of the blockchain technology used in this study was measured by a total of five items. From the descriptive analysis shown in Table 6.38, the composite value **M**=2.2 indicated a very positive influence of this factor on the employers' perception about blockchain security and privacy features. Therefore, the assumed hypothesised relationship is supported so far in this study. From Table 6.39 it was clear from the scores obtained in the Shapiro-Wilk's test that the data in two variables PSP and SP were normally distributed ($p > 0.5$). Then, the researcher sought to support the results from the descriptive analysis by investigating the correlation between these variables by using Spearman's correlation test for the PSP and SP factors. A statically significant and positive relationship was found between them as ($r_s = .900$, $n = 5$, $p < .05$). The results and findings of these tests supports the hypothesis that increasing the level of perceiving blockchain security related features leads to an increase in the level of understanding the SP of blockchain technology. Thus, the hypothesised relationship (**H2a**) is supported and acceptable.

Perceived Risk (PR)

> ***H2c****: The* ***perception of low risk*** *associated with the use of blockchain technology positively influences users' understanding of the level of* ***security and privacy*** *provided by blockchain technology in the certification process.*

This factor was measured by four items in the employers' questionnaire. It was discovered from the descriptive analysis that PR is very influential on SP and so on the employers' intention to adopt, and this is a key measure for this study. The composite value of PR was **M**=2.55 that indicated a positive influence of PR on the employers' perceptions about SP, as shown in Table 6.38. To support this finding, the relationship between PSP and SP was statistically investigated by applying the proper correlation test. Before investigating the correlation, the normal distribution among the data of these two variables was assessed by applying Shapiro-Wilk test as (p >.05) which revealed the data were normally distributed. Lastly, the correlation test was performed to fulfil the validation process of the hypothesized relationship. Spearman's correlation test was chosen to examine the relationship, and found that there was a moderate positive correlation as (r_s=.667, n=5, p>.01) (see Table 6.38). Consequently, the proposed hypothesized relationship in this section (**H2c**) is valid and supported.

After evaluating the relationships between SP and its factors (PSP and PR), the impact of SP on the employers' intention to adopt blockchain for the certification process needed to be assessed. The proposed relationship between SP and the employers' intention to adopt blockchain for the certification process is represented in the following hypothesis:

> ***H2:*** *In the certification process in the higher education sector, an increase in understanding the level of* ***security and privacy*** *provided by blockchain technology will increase users'* ***intention to adopt blockchain technology****, given that this allows for better maintenance of student certificates.*

From the descriptive analysis results shown in Table 6.38, the composite score was **M**=2.68, which indicated a moderately positive influence on the employer's intention to adopt blockchain on the certification process. Thus, the hypothesis above is supported but needed further verification with the statistical analysis findings.

Table 6.40. Validating the research hypotheses of the SP Factor

Variables Relationship (Hypothesis)	Correlation Coefficient	Sig. (*p*)	Hypothesis Validation	Results interpretation
SP → Blockchain Adoption	**.866***	**.029**	**Yes**	Strong positive relationship
PSP→ SP	.900**	0	Yes	Strong positive relationship
PR → SP	.667	.219	Yes	Strong negative relationship

To validate the normal distribution procedure among the data of these variables (SP and intention to adopt blockchain) the Shapiro-Wilk test was applied, as shown in Table 6.39, and the findings verified the data were normally distributed as $p > 0.05$. Then, Spearman's correlation coefficient test was utilised to assess the relationship between SP and the employers' intention to adopt blockchain for the certification process. The result from the correlation test revealed a very strong positive relationship between employers' level of perceiving SP of blockchain and their intention to adopt it and was found to be statistically significant as (r_s= .866, n = 5, $p < .05$) as presented in Table 6.40. This indicated that a high level of understanding blockchain security and privacy features was associated with a high level of employers' intention to adopt a blockchain-based system. Therefore, the research found the hypothesis (**H2**) is valid and supported.

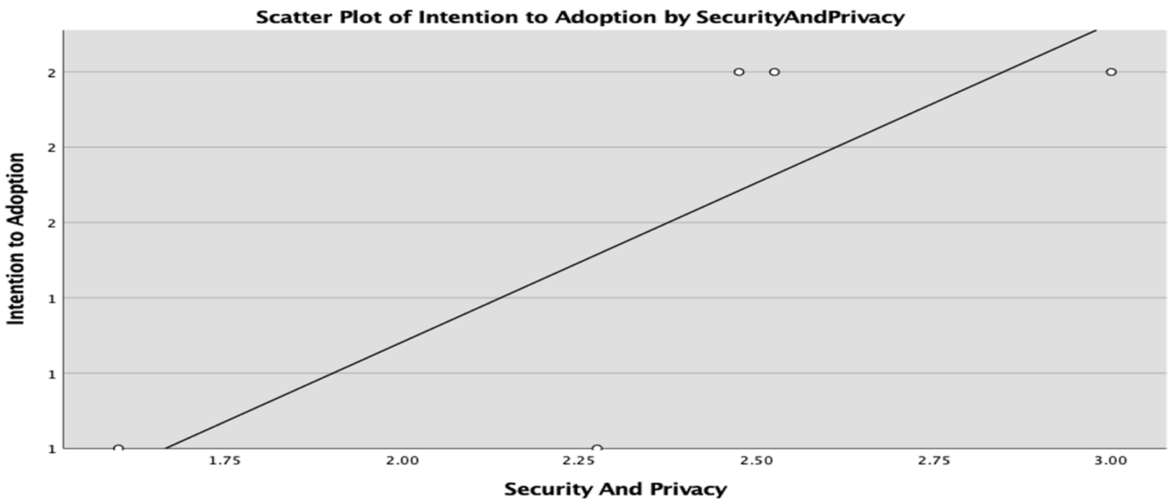

Figure 6.46. Representation of the relationship between SP and Intention to Adopt Blockchain

Figure 6.46 above is a graphical representation of the relationship between the variables SP and intention to adopt blockchain. It is clear from this figure that there is a strong positive relationship between these variables. Additionally, the fit line indicates a correlation between these variables whereby an increased level of the employers' perception about blockchain security and privacy features, after testing the DASC, increases their intention to adopt blockchain for the certification process.

6.5.3 Social Influence (SI)

This research involved SI as an essential influence on intention to adopt blockchain for the certification process. This factor as measured by four items in this study. Table 6.41 contains the summary the of the descriptive analysis of SI factor and the interpretations of the results.

Table 6.41. Summary of the descriptive analysis of the SI factor from the employers' perspective

Construct	N	No. of Items	Mean	S.D.	S. E.	Results interpretation
Social Influence (SI)	**5**	**4**	**2.05**	**.715**	**.320**	Influential

Also, Table 6.42 includes the results of the normal distribution tests that verified whether the data was normally distributed or not.

Table 6.42. Normal Distribution results for the SI factor

Construct	No. of Items	Shapiro-Wilk	Skewness Statistic	Kurtosis Statistic
Intention To Adopt	2	**.881**	**-.512**	**-.612**
Social Influence (SI)	4	.962	.307	-1.544

The relationship between SI and the employer intention to adopt blockchain, after they tested the prototype DASC, was assessed to measure the validity of the proposed hypothesis below (**H3**).

> ***H3:*** *In the certification process in the higher education sector, level of positive* ***social influence*** *is positively associated with users'* ***intention to adopt blockchain technology****.*

From the descriptive analysis results in Table 6.41, a composite score (**M**= 2.05) for this factor indicated SI had a positive influence on the employers' intention to adopt blockchain for the certification system which supported the proposed relationship. Then, the researcher intended to statistically investigate the relationship between the proposed variables and check the strength and direction of their relationship. Prior to this investigation, the normal distribution results of the SI and intention to adopt blockchain variables were calculated, as shown in Table 6.42. According to the Shapiro-Wilk's test the data was normally distributed, where $p > 0.05$. Therefore, the correlation between SI and intention to adopt blockchain was calculated by utilising Spearman's correlation coefficient test, which was more suitable to the sample size. The results indicated a moderate positive relationship between SI and employers' intention to adopt blockchain for the certification process as shown in Table 6.43 (r_s= .577, n = 5, $p < .05$). Thus, an increase of social influence pressure is associated with increase on their intention to adopt blockchain. Thus, the proposed hypothesized relationship in this section (**H3**) is valid and supported by this study.

Table 6.43. Validating the research hypothesis for the SI Factor

Variables Relationship (Hypothesis)	Correlation Coefficient	Sig. (*p*)	Hypothesis Validation	Results interpretation
SI → Blockchain Adoption	**.577**	**.154**	**Yes**	Moderate positive relationship

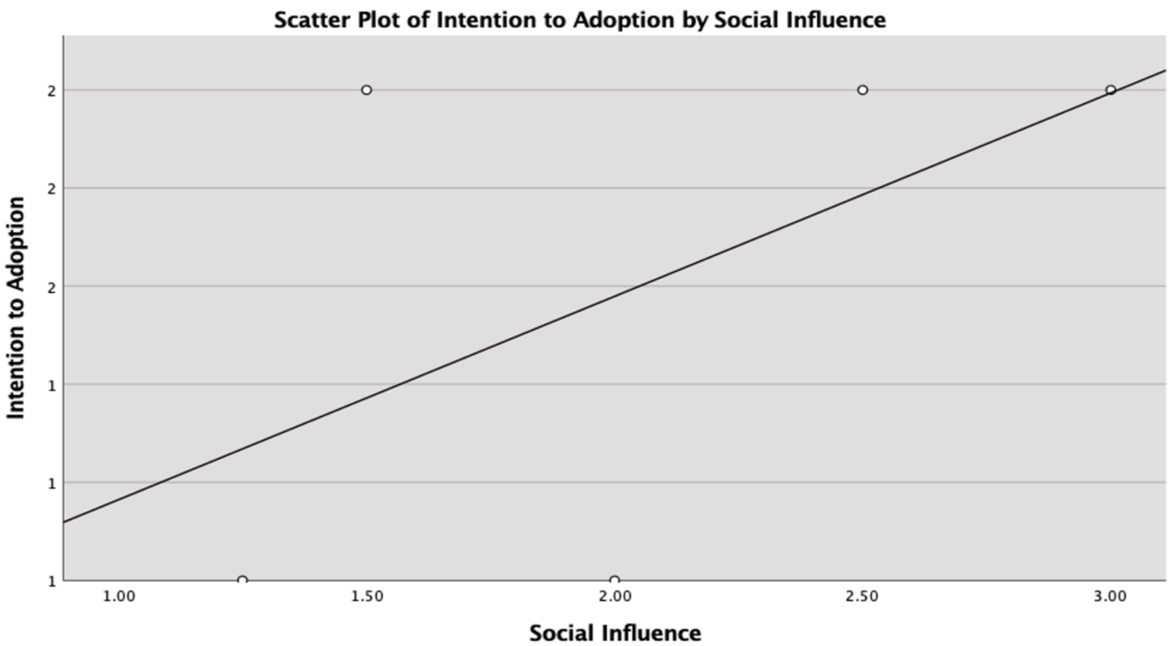

Figure 6.47. Representation of the relationship between SI and Intention to Adopt Blockchain

Figure 6.47 demonstrates the positive relationship between the impact of SI and the employers' intention to adopt after they tested the DASC. To sum up, this is the same result as for the students' sample, where the impact of adopting blockchain could act as a social pressure on the other academic institutes.

6.5.4 User Awareness (AW)

The researcher measured this factor by 4 items that enabled calculating and assessing the relationship between the AW and the employers' intention to adopt blockchain after they had tested the DASC. Table 6.44 contains the results of the descriptive analysis of the AW which shows its positive influence on the employers' intention to adopt blockchain technology for the certification process.

Table 6.44. Summary of the descriptive analysis of the AW factor from the employers' perspective

Construct	N	No. of Items	Mean	S.D.	S. E.	Results interpretation
User Awareness (AW)	**5**	**4**	**2.50**	**.395**	**.176**	Influential

Table 6.45. Normal Distribution results for AW

Construct	No. of Items	Shapiro-Wilk	Skewness Statistic	Kurtosis Statistic
Intention To Adopt	2	.881	-.512	-.612
User Awareness (AW)	4	.987	.000	-1.200

Furthermore, Table 6.45 presents the values obtained from applying normal distribution tests on the data to check if it was normally distributed. The findings and results of this section helped in determining the validity of the hypothesised relationship between AW and the employers' intention to adopt blockchain technology in the certification process as follows:

> ***H4**: **User awareness** positively influences the users' **intention to adopt blockchain technology** for the certification process.*

As was done with the previous factors, a detailed descriptive analysis of AW was conducted (see Table 6.44). The composite score of AW was equal to 2.50 that indicated the positive influence of AW on the employers' intention to adopt blockchain. Thus, the higher the level of awareness the users have about blockchain, the stronger the intention to adopt this technology. Consequently, the proposed relationship between AW and employers' intention to adopt blockchain technology is valid according to the descriptive analysis. After interpreting the composite score of this factor, the correlation between the two variables was investigated in order to validate the proposed relationship. Additionally, applying the correlation test would help to observe the strength and direction of the relationship between AW and intention to adopt in the employers' sample. The normal distribution of the data among the two variables was checked. As presented in Table 6.45, the data of the two variables as assessed by Shapiro-Wilk test were normally distributed with $p > 0.05$. Spearman's correlation test was used to assess the relationship, and the result showed a weak positive correlation ($r_s = .289$, $n = 5$, $p <$

0.05). as shown in Table 6.46. Thus, the hypothesized relationship (**H4**) is valid and supported in this research.

Table 6.46. Validating the research hypothesis about the AW Factor

Variables Relationship (Hypothesis)	Correlation Coefficient	Sig. (*p*)	Hypothesis Validation	Results interpretation
AW → Blockchain Adoption	.289	.319	Yes	Low positive relationship

Figure 6.48 provides a graphical illustration of the relationship between AW and the employers' intention to adopt a blockchain-based certification system. It shows that as the score for user awareness increases, so does the score for the intention to adopt.

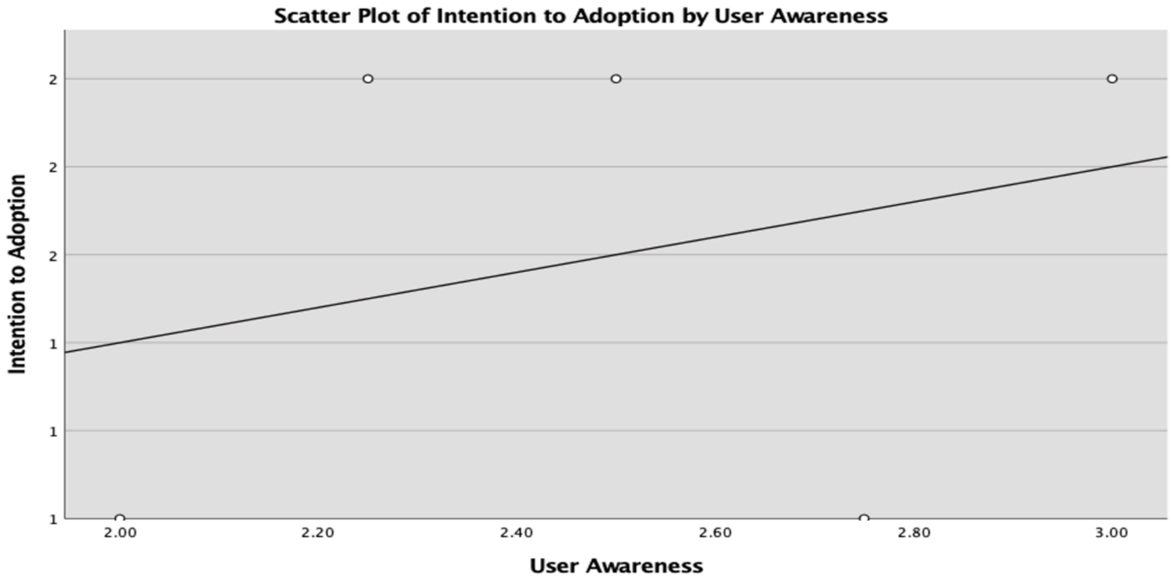

Figure 6.48. Representation of the relationship between AW and Intention to Adopt Blockchain

All these findings and results obtained from the participants indicated the positive impact that AW has on the employers' intention to adopt blockchain technology.

6.5.5 Efficiency (EF)

As with the students' sample (see section 6.3.5), this construct consisted of two major constructs namely, the efficient smart certificate and cost reduction. Table 6.47 shows the summary of the descriptive analysis of all of efficiency-related factors with interpretations of the results. It is clear from the descriptive analysis that the efficiency and its related factors have an influence on the intention to adopt blockchain for higher education. Moreover, Table

6.48 below contains all the results of the normal distribution tests applied to the data to determine whether the data in these variables was normally distributed.

Table 6.47. Summary of the descriptive analysis of EF factors from the employers' perspective

Construct	N	No. of Items	Mean	S.D.	S. E.	Results interpretation
Efficiency (EF)	**5**	**10**	**2.03**	**.700**	**.313**	Influential
ESC	5	6	2.06	.672	.300	Influential
CR	5	4	2.00	.728	.325	Influential

Efficient smart certificate (ESC)

H5a: *The* ***efficient smart certificates*** *enabled by blockchain technology positively influence the* ***efficiency*** *of the certificating process.*

Six items were used to measure the employers' points of view about the concept of the smart certificate. From the descriptive analysis result, shown in Table 6.47, the composite score of ESC was **M**=2.06 that indicated a positive influence of ESC on the employers' perception about efficiency as an influential factor in the certification process. The DASC helped the users to understand the idea of smart certificates, then prospective employers could be questioned as to whether it was an efficient method. The researcher then investigated the correlation between the ESC and EF to validate the proposed hypothesised relationship. The normality test on EF and ESC showed a normal distribution among these two variables as evaluated by the Shapiro-Wilk test, $p > .05$ (see Table 6.48). The correlation was subsequently assessed using Spearman's correlation procedure. The results revealed a statistically significant, strong positive relationship between ESC and EF ($r_s = 1$, $n = 5$, $p < 0.01$), as shown in Table 6.49. Thus, the findings from both descriptive and statistical analysis support the hypothesised relationship (**H5a**).

Table 6.48 Normal Distribution results for EF-related factors

Construct	No. of Items	Shapiro-Wilk	Skewness Statistic	Kurtosis Statistic
Intention To Adopt	2	.881	-.512	-.612
Efficiency (EF)	**10**	**.991**	**.059**	**.799**
ESC	6	.990	.123	.676
CR	4	.989	.000	.893

Cost reduction (CR)

> ***H5b: Cost reduction*** *provided by blockchain technology positively influences the* ***efficiency*** *of the certificating process*

From the descriptive analysis results which involved measuring four items, cost reduction (CR) had a very strong influence on the employers' perception about the efficiency of the certificating process. The composite score was **M=** 2 which indicated a positive influence of CR on the efficiency provided by blockchain technology, according to the employers. To check the normal distribution among the data of CR and EF, the Shapiro-Wilk test was used, and the results showed the data was normally distributed as $p > .05$. Due to the sample size, Spearman's correlation coefficient test was utilised to investigate the strength and direction of the relationship between CR and EF. A strong positive correlation between CR and EF, ($r_s = 1$, $n = 5$, $p < 0.01$) was found, as shown in Table 6.49. This correlation was statistically significant. Thus, the proposed hypothesis about this factor (**H5b)** is supported and valid in this study.

After assessing the relationships between EF and its subfactors (Efficient smart certificates and cost reduction), the impact of EF on the employers' intention to adopt blockchain needed to be assessed. The proposed relationship between EF and the prospective employers' intention to adopt blockchain for the certification process is represented in the following hypothesis:

> ***H*5:** *In the certification process in the higher education sector, an increase in the level of* ***efficiency*** *and reduction in the associated cost of blockchain technology will increase users'* ***intention to adopt blockchain technology*** *for the certification process.*

There was a strong agreement from the results of the descriptive analysis shown in Table 6.47 about the positive influence of the EF and its related factors on the employers' intention to adopt a blockchain-based certification system. The composite score of EF was **M**=2.03 which indicated EF was an influential factor on the employers' intention to adopt blockchain for the certification process. As the sample was small and the data for EF and intention to adopt blockchain was normally distributed (as assessed by the Shapiro-Wilk test $p > .05$), Spearman's correlation test assessed the validation of the proposed hypothesis. The result revealed a weak, positive correlation between these two variables ($r_s = .577$, n = 5, $p > .01$) and this correlation was found to be statistically significant. Thus, the proposed hypothesis (**H5**) is supported and valid in this study.

Table 6.49. Validating the research hypotheses by correlation results

Variables Relationship (Hypothesis)	Correlation Coefficient	Sig. (*p*)	Hypothesis Validation	Results interpretation
EF → Blockchain Adoption	**.577**	**.154**	**Yes**	Moderate positive relationship
ESC→ EF	1.00	0	Yes	Strong positive relationship
CR → EF	1.00	0	Yes	Strong negative relationship

Table 6.49 contains the summary of the overall results of the correlation coefficient tests applied to the efficiency and cost related factors to check the validity of their hypothesized relationships that have been discussed above.

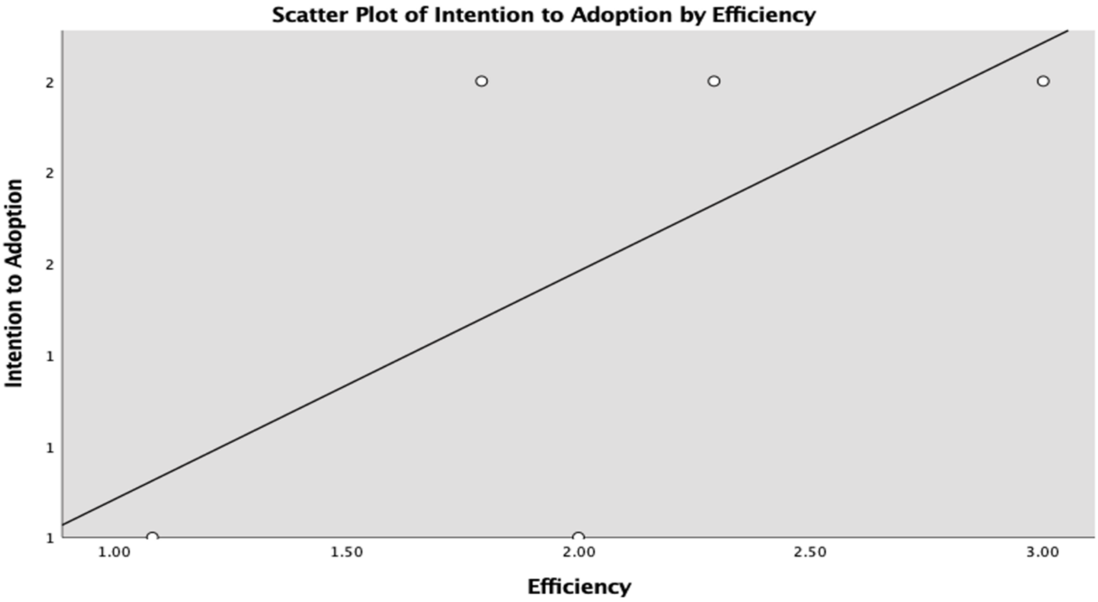

Figure 6.49. Representation of the relationship between EF and Intention to Adopt Blockchain

Figure 6.49 is a graphical representation of the relationship between these variables. It is clear from this figure that there is a moderate positive relationship between efficiency and intention to adopt blockchain. An increase in the employers' perceptions of efficiency, resulted in increasing the level of their intention to adopt blockchain for the certification process.

6.6 Comparing the Users' Intention to Adopt Blockchain between the Two Studies

After conducting the two studies, a final investigation consisted of measuring the differences between the users, both students and employers, in their level of intention to adopt a blockchain-based certification system. Studying the differences between the two studies in relation to the other factors in the conceptual model is a future research opportunity that falls outside the scope of the thesis.

To perform this task, an independent samples test was used to verify the differences between the two samples, the students before testing DASC and the test group who tried the DASC. The T-test is one of the most widely-utilised statistical tests for finding the differences between the means of two samples (H. M. Park, 2009). The purpose of using a t-test was to determine the differences between the defined measurement between the participants in two samples and see if it was statistically significant. Since there were two unequal samples in the two studies, Welch's t-test was chosen. Welch's test is defined as "the parametric test for comparing means between two independent groups without assuming equal population variances." (Ahad, Soaad, & Yahaya, 2014). Analysing the data obtained from the t test reveals how significant the differences between the samples means actually are.

The t-test decision is based on a p-value that is represented as the probability that the results from the sample data occurring by chance, where the acceptable level of *p*-value is < 0.05 which indicates the result is statistically significant. Any calculated difference resulting in a *p*-value less than the significant level, α, to a 100 (1-α) % confidence interval would include the true population parameter and would be considered significant. For instance, If the *p*-value was less than .01, this means there was only a 1% probability that the results from an experiment happened by chance.

Thus, this would be evidence for rejecting the null hypothesis that there was no statistically significant difference between the two means, and could be a proof of the alternative hypothesis having a statistically significant difference. The purpose of this section is to verify the validity of the hypothesised relationship as follows:

H6. *After the users test the proposed system DASC, users'* ***intention to adopt blockchain technology*** *for the certification process in HE will be significantly higher.*

Table 6.50 Results of Independent Sample t-test between the users' intention to adopt blockchain in the two studies

Variables	Group	Mean	S.D.	*t*-value	Sig. (*p*)
Intention to Adopt Blockchain	Student-Survey	2.80	.705	5.899	.000*
	Student -Experiment	1.89	.657		
Intention to Adopt Blockchain	Employer-Survey	2.20	.274	1.648	.049
	Employer -Experiment	1.60	.418		

* p < 0.001

In order to examine this hypothesis, Welch's t-test was performed to find the differences between the mean scores of the two employers' samples in their intention to adopt the blockchain in the certification process. Results are shown in Table 6.50 where for the participants in the post-experiment survey, the intention to adopt blockchain score was (**M**=1.60) whereas the mean in the employer's sample, before testing the DASC, was (**M**= 2.20). To interpret these results, it is confirmed that the participants who tested the DASC and evaluated its functionalities had a higher intention to adopt the blockchain for the certification process than the employers who were not involved in the experiment. Welch's t-test discovered this pattern to be significant, t=1.648, p<0.05. Therefore, the difference between these two means was statistically significant according to the above findings of significance. Together this suggests the assumed relationship between, the hypothesis (**H6)** is accepted.

For the student's samples, the mean for the intention to adopt blockchain in the 1st study was (**M=**2.80) which was less than the mean for their intention after testing DASC (**M=**1.89), see Table 6.50. The t-test presents t=5.899, p< .001 from which it can be inferred that the difference between these two means (student's intention to adopt in survey and intention to adopt after testing DASC) was statistically significant to a 99.9% confidence level. To interpret these results, it is confirmed that the participants who tested DASC and evaluated its functionalities had higher intention to adopt the blockchain for the certification process than the students who were not involved in the experiment. Therefore, the difference between these two means is statistically significant according to the above findings. Consequently, the hypothesis (**H6**) is accepted and supported by the findings of this research. All the users who participated in the studies related to this research showed a significantly higher intention to adopt the blockchain in the certification process after testing the DASC.

6.7 The Revised Conceptual Model

This section presents the revised models after amending the findings from the inferential analysis for both categorises of users: students and prospective employers in the 2nd study of this research. The revised research framework proposed (as presented in Figures 6.50 and 6.51) have been shown fully capable of providing an efficient and reliable way to assess the intention to adopt blockchain for the certification process.

Table 6.51. Summary of the results of the hypothesised relationships in the 2nd study

Variables Relationship (Hypothesis)	Hypothesis Validation	Results interpretation
Student's Sample		
T → Intention to Adopt Blockchain	Yes	Low positive relationship
SP → Intention to Adopt Blockchain	Yes	Low positive relationship
SI → Intention to Adopt Blockchain	Yes	Low positive relationship
AW → Intention to Adopt Blockchain	Yes	Moderate positive relationship
EF → Intention to Adopt Blockchain	Yes	Low positive relationship
Employer's Sample		
T → Intention to Adopt Blockchain	Yes	Low positive relationship
SP → Intention to Adopt Blockchain	Yes	Strong positive relationship
SI → Intention to Adopt Blockchain	Yes	Moderate positive relationship
AW → Intention to Adopt Blockchain	Yes	Low positive relationship
EF → Intention to Adopt Blockchain	Yes	Moderate positive relationship

Table 6.51 summarizes all the results of the correlation tests obtained in this study for both students and employers. Figure 6.50 summarizes the results of the impact of the influential factors and presents the revised conceptual model based on the findings collected from the student's sample.

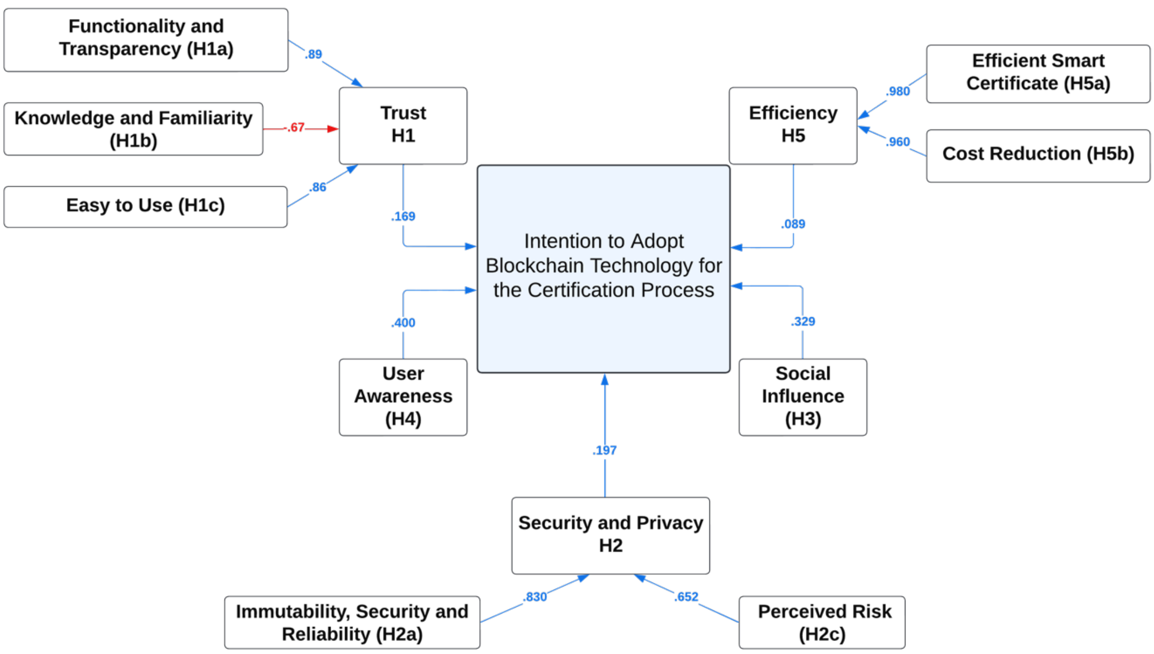

Figure 6.50. 2nd Study: The Revised Conceptual Model for the Students' Sample

It shows the influence of all factors as low impact except User Awareness which can be considered as a highly influential factor with a moderate positive relationship on the students' intention to adopt a blockchain-based certification system. The results for the employers' sample and the findings about the hypothesised relationships for the influential factors of the proposed conceptual modal are summarised in Figure 6.50 below, which illustrates the impact of each factor on the employers' intention to adopt blockchain for the certification process. Trust and Awareness had the least positive impact from the employer's perspective followed by Efficiency and Social Influence, with moderate positive influence. Moreover, the results demonstrate a strong positive impact of the features related to security and privacy on the employers' intention to adopt a blockchain-based system in their hiring processes. This high intention to adopt blockchain by the participants in the studied categories was influenced by blockchain technology's enhanced security, greater transparency, provided trust and traceability. Blockchain was perceived to deliver benefits to the academic organisation, and this research focused on the certification process, which could be expanded to other, related processes in higher educational institutes.

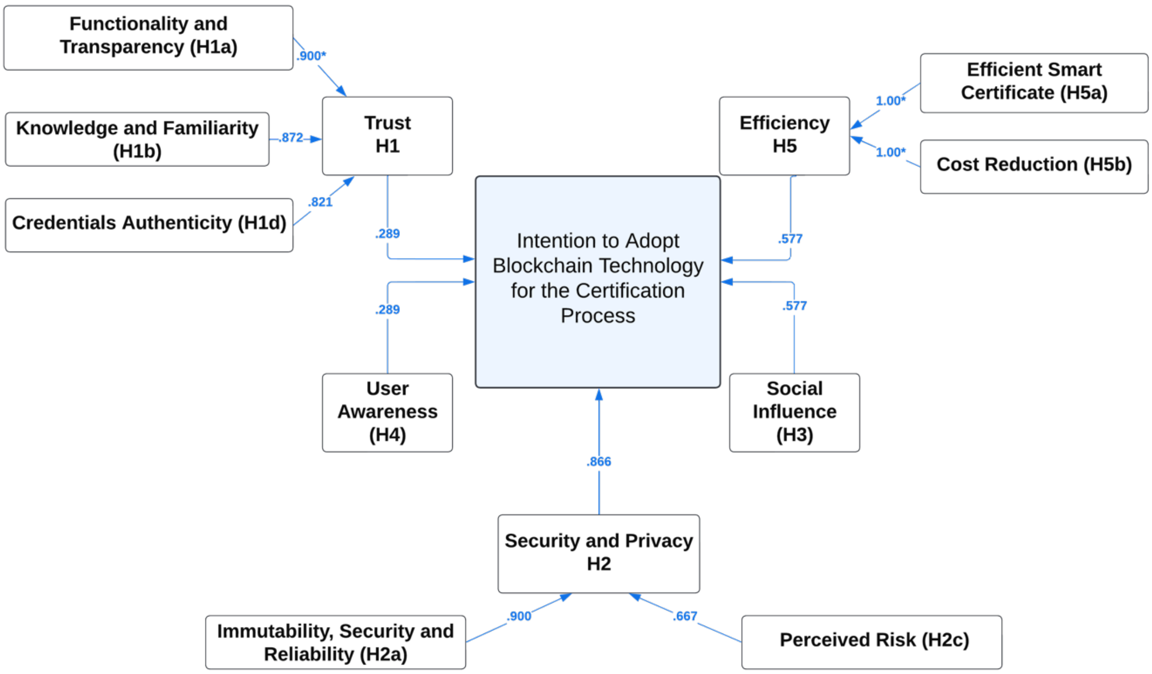

Figure 6.51. 2nd Study: The Revised Conceptual Model for the Employers' Sample

Finally, from the findings of this study, higher educational institutes should be thinking about embracing blockchain technology due to increasing evidence that it has the potential to be a promising innovation in this field. Moreover, blockchain technology is considered to be able to address the issues that both higher education and the marketplace are now confronting. To sum up, as stated by (Chivu et al., 2022), blockchain technology can provide all the benefits of a decentralised environment, a reduction in fraud, secure data storage and lower transaction costs related to data monitoring, control and verification.

6.8 Summary

In conclusion, this chapter addressed the main findings of the 2nd study of this research. It included the results obtained from main samples of this research namely: students in HE and employers. For both students and employers, a detailed presentation and discussion of the descriptive analysis of framework's factors that influenced their intention to adopt blockchain was provided. This included a discussion about all the items used to measure the influence of each factor. The results of the descriptive analysis were interpreted to accept or reject the hypothesized relationships between the proposed factors and the users' intention to adopt blockchain-based certification systems. The results from the students' sample showed that all factors had a low positive impact except User Awareness, which was a highly influential factor with a moderate positive relationship on their intention to adopt a blockchain-based certification system. Employer results, on the other hand, revealed that Trust and Awareness had a low positive impact, followed by Efficiency and Social Influence, which had a moderate positive impact. Furthermore, the findings show that features related to security and privacy have a strong positive impact on employers' acceptance of a blockchain-based system.

Chapter VIII

7 Conclusion and Recommendations for Future work

This chapter concludes the thesis that addresses the leveraging of blockchain as a distributed ledger technology (DLT) in the certification process in the higher education (HE) sector in Saudi Arabia. This thesis contributes to the existing research and literature regarding the adoption of blockchain technology for the higher education sector. This study proposes a conceptual model to investigate the influential factors affecting the users' intention to adopt a blockchain-based certification system to fulfil the aim of this research within the Saudi HE context. This research therefore helps in identifying the influential factors for adopting blockchain technology certification systems in developing countries. These factors have been drawn from the existing literature on technology acceptance models and theories, besides adding some factors borrowed from existing blockchain adoption frameworks.

Moreover, the study proposes an architectural structure as a blueprint and as a clear vision of design to develop the prototype DASC (Decentralised Application of Smart Certificate). This involves designing the logical representation to represent the interactions and relationships and implementing the prototype with all the given requirements and illustrations. The thesis provides a background to the Saudi HE situation and systems and creates a comprehensive picture of prior studies about the use of blockchain technology in higher education and in other fields. Furthermore, the research addresses the issues in the existing certification systems in Saudi Arabia that offer opportunities for improvement.

The researcher then uses the knowledge obtained from a review of the literature to develop the research hypotheses, which are mainly about determining the relationships between the proposed constructs and the user's intention to adopt blockchain technology. As presented in the previous chapters, this thesis consists of two main studies. The 1st study is about measuring the users' acceptance towards adopting blockchain technology for the certification process. The 2nd study is about measuring and testing the users' behaviour towards adopting blockchain-based certification systems after they experienced the DASC. The sample of the users and case studies targeted in this research were students at higher education level, prospective employers, and top managers in academic organizations. Then the data collected for both studies were analysed in order to validate the proposed conceptual model and to test the hypotheses. Moreover, this involved testing the validity of the proposed hypothesized relationships and presenting revised conceptual models based on the results of these tests (see Chapters 4 and 6). Finally, after discussing the findings, the results confirmed that the users have a significant positive intention to adopt blockchain-based certification system with different levels of influence among the various factors in the model.

7.1 Mapping Research Questions, Contributions and Findings

Given the restrictions on time and resources it was not possible to examine every aspect of blockchain technology. Therefore, it was essential to identify a specific problem for the study and limit the research area so that proper attention could be given within the specific research context, including identifying the influential factors in adopting blockchain technology. In view of this, the current research is centred on assessing the benefits of deploying blockchain technology in the certification process as a case of leveraging the HE sector by adopting DLT. However, a thorough review of the literature and recently published research articles, confirms that no study has previously examined these factors and aspects within the broad context of developing countries, or Saudi Arabia specifically. The findings highlighted in the previous sections have made a novel contribution to the theoretical knowledge of blockchain adoption and supported this knowledge with empirical evidence. The conceptual model that has been developed and its associated critical factors also make a constructive contribution for academic researchers and practitioners. The present research results have further extended the knowledge about the adoption of blockchain technology in HE by carrying out an intervention to assess the leveraging of blockchain technology in the certification process in a specific context and in higher education in general.

7.1.1 Research Questions

This research has accomplished the presented research aim in Chapter 1 that is about "*leveraging blockchain technology in higher education systems in Saudi Arabia, particularly the 'certification process', which is the process of generating and verifying learners' certificates.".* the overall research question for the study was:

RQ. How can the certification systems in Saudi's HEIs be enhanced by leveraging the decentralised ledger technology embodied by blockchain technology to generate more immutable and transparent Smart certificates?

To fulfill the research's aim and to answer the main research question and part of the specific questions, a conceptual model involving the influential factors on the adoption of blockchain in the certification process was proposed and validated. The proposed research problem and overall question was refined into six specific research questions. The following section details the specific research questions and how they have been answered, thus mapping the research contribution onto the research findings.

Specific Research Question 1:

This research aimed to conduct a literature review on existing systems to provide an in-depth perspective on adopting blockchain technology in higher education. The research addresses the current issues and problems in the higher education certification process. The potential benefits of blockchain technology and prior research specifically investigating its impact on solving problems in HE were the drivers to answering the first specific research question:

SQ1- What research topics have been addressed and studied in current research on higher education systems based on blockchain technology, including the benefits brought by blockchain technology to resolve the current problems in the higher education sector?

The research found that implementing education systems based on blockchain technology will increase awareness of its huge potential in solving problems. Current systems in higher education institutions (HEIs) in Saudi Arabia are facing unresolved issues and there are latent opportunities for using blockchain to address them. These include issues as centralisation, lack of standardization, using hard copies and dishonesty. This research also addresses the ability to provide sharable qualifications feature that is verified by adopting blockchain technology in the certification system, since the current HEI systems do not allow sharing of student records with any external party. This research provides a comprehensive guide to the adoption of blockchain in the certification process including current issues and the methods by which it is able to overcome issues and enhance the HEI's certification systems.

Specific Research Question 2:

This research investigates the user's acceptance and intention to adopt blockchain technology in the certification process. This task includes analysis of the major factors affecting this intention to adopt blockchain drawn from the most common theories combined with the nature of blockchain as cutting-edge revolution. These factors include the user's trust, their perceptions of security and privacy, social influence, user awareness and efficiency. This research thus addresses the following specific question:

SQ2- What are the influential key factors affecting the user's intention to adopt blockchain technology on the certification process in the context of Saudi Arabia?

The conceptual model was proposed and validated as showing the influential factors for the adoption of blockchain by higher education in the context of Saudi Arabia. The model addresses the acceptance of a technology that can solve the issue of logging all the credits obtained by a learner, not only the certificates issued. The factors influencing the adoption of blockchain in this context have been drawn from the extant and commonly-used technology acceptance theories including: the Technology Acceptance Model (TAM), the Diffusion of Innovation (DOI) theory and the Unified Theory of Acceptance and Use of Technology (UTAUT). Moreover, to develop the conceptual model, the nature of blockchain acceptance literature was reviewed to identify the potential factors surrounding blockchain technology adoption and incorporate factors that had not previously been considered in the technology acceptance models mentioned above.

The answer to this sub-question therefore the result of the 1st study of this research which was designed to collect data from the users (students, prospective employers, and top managers in academic institutes). This part of the research is focused on investigating the key factors that influence users' acceptance and intention to adopt blockchain technology in the certification process. The result of this study is that both groups of respondents in this study had reasonable perceptions of blockchain technology and a noticeable desire to adopt the technology in higher education. Statistical analysis confirmed that the data collection instrument was valid and applicable in evaluating employers' and students' acceptance levels of blockchain technology. However, the results indicated that students have limited awareness of the benefits, disadvantages, and perceived risks associated with using blockchain technology in the certification process for higher education institutions. Moreover, the data obtained from employers indicate a strong desire to validate applicants' certificates using an immutable and reliable system based on blockchain technology (e.g., DASC) to prevent fraud and dishonesty. The findings are illustrated as the revised conceptual models in Chapter 4 and have been published in a peer reviewed journal (Alshahrani et al., 2021).

The research findings demonstrate a high level of acceptance for the adoption of blockchain technology for the certification process among all related users. In the sample of employers, the was a lower level of trust, compared to the other four factors, especially in regard to knowledge and familiarity with blockchain technology. This is considered a reflection of employers' need to learn more about the benefits and features of DLT to belief in its trustworthiness.

Specific Research Question 3:

The research addresses the main issues facing existing certification systems in the Saudi HE context. The two studies conducted in this research explored this area by collecting and analysing users' opinions about the problems related to the current certification systems. Thus, these data answer the third specific question:

SQ3- What are the issues and problems with the current higher education systems that could be solved by a blockchain-based system?

This question has been answered in different parts of this research including Chapters 4 and 6 (sections 4.2.3, 4.4.3, 6.2.3, and 6.4.3) which are about investigating the current system's issues. The research found that the majority of users from all categories who participated in this research agreed about the issues they faced while dealing with the current certification systems. The major issues were about processes being time-consuming, dealing with a lot of paperwork, wanting information that was easy to receive and share, and dishonesty. Moreover, in the interviews, the top managers who participated identified some of issues the current certification systems in their institutes were facing. One of them said: "*The graduates'* *transcripts are reviewed and checked manually to confirm each student has met all of the requirements and no graduating students have been missed."* Another interviewee identified other issues related to the current certification process: *"Sure, the traditional system suffers due to cost, time and repetition. It also faces some problems related to certificate fraud and dishonesty."*

this part of the survey measures the students' perceptions about the existing issues and problems in the current certification systems in the HEI in Saudi Arabia. The result of this investigation reveals that majority of the students exceed 70% of the whole sample strongly agreed on the following issues. The first is that the process of issuing certificate is a time-consuming task and needs effort to be finished. The second is the current process is needing too much paperwork in order to generate educational certificates. Moreover, one of the critical issues the students agreed on is that the current system don't allow them to access their achievements and certificates easily during their study. Finally, is the issue related to them sharing credentials with prospective employers which is not easy task with the consideration of the hard copy version of certificates. These issues are the most agreed on during this part of the study which the researcher are trying to solve by proposing the blockchain-based certification system as addresses in the chapter 5. To sum up, this research demonstrates that these issues are critical motives for adopting blockchain technology in the certification process, with all the features and capabilities provided by the nature of DLT.

Specific Research Question 4:

The researcher proposed a conceptual architectural for a prototype certification system based on blockchain technology to overcome the issues of the current systems and provide more transparent, authentic and immutable smart certificates. This prototype was intended to answer the fourth specific research question:

SQ4- What are the logical and functional requirements for the architectural model for the Decentralised Application for Smart Certificates (DASC)?

This thesis proposed a proof-of-concept blockchain-based certification prototype system (DASC) for higher education institutions in Saudi Arabia. The major contribution of this study is to propose a DASC prototype for leveraging the higher education field with blockchain services. Provision of the DASC prototype will involve providing an architectural model for a distributed and shareable system for HEIs’ certificating systems that could satisfy the requirements of students, prospective employers and HEIs. This solution includes all the following features: Firstly, it records the learner’s data and shares these data with all the authorized parties, including college and university administrators and prospective employers. Secondly, it verifies all the learner’s certificates, achievements and training courses attended. The DASC aims to provide prospective employers with a clear picture of the learners’ capabilities allowing prospective employees to be more efficiently matched to the employers’ needs. Moreover, it will help colleges and universities in Saudi Arabia to share data about the learner’s skills and abilities so that teaching staff can more easily design and implement unique teaching methods for each learner. This research contribution has been published in a peer-reviewed conference (Alshahrani et al., 2020). Finally, the DASC is considered as single repository of information that may consolidate learners’ digital certificates, transcripts and achievements (represented as ‘badges’) from different educational institutions.

Specific Research Question 5:

This research is designed to measure and validate the user’s acceptance after testing the prototype DASC. This is a novel contribution of this thesis where the proposed influential factors in the conceptual model were measured, and a revised model was created as a result of users testing the DASC and responding to a subsequent questionnaire. This process was designed to answer the following specific question:

SQ5- How can testing a blockchain-based certification system improve the user’s intention to adopt blockchain technology in the certification process?

This thesis measured the influential factors on users’ behavioural intention to adopt a blockchain-based certification system after testing the prototype DASC. This analysis represents the 2nd phase of the study and contributes by measuring the factors affecting the user’s intention to adopt a blockchain-based certification system after they tested the DASC and comparing these results with the findings from the 1st phase of the study. The results of the empirical study reflect the fact that the employers and students considered the adoption of blockchain technology from the perspective of the investigated influential factors as it encourages educational institutions to have the same transparency level in terms of their outcomes. Moreover, this technology motivates prospective employees to build the productive skills needed to support their career decisions. Furthermore, the researcher performed the independent t-test in section (6.7) to measure the differences between the user's intention to adopt blockchain in certification process before and after they tested DASC. Consequently, blockchain adoption in higher education may help to reduce the overwhelming burden of administrative tasks, thereby improving employee productivity. Finally, the findings are illustrated in the revised conceptual models in Chapter 4 and 6.

7.1.2 The Methodological Contribution of the Research

The methodological contribution of the thesis is the use of a mixed-method design to investigate and test users' acceptance of innovative, complex and not easily understandable technology. This research sought to collect and analyse data from potential users of the proposed blockchain-based certification system; and proposed a systematic framework for technology acceptance among different types of users. These were the most critical users in the certification process, namely students, top management and prospective employers; and incorporating all these users represents a comprehensive approach to investigating the impact of the proposed framework. This framework was gauged by the research instruments (questionnaires and interviews) that involved items that measured the proposed hypothesised relationships and significant aspects of the proposed factors to assess their influence on the targeted users.

The study used questionnaires for the quantitative approach and interviews for the qualitative approach. Using the qualitative approach will allow the researcher to validate the analysis of the quantitative data; and also allow the researcher to confirm the research hypotheses. Using the mixed method approach significantly contributes to the study by adding reliability to the study by compensating for the limitations of each method. Additionally, a survey was conducted before and after testing the prototype and analysed from the perspective of employers as the main driver of this research, as adoption of this system would potentially enhance the employment process. This methodology might be useful for future research such as testing the use of in-home medical devices like smart sensors or projects that seek to explore how new and complex technologies, like blockchain, could improve the manufacturing process. Studies which focus on comparing how users feel about new and unfamiliar technologies before and after using a prototype could also benefit.

7.1.3 Fitting the specific blockchain case scenario to the broader context of Smart Campus

This research's contributions also include participating in supporting a developed comprehensive guiding framework for emerging IoT and blockchain technologies deployment in the smart campus environment. This a joint work is presented in chapter that shows how this research is applicable to a bigger domain rather than just the context of the process of certification. It is particularly emphases the emerging in relation to security and privacy, and for the mitigation of known problems with IoT and blockchain in existing applications. This work discusses the security considerations that need to be taken into account when developing a smart campus and its case scenarios. This work proposes a novel architectural framework for the IoT and blockchain applications deployed within a smart campus environment, and compares the main technologies involved. It emphasises how this research is worked as a specific example, wherein the framework is tested for the integration of blockchain and other relevant technologies into the higher education certificating system for the purpose of issuing authentic, verifiable, and sharable student credentials. Moreover, this chapter helps in a demonstration of the applicability of the findings of this research to other fields including other technology which is here a smart campus context. I have very specific case study to broader context of Smart Campus. The findings of this work are particularly useful in the context of developing countries. It is expected that the proposed framework will have useful applications in a variety of fields, where it is necessary to determine whether a satisfactory level of IoT and Blockchain technologies has been achieved and maintained in accordance with the relevant safety and security standards. Furthermore, the findings of this work imply that applying blockchain technology to the proposed framework can provide data integrity, which leads to increase users trust in the system. This collaboration has been reviewed and published in (Alkhammash et al., 2022). Lastly, deploying blockchain technology to the proposed smart campus framework will provide more benefits by managing the problems associated with a centralised IoT architecture, especially from a security perspective. It demonstrates how blockchain technology fits in a bigger domain and with different scenarios.

Finally, the sections above present the major contributions of the research. Four published papers in journals and conferences confirm that the research has made positive contributions to the investigation of adopting blockchain technology in the certification process in higher education which can be expanded to the broader context. The revised theoretical conceptual model can be used by researchers to comprehend and examine more aspects related to blockchain adoption and to examine the challenges that might obstruct the implementation of blockchain-based systems.

7.2 Recommendations for adoption Blockchain Technology in the Certification Process

The practical recommendations derived from the insights afforded by this study is one of the research objectives. This section presents several recommendations, strategies, guidelines and solutions based on the findings for the improvement and success of the provision of blockchain-based systems in developing countries in general and Saudi Arabia in particular.

- **Adopting an agile cycle to involve the end users in defining all the system's requirements.** One of the main goals of this study is to increase the involvement of the end users in several roles in the certification process. The agile cycle involves creating an environment in which the program developer can communicate with prospective users to understand their needs, and how blockchain could fulfil them. One of the most valuable findings of this research has been potential blockchain users' input about what they require from the system; and thus, user involvement has been demonstrated as an important part of development and adoption by this study.
- **Increasing user awareness about blockchain technology**. It is very important that the decision-makers in the HEIs prepare the plan about how to educate prospective users about blockchain technology. This applies to all the users involved in the proposed blockchain solution where their awareness plays a vital role in their decision to adopt the system. Thus, the top management in the academic institutes must devise a strategy to increase the relevant stakeholders' awareness about blockchain technology. On this research, it was found that in 1st study, more than half of the participant don't have a clue about how to start their journey to understand the concept and functionalities of blockchain. This raises flag about the amount of effort that academic institutes have to do to spread the knowledge about this cutting-edge technology.
- **Providing sufficient training and skills for the development teams.** This is a major aspect of deploying a complex and innovative technology in any process where the

development teams take the responsibility for producing a blockchain-based system to match the users' requirements. As one of the interviewee's said "*All we need is a good program to train the employees about programming with blockchain. The university has the capability and technical infrastructure to handle the expenses related to blockchain technology adoption, and the team has good experience and a willingness to learn about new technology*.". Having an on-site trained and skilled development team in the academic institute will, in the long run, eliminate the issues of having unsolved problems after launching a blockchain-based certification system.

- **Understanding social influence and its impact on the implementation of blockchain-based systems.** In the context of developing countries such as Saudi Arabia, it is important to understand the major role played by social influence and how it could affect the embracing of innovative technologies in any field.
- **Maintaining the simplicity and ease of use aspects for all targeted users.** The results of the two studies conducted in this research demonstrate that, from the user's perspective, the simplicity of the system is a very important factor in whether or not the system will be adopted. As shown in Chapters 4 and 6, the majority of users surveyed about whether they found the DASC easy to access and share agreed that this ease-of-use would lead them to use and trust this system.

7.3 Research limitations

During the research process, the researcher faced certain limitations some of which present a good opportunity for future investigation. These limitations can be summarised as follows:

- **Limitation One**: There is a lack of existing literature on blockchain use in higher education, especially in the developing countries; in particular, from the perspective of two main groups relevant to this research, i.e., students and prospective employers. Moreover, when the researcher started to review the existing literature, there was also a lack of studies specifically focused on the certification process. Due to this limitation, the researcher had some difficulties comparing the findings and results of this research with those of other relevant studies.
- **Limitation Two:** The Covid-19 pandemic affected stages of the research; since the pandemic started during the phase involving interaction with the users to collect the data required. Due to the restrictions imposed by the government regarding Covid-19, this data

collection could not be conducted face-to-face. Therefore, some delays happened to the plan and all the data collection procedures had to be carried out through online services. This situation meant that the prototype could not be tested by the researcher in-person, which would have been useful for gaining more insights through informal communication. Nevertheless, online software was successfully used to test and evaluate the DASC.

- **Limitation Three:** One of the limitations of this study is that the researcher only used two HEIs. Conducting a study across all the universities in the Kingdom of Saudi Arabia would yield results that were more accurate and comprehensive. Thus, this limitation generates the recommendation that these other HEIs could be investigated and their members questioned in order to extend the knowledge gained from this research that would include different areas and cities in Saudi Arabia.

7.4 Future Work

In several domains, the deploying and adoption of blockchain technology is still in the early stages, particularly in the developing countries, which is the context of this research. The researcher suggests the following future extensions to the work done in this thesis to increase reliability and to ensure that the application of blockchain technology would properly fit the context:

7.4.1 Applying the conceptual model to other cases in the higher education context and other fields

The proposed conceptual model used in this research could be utilised to understand adoption and acceptance of blockchain technology in different contexts. This expansion could include several processes in the higher education sector involving in developing countries as well as developed countries. Moreover, doing this would extend the generalisability and contribution of the developed framework such that it could be applied in different domains such as medical applications and payments, supply chain systems, electric voting systems... etc. The researchers could use this model to evaluate users' behavioural intention to adopt blockchain in such processes and applications.

7.4.2 Implementing DASC

This is a future direction for implementing a DASC which involves the development team from a Saudi higher education institute following the models and prototype provided in this research. This system will be linked to real student and alumni data from the HEI, and be responsible for verifying, posting, sharing and authenticating the students' qualifications that will be direct accessed by prospective employers. This implementation will involve other parties such as the Saudi Ministry of Labour, who are anxious to have the labour market enhanced by access to qualified, authentic candidates who match its requirements.

7.4.3 Deploying the blockchain smart contract in an AI recruiting system

This future recommendation proposes work combining artificial intelligence (AI) and blockchain; and which is demonstrated in Figure 7.1 In this proposed solution the application of a blockchain smart contract was adopted to address the issue of trust in the robustness and traceability of AI algorithms which is a relatively recent idea. It is a psychological issue, that people don't trust machines to make decisions, because their opinion cannot be traced back. It is the perception of human beings that such decisions are not traceable.

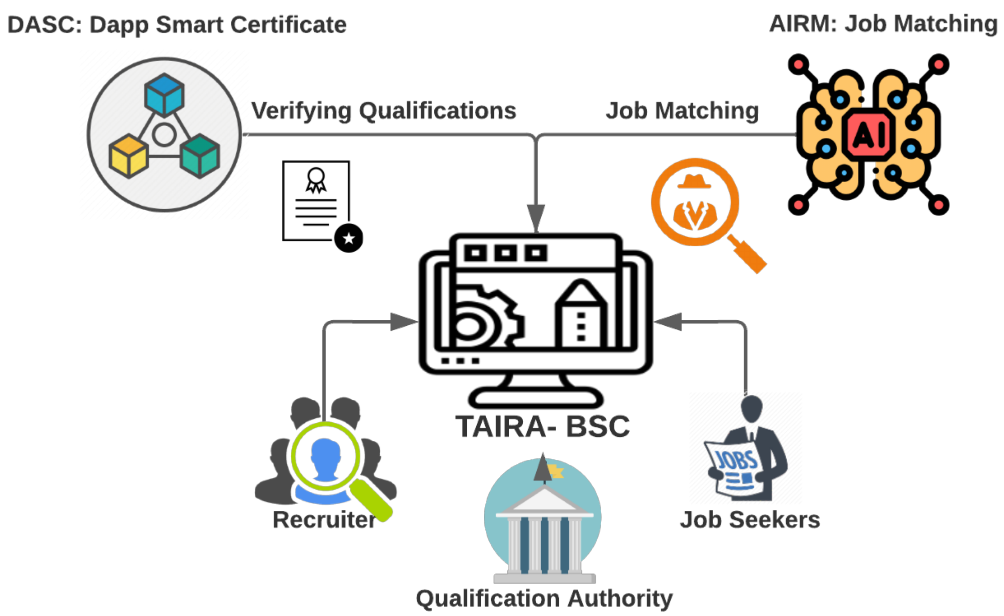

Figure 7.1 TARIA-BSC and previous models (Source: author)

Thus, the researcher proposes that if the decision-making process can be recorded in the form of a Smart contract, trust in an AI-based application will be increased. This work has been started at this stage, and it is proposed to implement the actual system in the future. AI is an active form of technology: it carries out an analysis of what is around; and comes up with solutions based on the history of what it has been exposed to. Conversely, blockchain, which has become ever more popular over the last 6 years, is largely a passive bundle of technology: when anything is written into the network, its cryptographically secured blocks act in a data-agnostic fashion. Due to this balance, each technology bumps up the strengths and modifies the weaknesses of the other. In and of itself, blockchain technology is not able to access the truth of the data which is written into its changeless network.

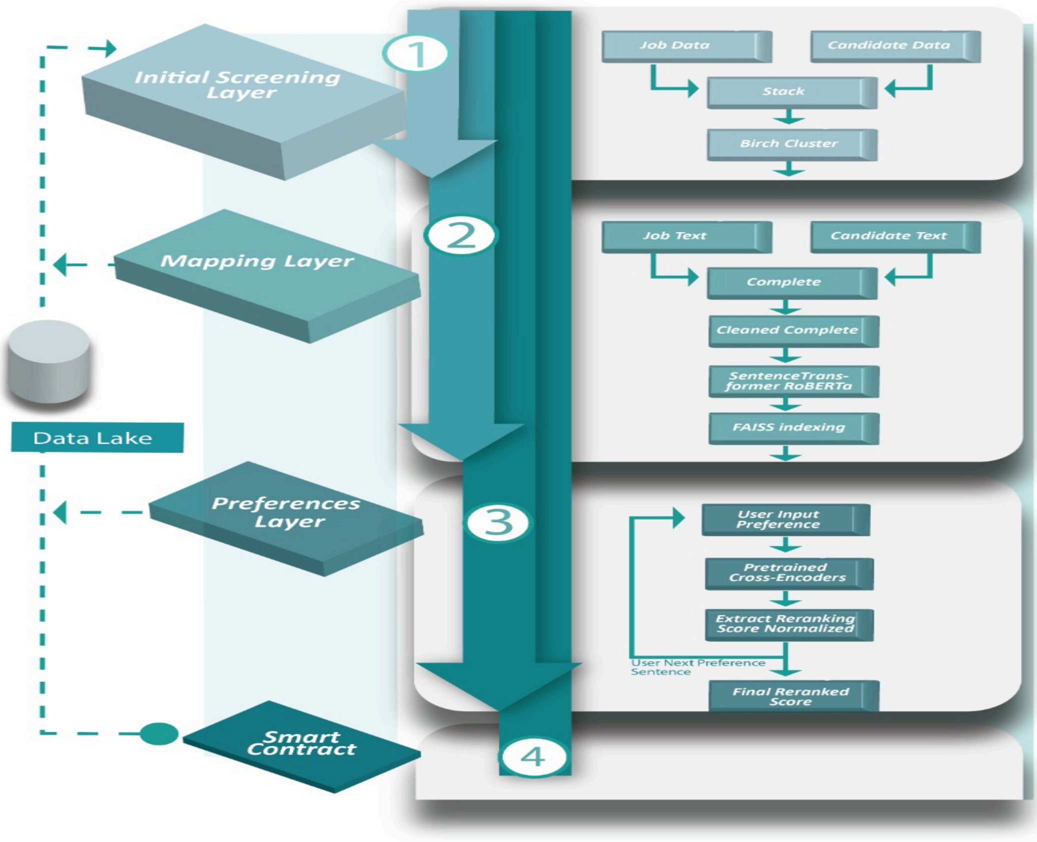

Figure 7.2. The proposed recruitment model for adopting blockchain smart contracts in AI (Aleisa et al., 2022)

Conversely, AI can play the role of a knowledgeable gatekeeper, with regard to what information comes on and off the network, and from whom. Looking to the future, it seems probable that the interaction between these two diverse capabilities will result in improvements across a vast spectrum of industries, many of which will have unique challenges, that this super technology duo could defeat (Borecki, 2020). AI can be embedded into blockchain-enabled smart contracts to the already proposed AI-based recruitment model (AIRM) that would significantly increase its efficiency as shown in figure 7.2. This joint work has already been published in (Aleisa et al., 2022). In this paper the researcher proposed the design of a new solution for trusting AI in recruitment applications through the use of Blockchain Smart Contracts (**TAIRA-BSC**).

This project will integrate AI and blockchain capabilities. It enables a more in-depth examination of the efficacy of the contract's terms and the procedures it governs. Consequently, human analysis, intervention and verification are considerably minimised. The cutting-edge, dynamic combination of AI and blockchain significantly simplifies the negotiation, the execution process and builds more trust in AIRM. Because AI performs better when data is collected through a reliable, secure, trustworthy and credible data repository or platform, trust in TAIRA-BSC will be enhanced. The combination of AI and blockchain-enabled intelligent contracts will create business solutions of next-generation alternatives that can build on existing enterprise systems.

7.5 Summary

This chapter highlights the main conclusions from the research work presented in this thesis as well as identifying useful directions for future work. In summary, it provides a conclusion for the reader convenience which presents an overview of all the findings while reminding the reader of the how the aims of the study were achieved, the research questions were answered and the contributions of the thesis. Furthermore, the proposed conceptual model's evaluation, the research's overall orientation, and the projected direction are all discussed. The importance of a future collaborative effort and its relevance to this thesis was emphasised in the section on future work.

Finally, it is hoped that the thesis contributes to knowledge in the field of Informatics, in particular in the field of adopting new technologies for higher education, and especially the application of blockchain technology in the certification process. I wish this thesis to make a statement in its field and other researchers, decision-makers and leaders in industry to find it useful and valuable research.

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9 Appendixes

9.1 Appendix A: Ethical Application Approvals

UNIVERSITY OF SUSSEX

Sciences & Technology C-REC
crecscitec@admin.susx.ac.uk

Certificate of Approval	
Reference Number	ER/MA2026/1
Title Of Project	Leveraging Blockchain as Decentralized Technology in Higher Education Sector in Saudi Arabia
Principal Investigator (PI):	Natalia Beloff
Student	Mona Alshahrani
Collaborators	
Duration Of Approval	3 months
Expected Start Date	28-Sep-2020
Date Of Approval	25-Sep-2020
Approval Expiry Date	28-Dec-2020
Approved By	Karen Long
Name of Authorised Signatory	Lauren Shukru
Date	25-Sep-2020

*NB. If the actual project start date is delayed beyond 12 months of the expected start date, this Certificate of Approval will lapse and the project will need to be reviewed again to take account of changed circumstances such as legislation, sponsor requirements and University procedures.

Please note and follow the requirements for approved submissions:

Amendments to protocol

* Any changes or amendments to approved protocols must be submitted to the C-REC for authorisation prior to implementation.

Feedback regarding the status and conduct of approved projects

* Any incidents with ethical implications that occur during the implementation of the project must be reported immediately to the Chair of the C-REC.

Feedback regarding any adverse(1) and unexpected events(2)

* Any adverse (undesirable and unintended) and unexpected events that occur during the implementation of the project must be reported to the Chair of the Science and Technology C-REC. In the event of a serious adverse event, research must be stopped immediately and the Chair alerted within 24 hours of the occurrence.

Monitoring of Approved studies

The University may undertake periodic monitoring of approved studies. Researchers will be requested to report on the outcomes of research activity in relation to approvals that were granted (full applications and amendments).

Research Standards

Failure to conduct University research in alignment with the Code of Practice for Research may be investigated under the Procedure for the Investigation of Allegations of Misconduct in Research or other appropriate internal mechanisms (3). Any queries can be addressed to the Research Governance Office: rgoffice@sussex.ac.uk

(1) An "adverse event" is one that occurs during the course of a research protocol that either causes physical or psychological harm, or increases the risk of physical or psychological harm, or results in a loss of privacy and/or confidentiality to research participant or others.

(2) An "unexpected event" is an occurrence or situation during the course of a research project that was a) harmful to a participant taking part in the research, or b) increased the probability of harm to participants taking part in the research.

(3) http://www.sussex.ac.uk/staff/research/rqi/policy/research-policy

UNIVERSITY OF SUSSEX

Sciences & Technology C-REC
crecscitec@admin.susx.ac.uk

Certificate of Approval	
Reference Number	ER/MA2026/2
Title Of Project	Leveraging Blockchain as Decentralized Technology in Higher Education Sector in Saudi Arabia
Principal Investigator (PI):	Natalia Beloff
Student	Mona Alshahrani
Collaborators	
Duration Of Approval	2 months
Expected Start Date	10-Mar-2021
Date Of Approval	10-Mar-2021
Approval Expiry Date	30-Apr-2021
Approved By	Karen Long
Name of Authorised Signatory	Lauren Shukru
Date	10-Mar-2021

*NB. If the actual project start date is delayed beyond 12 months of the expected start date, this Certificate of Approval will lapse and the project will need to be reviewed again to take account of changed circumstances such as legislation, sponsor requirements and University procedures.

Please note and follow the requirements for approved submissions:

Amendments to protocol

* Any changes or amendments to approved protocols must be submitted to the C-REC for authorisation prior to implementation.

Feedback regarding the status and conduct of approved projects

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(3) http://www.sussex.ac.uk/staff/research/rqi/policy/research-policy

بسم الله الرحمن الرحيم

المملكة العربية السعودية
وزارة التعليم
جامعة الإمام محمد بن سعود الإسلامية
وكالة الجامعة للدراسات العليا والبحث

الرقم: ....
التاريخ: ....
المشفوعات: ....

VISION رؤية 2030 المملكة العربية السعودية KINGDOM OF SAUDI ARABIA

التاريخ: 2020-10-08 م
21-02-1442 هـ

تسهيل مهمة باحث

فضيلة/سعادة عميد بجامعة الإمام محمد بن سعود الإسلامية حفظه الله

سلام عليكم ورحمة الله وبركاته .. أما بعد :

فأشير إلى رغبة الدارس/ـة منى جبران بن سعيد الشهراني بـ كلية علوم الحاسب والمعلومات بـ جامعة الامام في إجراء دراسة بعنوان (Leveraging Blockchain as Decentralized Technology in Higher Education Sector in Saudi Arabia) استكمالاً لمتطلبات الحصول على درجة الجامعية بـ .
ونظراً لأن موضوع البحث يتطلب إجراء دراسة ميدانية والحصول على بيانات علمية وإحصائية لذا آمل تسهيل مهمة مقدم الطلب منى جبران بن سعيد الشهراني لتطبيق أداة الدراسة وتزويده بالبيانات اللازمة.

والله ولي التوفيق ,,,

وكيل الجامعة للدراسات العليا والبحث العلمي

أ.د. عبدالله عبدالعزيز بن عبدالله التميم

Ref No: 637-377-527-283-277-626

To verfy the information of this certifecate visit: dv.imamu.edu.sa : يمكنك التحقق من صحة هذه الشهادة بالدخول على

9.2 Appendix B: 1st Study Data collection documents

Adoption of Blockchain in Higher Education sector's Survey

Part 1: Demographic of research

1. **Please select the category that includes your age.**
    - o 18 to 25 years
    - o 26 to 35 years
    - o 36 to 45 years
    - o 46 to 60 years
    - o 60 years or more
2. **Please indicate your education level.**
    - o High school graduate or equivalent
    - o Undergrad
    - o Bachelor's degree
    - o Postgraduate or higher
3. **Please Indicate your gender.**
    - o Female
    - o Male
    - o Prefer not to say
4. **Your study or field domain**.
    - o Science, Technology and Engineering
    - o Business and Economics
    - o Humanities and art
    - o Other

Part 2: Level of the knowledge and the usage of Blockchain technology in Higher education

5. **Please indicate your level of awareness for the Blockchain technology.**
    - o Highly aware
    - o Moderately aware
    - o Neutral
    - o Not aware
6. **Have you ever used a Blockchain technology in any aspect?**
    - o Yes
    - o No
7. **How often do you to attend or provide workshops/seminars and receive or give certificates?**
    - o Always
    - o Very often
    - o Often
    - o Rarely
    - o Never
8. **In your opinion, which of the following factors affect the adoption of Blockchain technology in the field of Higher education?**

- Trust on Blockchain technology.
- Privacy and security concerns.
- Quality of stored documents.
- The efficiency of retrieving information.
- The authentication associated with the provided documents.

9. **Do you think you have adequate skills and training to use Blockchain technology in any aspects?**
   - Yes
   - No
   - Maybe

CATEGORY 1: Student's Questionnaire

Part 3: Issues with the current situation of handling students' credentials in the higher education institutes.

Statements	Strongly Agree	Agree	Fair	Disagree	Strongly Disagree
1. The process of issuing students certificate takes a lot of time and effort.					
2. There is too much paperwork needed to generate educational certificates.					
3. There is lack of information about the following procedures to issue my certificate.					
4. Dishonesty is one of the main issues related with the higher education certificates.					
5. I don't have access to my achievements and certificates throughout my study.					
6. Sharing my credentials with prospective employers is not easy with the hard copy version of certificates.					
7. The process of validating my certificates by the employers is taking long time.					
8. The current version of certificating systems does not reflect all my skills and achievements.					

Part 4: This part designed to evaluate the students' views on the adoption of Decentralized technology for storing and authorizing higher educational certificates.

1. Trust influence factors for using Blockchain technology in higher education sector.

1. Statements (Functionality and Transparency)	Strongly Agree	Agree	Fair	Disagree	Strongly Disagree
1. Blockchain technology transparency making it a suitable option for managing educational certificates.					
2. Blockchain technology can handle all forms of academic credentials, transcripts, and students' certificates.					
3. Blockchain technology provides high level of trust to the students by eliminating the control of third party.					
4. Adopting Blockchain technology in Higher education enables students to share their official documents directly with anyone requesting them.					

5. Blockchain technology embody the learning outcomes and enhances the attainment of competencies within the educational scope.					
6. Blockchain technology immutable feature will give me full trust of the provided certificates.					

2. Statements (Knowledge and Familiarity)	**Strongly Agree**	**Agree**	**Fair**	**Disagree**	**Strongly Disagree**
1. I am familiar with the benefits associated with using Blockchain technology in the higher education.					
2. I trust the Blockchain technology even without any knowledge about its functionality.					
3. I am aware about how to get the information needed to understand the concept of Blockchain technology.					

3. Statements (Easy to access and share)	**Strongly Agree**	**Agree**	**Fair**	**Disagree**	**Strongly Disagree**
1. Using Blockchain technology will give me the full access to my certificates in any time.					
2. Using Blockchain technology will allow me to share my credentials with any prospective employers.					
3. Using Blockchain technology will reduce the time and effort in controlling my credentials.					
4. The Blockchain technology is useful, and the universities will be convinced to trust this technology and adopt it.					

2. Efficiency and Cost influence factors for using Blockchain technology in higher education sector.

1. Statements (Efficient Smart Certificate)	**Strongly Agree**	**Agree**	**Fair**	**Disagree**	**Strongly Disagree**
1. The Blockchain technology offers an efficient sharable system among employer and students.					
2. The Blockchain technology improves the generating process of student records.					
3. The Blockchain technology enhances the process of validating the students' certificates.					
4. The Blockchain technology provides the efficient smart certificate that the student has full access control to it.					
5. Blockchain technology broadens my approach to other institutions and I can easily share my educational credentials without any physical barriers.					
6. Blockchain technology helps in managing and measuring the qualifications earning activities in the institution, thus, increasing the overall efficiency of the organization.					

2. Statements (Cost Reduction)	Strongly Agree	Agree	Fair	Disagree	Strongly Disagree
1. The Blockchain technology reduces the cost associated with the process of generating and maintaining the students' certificates.					
2. The Blockchain technology accelerate the time needed to issue the students' certificates.					
3. The blockchain technology can help reduce the unnecessary cost associated with the transactions and centralized data storage.					

3. Social influence factor for using Blockchain technology in higher education sector.

1. Statements	Strongly Agree	Agree	Fair	Disagree	Strongly Disagree
1. Adopting Blockchain technology creates better careers opportunities for me.					
2. Adopting Blockchain technology encourages other educational institutes to have the same transparency level to their outcomes.					
3. Adopting Blockchain technology encourages students in building productive skills needed to support their career decisions.					
4. The Blockchain technology reputation in various fields, should encourage higher education to adopt it.					

4. User Awareness factor for using Blockchain technology in higher education sector.

2. Statements (User Awareness)	Strongly Agree	Agree	Fair	Disagree	Strongly Disagree
1. Blockchain technology can be adopted for generating and validating student's certificate.					
2. Adoption of Blockchain technology will allow the institutes to easily integrate it with existing centralized system.					
3. I have a good perception of the advantages of adopting Blockchain in higher education institutes.					
4. I am aware about the challenges that prevent adopting Blockchain in higher education institutes					

5. Security and Privacy factors for using Blockchain technology in higher education sector.

1. Statements (Privacy, Immutability, Security and Reliability)	Strongly Agree	Agree	Fair	Disagree	Strongly Disagree
1. Security is an important benefit of integrating Blockchain technology in higher education.					
2. Knowing that Blockchain is maintaining high level of security includes data protection, integrity and privacy could affect my trust toward it.					

3. Blockchain technology helps in attaining high levels of security and privacy for smart certificates stored on the chain.					
4. Blockchain technology enhances the students' certificates reliability and transparency.					
5. Blockchain technology can establish secure connections between all included parties and ease interactions between them.					
6. Blockchain technology can be very useful in authenticating students' original identities as well as their authentic smart certificates.					

2. Statements (Perceived Risk)	Strongly Agree	Agree	Fair	Disagree	Strongly Disagree
1. I think using Blockchain technology would not risk my privacy or security.					
2. I feel very confident while using and sharing my credentials through Blockchain technology.					
3. I will use my smart certificate in the Blockchain even if I have no idea about its security.					
4. I feel my information is secured if I can control who is seeing my credentials.					

Part 5: Intention to adopting Blockchain technology

2. Statements	Strongly Agree	Agree	Fair	Disagree	Strongly Disagree
1. I have a desire to use blockchain systems in dealing with certificates issued by higher education institutions					
2. I do not mind learning how to use blockchain systems in the field of exporting and documenting certificates issued by higher education institutions					

CATEGORY 2: Employer Questionnaire

Part 3: This part designed to evaluate the Employers' views on the adoption of Decentralized technology, Blockchain technology, for storing and authorizing higher educational certificates.

1. **Trust influence factors for using Blockchain technology in higher education sector.**

1. Statements (Functionality and Transparency)	Strongly Agree	Agree	Fair	Disagree	Strongly Disagree

1. Blockchain technology transparency making it a suitable option for managing educational certificates.					
2. Blockchain technology can handle all forms of academic credentials, transcripts, and students' certificates.					
3. Blockchain technology provides high level of trust to the employers by eliminating any dishonesty.					
4. Adopting Blockchain technology in Higher education enables students to share their official documents directly with anyone requesting them.					
5. Blockchain technology emphases the actual learning outcomes and alumni skills and accomplishments.					
6. Blockchain technology immutable feature will give me full trust of the provided certificates.					

2. Statements (Knowledge and Familiarity)	Strongly Agree	Agree	Fair	Disagree	Strongly Disagree
1. I am familiar with the benefits associated with using Blockchain technology.					
2. I trust the Blockchain technology even without any knowledge about its functionality.					
3. I am aware about how to get the information needed to understand the concept of Blockchain technology.					

4. Statements (Applicants credentials authenticity)	Strongly Agree	Agree	Fair	Disagree	Strongly Disagree
1. I believe that benefits will be achieved by using block chain technology in education and value will be generated to the employment process.					
2. Blockchain technology helps in streamlining the process to prospective employees and guarantee they are qualified candidates.					
3. I believe that employing Blockchain technology in higher education opens up the outputs of the institution to a worldwide application.					
4. Using Blockchain technology will allow the organisation to check the authenticity of the applicant's credentials.					
5. Adopting Blockchain technology encourages improvement in teaching practice thus in learning outcomes.					

2. Efficiency and Cost influence factors for using Blockchain technology in higher education sector.

1. Statements (Efficient Smart Certificate)	Strongly Agree	Agree	Fair	Disagree	Strongly Disagree

1. Adopting Blockchain technology maximizes the visibility of an institution and student outputs are easily observed.					
2. The Blockchain technology enables several features measure and evaluate the students' performance.					
3. The Blockchain technology offers an efficient sharable system among employer and students.					
4. The Blockchain technology can allow institute to interoperate with other university systems and maximise efficiencies between them by sharing information.					

2. Statements (Cost Reduction)	**Strongly Agree**	**Agree**	**Fair**	**Disagree**	**Strongly Disagree**
1. The Blockchain technology reduces the cost associated with the process of verifying and authenticating the applicants' certificates.					
2. The blockchain technology can help reduce the unnecessary cost associated with the transactions and centralized data storage.					
3. The Blockchain technology minimize the time required to verify the applicant's credentials.					
4. It is cost efficient approach for the organisation.					

3. Social influence factors for using Blockchain technology in higher education sector.

1. Statements	**Strongly Agree**	**Agree**	**Fair**	**Disagree**	**Strongly Disagree**
1. Adopting Blockchain technology creates better qualified prospective employees for my organisation.					
2. Adopting Blockchain technology encourages educational institutes to have the same transparency level to their outcomes.					
3. Adopting Blockchain technology encourages prospective employees in building productive skills needed to support their career decisions.					
4. The Blockchain technology reputation in various fields, should enforces higher education to adopt it.					
5. Adopting Blockchain technology in higher education reducing overwhelming administrative tasks that helps in increasing employee's productivity.					

4. Security and Privacy influence factors for using Blockchain technology in higher education sector.

1. Statements (Privacy, Immutability, Security and Reliability)	**Strongly Agree**	**Agree**	**Fair**	**Disagree**	**Strongly Disagree**

1. Security is an important benefit of integrating Blockchain technology in higher education.					
2. Knowing that Blockchain is maintaining high level of security includes data protection, integrity and privacy could affect my trust toward it.					
3. Blockchain technology helps in attaining high levels of security and privacy for smart certificates stored on the chain that effect the decision about the prospective employees' qualifications.					
4. Blockchain technology enhances the prospective employees' certificates' reliability and transparency.					
5. Blockchain technology can establish secure connections between all included parties and ease interactions between them.					
6. Blockchain technology can be very useful in authenticating students' original identities as well as their authentic smart certificates.					
7. Blockchain technology decreases the probability of duplication of educational certificates.					
8. Blockchain technology supports storage, management, preservation, authentication and retrieval of student content safely.					

2. Statements (Perceived Risk)	Strongly Agree	Agree	Fair	Disagree	Strongly Disagree
5. I think using Blockchain technology would not risk my privacy or security as an organisation and prospective employers.					
6. I feel very confident while using and verifying my applicants' credentials through Blockchain technology.					
7. I feel applicants' credentials information is secured if the issuer can control who is seeing them.					

3. Statements (Fraud and Dishonesty)	Strongly Agree	Agree	Fair	Disagree	Strongly Disagree
1. Blockchain technology contains high quality content could be used as a marketing tool to entice staff, students and funding for the organisation					
2. Adopting Blockchain technology helps in reduce the applicant's credentials frauds and dishonesty.					
3. Digital repositories increase transparency and quality of applicants provided qualifications.					

Part 4: Intention to adopting Blockchain technology

2. Statements	Strongly Agree	Agree	Fair	Disagree	Strongly Disagree
1. I have a desire to use blockchain systems in dealing with certificates issued by higher education institutions					
2. I do not mind learning how to use blockchain systems in the field of exporting and documenting certificates issued by higher education institutions					

Interview Questions (Top Management in Academic institutes)

- Describe your role and responsibility in your organisation? Does your role include the process of generating and validating the higher education student's certificate and credentials?
- From your experience, could you please tell me about the issues and challenges your organisation faces in the current process of certificating system in term of (e.g. cost, time, security, quality)?
- Have you ever participated in the process of auditing the alumni's transcript that considered as one step of generating student's certificate? If yes, can you describe the process and what are the drawbacks and challenges related to it?
- To what extent do you think you and your institute are aware of Blockchain Technology?
- What do you think about adopting and deploying Blockchain in the certificating process in Higher education fields?
- From your point of view, what are the benefits of adopting Blockchain in the certificating process of your organisation?
- From your own perspective, what are the main factors that may impact the adoption of Blockchain technology in the certificating process in your organisation?
- What are the trust-related issues that may impact the adoption of Blockchain technology in the certificating process in your organisation? Example
- Do you agree with this statement "Adopting Blockchain technology in any educational institute would positively encourage other institutes to have the same transparency level to their outcomes"? Do you think social influence is one of the major factors for adopting Blockchain technology?
- In terms of security and privacy concerns, what do you think about the influence of these concerns on the adoption of Blockchain technology in the certificating process in your organisation?
- From your experience, what are the efficiency aspects that are required in the certification process that would be fulfilled by adopting Blockchain technology in your organisation?
- Adopting Blockchain technology in educational institutes provides a direct support and meaningful feedback to students. Do you agree with this statement? Can you explain your answer?
- Do you think your organisation's technical infrastructure is willing to adopt Blockchain technology in the future? Can you justify your answer?
- Any additional information you want to add?

Participant Information Sheet (For Questionnaire Participants)

Dear Participant,

Thank you for participating in this survey about adopting Blockchain technology in the certificating process on the Higher education sector in Saudi Arabia. The information you provide will be treated as strictly confidential and for academic research purpose only and please endeavour to fill out the questionnaire.

I am Mona Alshahrani a PhD student at University of Sussex, Informatics Department, United Kingdom. I am conducting my PhD research into "Leveraging Blockchain as Decentralized Technology in Higher Education Sector in Saudi Arabia". I am carrying out a field study in Saudi Arabia to collect data from students, faculty, IT representatives and prospective employers for Higher Education sector. You are invited to participate in this research if you are from the above list and 18 years or over. The purpose of this study is to investigate the factors affecting students' and employers' adoption of Blockchain technology to generate and validate the student's qualification, certificates and experience in the Higher education sector in Saudi Arabia. In particular, this questionnaire addresses four important aspects; trust, efficiency, adaption and privacy aspects to influence students' and employers' decision to embrace Blockchain technology for generating and validating student's educational credentials. Blockchain technology is recognized as a revolutionary invention that can be described as a distributed record of digital events stored across all the participating computers in a linked chain.

Your participation in the study is greatly appreciated and will highly contribute to this research. This questionnaire should not take more than 25 minutes of your time. The questionnaire has been tested and have been estimated for the duration time. The questionnaire will be in two different sections. The first section will collect Demographic information about (e.g. age and education) which will be stored separately from the answers you give to the questions. The second section will collect information related to factors that may influence blockchain technology adoption in Saudi Arabia.

Participation in the questionnaire is voluntary, meaning that you can decide not to continue with the questionnaire at any time. All of the data will be anonymized and will only be used in this study for research purposes, without any possibility of secondary re-use or de- anonymization. In this study, all data and information will be kept strictly confidential, on a secure server and password protected in accordance with the University of Sussex Data Protection regulations and Data

Protection Act 2018. The data and information in this study will be analysed only for research purpose, and the result of the study will be used in my research thesis. If you would like to receive a copy of the results, please contact me at my email address.

University of Sussex has insurance in place to cover its legal liabilities in respect of this study. This study has been approved by the Sciences & Technology Cross-Schools Research Ethics Committee (crecscitec@sussex.ac.uk). The project reference number is (ER/MA2026/1). If you would like to withdraw your data from this research, you will need to email this request to the researcher email. The deadline for such withdrawal will be 2 weeks after the data collection date.

Researcher contact:

Mona Alshahrani: E-mail: ma2026@sussex.ac.uk
If you have any concern about the way in which the study has been conducted, please contact my supervisor and the ethics committee (C-REC):

Dr Natalia Beloff: E-mail: N.Beloff@sussex.ac.uk, Phone: +44 (0) 1273 678919
Department of Informatics, University of Sussex, Falmer, Brighton BN1 9QJ

Ethics Committee (C-REC): crecscitec@sussex.ac.uk.
Thank you for taking time to read the information sheet.

Would you like to take part in this research?

Yes, I agree to take part in this research, and I understand our participation is voluntary and I may withdraw at any time up to [state approximate date] when the data will be analysed.

Disagree.

9.3 Appendix C: 2nd Study Data collection documents

Adoption of Blockchain in Higher Education sector's Survey (User Experience)

Part 1: Demographic of research

10. Please select the category that includes your age.
- 18 to 25 years
- 26 to 35 years
- 36 to 45 years
- 46 to 60 years
- 60 years or more

11. Please indicate your education level.
- High school graduate or equivalent
- Undergrad
- Bachelor's degree
- Postgraduate or higher

12. Please Indicate your gender.
- Female
- Male
- Prefer not to say

13. **Your study or field domain**.
- Science, Technology and Engineering
- Business and Economics
- Humanities and art
- Other

Part 2: Level of awareness and the usage of Blockchain technology in Higher education

14. Please indicate your level of awareness for the Blockchain technology.
- Highly aware
- Moderately aware
- Neutral
- Not aware

15. Have you ever used a Blockchain technology in any aspect?
- Yes
- No

16. How often do you to attend or provide workshops/seminars and receive or give certificates?
- Always
- Very often
- Often
- Rarely
- Never

17. In your opinion, which of the following factors affect the adoption of Blockchain technology in the field of Higher education?
- Trust on Blockchain technology.
- Privacy and security concerns.
- Quality of stored documents.
- The efficiency of retrieving information.
- The authentication associated with the provided documents.

18. Do you think you have adequate skills and training to use Blockchain technology in any aspects?
- Yes

- No
- Maybe

Part 3: Issues with the current situation of handling students' credentials in the higher education institutes.

Statements	Strongly Agree	Agree	Fair	Disagree	Strongly Disagree
1. The process of issuing students certificate takes a lot of time and effort.					
2. There is too much paperwork needed to generate educational certificates.					
3. There is lack of information about the following procedures to issue my certificate.					
4. Dishonesty is one of the main issues related with the higher education certificates.					
5. I have access to my achievements and certificates throughout my study.					
6. Sharing my credentials with prospective employers is not easy with the hard copy version of certificates.					
7. The process of validating my certificates by the employers is taking long time.					
8. The current version of certificating systems does not reflect all my skills and achievements.					

Questions On Overall Students Experience with DASC

Part 4: This part is focusing on the user experience after testing the DASC prototype according to the use cases scenarios provided to the user.

1. **Trust influence factors.**

1. Statements (Functionality and Transparency)	Strongly Agree	Agree	Fair	Disagree	Strongly Disagree
1. I can access all my credentials through the system.					
2. In general, all the functions of the system are in the right place.					
3. The system provides me with high level of trust by giving me the control of my certificates.					
4. I can easily share my certificates with prospective employers.					
5. It is easy to understand the operation for each task in the system					
6. I can trust no one will change the posted certificate since it is relying on Blockchain technology.					
7. The system lets me understand the concept of blockchain.					

2. Statements (Knowledge and Useability)	Strongly Agree	Agree	Fair	Disagree	Strongly Disagree

1. They system functionalities are clear and easy to navigate.					
2. The screens layout and colour scheme are very appropriate.					
3. The text, buttons, and icons are easy to read.					
4. I am very satisfied about the overall appearance of the system screens.					

3. Statements (Easy to access and share)	Strongly Agree	Agree	Fair	Disagree	Strongly Disagree
1. I quickly learned how to use the system.					
2. Using the system reduced the time in controlling my credentials.					
3. Using the system took me less effort					
4. The system is very useful, and the universities must be convinced to trust this technology and adopt it.					
5. I would use support from the IT representatives to be able to use the system					

2. Efficiency and Cost influence factors for using Blockchain technology in higher education sector.

1. Statements (Efficient Smart Certificate)	Strongly Agree	Agree	Fair	Disagree	Strongly Disagree
1. I am very satisfied with the idea of having all my credentials in a system such as DASC.					
2. The process of generating the certificate is more efficient and smarter than the current process.					
3. I can easily check if the provided certificate is authentic and provided by the authorized issuer.					
4. I feel more confident during the experience of using a blockchain-based system since I have a record of all my certificates at any time.					
5. I can easily share my educational credentials without any physical barriers.					
6. The overall experience enhances the certification process for all the users involved.					

2. Statements (Cost Reduction)	Strongly Agree	Agree	Fair	Disagree	Strongly Disagree
1. DASC reduces the cost associated with the process of generating the students' certificates.					
2. DASC accelerate the time needed to issue the students' certificates.					
3. Using DASC helps in reduce the unnecessary cost associated with the transactions and centralized data storage.					

4. I would recommend this system to be adopted by all the national academia institutions.					

3. **Social influence factors for using Blockchain technology in higher education sector.**

1. Statements (Social Influence)	Strongly Agree	Agree	Fair	Disagree	Strongly Disagree
1. I feel using this system creates better careers opportunities for students.					
2. Using DASC, will encourages other educational institutions to want the same transparency level for their outcomes.					
3. I feel this system will encourage student to enhance their skills and earn more credentials.					
4. The reputation of blockchain technology in various fields, should encourage higher education institutions to adopt it.					

4. **User Awareness factors for using Blockchain technology in higher education sector.**

2. Statements (User Awareness)	Strongly Agree	Agree	Fair	Disagree	Strongly Disagree
1. I am aware of all the properties and functionality provided by DASC.					
2. I need to learn a lot about blockchain before I will be able to effectively use the system.					
3. After using DASC, I have a good perception of the advantages of adopting Blockchain in higher education institutes.					
4. After using DASC, I am aware about the challenges that prevent the adoption of blockchain for the certification process.					

5. **Security and Privacy influence factors for using Blockchain technology in higher education sector.**

1. Statements (Privacy, Immutability, Security and Reliability)	Strongly Agree	Agree	Fair	Disagree	Strongly Disagree
1. After using DASC, I can understand the security feature of blockchain based systems.					
2. I understand the immutability feature of blockchain as I know no one will change the certificate after it posted.					
3. This system is providing me with high levels of security and privacy for smart certificates.					
4. This system enhances the students' certificates' reliability and transparency.					
5. This system is very secure and maintains authentic certificates.					

2. Statements (Perceived Risk)	Strongly Agree	Agree	Fair	Disagree	Strongly Disagree
1. After using the system, I don't feel my information is secure in this system.					
2. I feel very confident while accessing and sharing my credentials through DASC.					
3. I would use my smart certificate in DASC even if I have no idea about its security.					
4. After using the system, I can control who sees my credentials.					

Part 5: Intention to use Blockchain Based systems in the Higher education Certification Process

2. Statements (Intention to Adopt Blockchain)	Strongly Agree	Agree	Fair	Disagree	Strongly Disagree
1. I intend to use Blockchain Technology in the Certification Process to generate and verify certificates.					
2. I do not mind learning how to use Blockchain technology in the process of generating and verifying Certificates in the Higher education sector					

Part 6: UI Design: Please rate the following transactions and functionalities

Student's Pages	Very Poor	Poor	Fair	Good	Very Good
1. The login page layout					
2. The overall appearance of the dashboard					
3. The document list page layout					
4. The clarity of the document properties					
5. The functionality of sharing the certificate					
6. The profile page and its layout					
7. The usefulness of the given user guide					

Questions On Overall Employer Experience With DASC

Part 4: This part is focusing on the user experience after testing the DASC prototype according to the use cases scenarios provided to the user.

1. Trust influence factors.

1. Statements (Functionality and Transparency)	Strongly Agree	Agree	Fair	Disagree	Strongly Disagree
1. The system transparency making it a suitable option for managing educational certificates.					
2. The system can handle all forms of academic credentials, transcripts, and students' certificates.					
3. The system provides high level of trust to the prospective employers by eliminating any dishonesty.					
4. The system enables students to share their official documents directly with me once requested.					
5. The system emphases the actual learning outcomes and alumni skills and accomplishments.					
6. Blockchain technology immutable feature gives me full trust of the provided certificates.					

2. Statements (Knowledge and Useability)	Strongly Agree	Agree	Fair	Disagree	Strongly Disagree
1. The DASC functionalities are clear and easy to navigate.					
2. The DASC layout and colour schema are very appropriate.					
3. The DASC is understandable and easy to deal with					
4. I am very satisfied about the overall usability of the system screens.					

3. Statements (Applicants credentials authenticity)	Strongly Agree	Agree	Fair	Disagree	Strongly Disagree
1. After using DASC I believe it is beneficial in higher education and will be expanded to enhance the employment process.					
2. The System helps in accelerating the process to prospective employees and guarantee they are qualified candidates.					
3. I believe that adopting DASC in higher education enables students' credentials to reach international organisations					
4. Using the system allows the organization to check the authenticity of the applicant's credentials.					

5. After using the system, I believe it encourages the applicants to improve their skills and achievements to match the employers' expectations					

2. Efficiency and Cost influence factors for using Blockchain technology in higher education sector.

1. Statements (Efficient Smart Certificate)	Strongly Agree	Agree	Fair	Disagree	Strongly Disagree
1. I am very satisfied with the idea of having all the student's credentials in a system such DASC.					
2. The process of verifying the certificate is more efficient and smarter than the current process.					
3. I can easily check if the provided certificate is authentic and provided by the authorized issuer.					
4. The system enables several features that measure and evaluate the students' performance.					
5. The system offers an efficient sharable system among prospective employers.					
6. The overall experience is showing an enhancement in the certificating process for all the users involved.					

2. Statements (Cost Reduction)	Strongly Agree	Agree	Fair	Disagree	Strongly Disagree
1. DASC reduces the cost associated with the process of generating the students' certificates.					
2. DASC accelerate the time needed to verify the students' certificates.					
3. Using DASC helps in reduce the unnecessary cost associated with the transactions and centralized data storage.					
4. The system is a cost-efficient approach for the organisations and prospective employers.					

3. Social influence factors for using Blockchain technology in higher education sector.

1. Statements (Social Influence)	Strongly Agree	Agree	Fair	Disagree	Strongly Disagree
1. Using this system among higher education institutes creates better careers opportunities for students.					
2. Using DASC, will encourages more educational institutes to obtain the same transparency level for their outcomes.					
3. I feel this system will encourage students to enhance their skills and earn more credentials.					
4. Blockchain technology reputation in various fields, should encourage higher education institutes to adopt it.					

4. User Awareness factors for using Blockchain technology in higher education sector

2. Statements (User Awareness)	Strongly Agree	Agree	Fair	Disagree	Strongly Disagree
1. I am aware of all the properties and functionality provided by DASC.					
2. After using the system, I know what I need to learn about blockchain before I will be able to effectively use the system.					
3. After using DASC, I have a good perception of the advantages of adopting Blockchain in higher education institutes.					
4. After using DASC, I am aware about the challenges that prevent adopting blockchain to verify certificates.					

5. Security and Privacy influence factors for using Blockchain technology in higher education sector.

1. Statements (Privacy, Immutability, Security and Reliability)	Strongly Agree	Agree	Fair	Disagree	Strongly Disagree
1. After using DASC, I can understand the security feature of blockchain based systems.					
2. I understand the immutability feature of blockchain as I know no one will change the certificate after it is posted.					
3. This system provides me with high levels of security and privacy for Smart certificates.					
4. This system enhances the applicants' certificate's reliability and transparency.					
5. This system is very secure and maintain authentic certificates.					

2. Statements (Perceived Risk)	Strongly Agree	Agree	Fair	Disagree	Strongly Disagree
1. I do not feel confident while using and verifying my applicants' credentials through this system.					
2. Using DASC would not risk my privacy or security as an organisation and prospective employers.					
3. This system helps in reduce the applicant's credentials frauds and dishonesty.					
4. DASC increases transparency and quality of applicants' certificates.					

Part 5: Intention to use Blockchain Based systems in the Higher education Certification Process

2. Statements (Intention to Adopt Blockchain)	Strongly Agree	Agree	Fair	Disagree	Strongly Disagree
3. I intend to use Blockchain Technology in the Certification Process to generate and verify certificates.					
4. I do not mind learning how to use Blockchain technology in the process of generating and verifying Certificates in the Higher education sector					

Part 6: UI Design: Please rate the following transactions and functionalities

Employer's Pages	Very Poor	Poor	Fair	Good	Very Good
1. The clarity of the system's home page					
2. Navigation for the button 'prospective employer'					
3. The search function either by name or email					
4. The useability of the advance search					
5. The effectiveness of the search result					
6. The ease of contacting specific students					
7. The usefulness of the given user guide					

INFORMATION & CONSENT SHEET

Dear Participant,

Thank you for participating in this study about adopting Blockchain technology in the certificating process on the Higher education sector in Saudi Arabia. The information you provide will be treated as strictly confidential and for academic research purpose only and please endeavour to fill out the questionnaire.

I am Mona Alshahrani a PhD student at University of Sussex, Informatics Department, United Kingdom. I am conducting my PhD research into "Leveraging Blockchain as Decentralized Technology in Higher Education Sector in Saudi Arabia".

I am carrying out a field study in Saudi Arabia to collect data from students, faculty, IT representatives and prospective employers for Higher Education sector. You are invited to participate in this research if you are from the above list and 18 years or over.

The purpose of this study is to investigate the factors affecting students' and employers' adoption of Blockchain technology to generate and validate the student's qualification, certificates and experience in the Higher education sector in Saudi Arabia. Blockchain technology is recognized as a revolutionary invention that can be described as a distributed record of digital events stored across all the participating computers in a linked chain. The blockchain relies on peer-to-peer (P2P) network transactions. This study addresses four important aspects; trust, efficiency, adaption and privacy aspects to influence students' and employers' decision to embrace Blockchain technology for generating and validating student's educational credentials.

Your participation in the study is greatly appreciated and will highly contribute to this research. This testing for the prototype should not take more than 30 minutes of your time. The study has been tested and have been estimated for the duration time. *This study will consist of two stages, the first stage is the virtual observation during our interview for the participant testing the prototype. Then, the second stage the participant answers subsequent questionnaire regarding the experience that you will be asked to fill during the session.* The subsequent questionnaire has two different sections. The first section will collect Demographic information about (e.g. age and education) which will be stored separately from the answers you give to the questions. The second section will collect information related your experience of the system.

Participation in the study is voluntary, meaning that you can decide not to continue with the it at any time. All of the data will be securely protected and will only be used in this study for research purposes, without any possibility of secondary re-use or de- anonymization. In this study, all data and information will be kept strictly confidential, on a secure server and password protected in accordance with the University of Sussex Data Protection regulations and Data Protection Act 2018.

The data and information in this study will be analysed only for research purpose, and the result of the study will be used in my research thesis. If you would like to receive a copy of the results, please contact me at my email address.

University of Sussex has insurance in place to cover its legal liabilities in respect of this study. This study has been approved by the Sciences & Technology Cross-Schools Research Ethics Committee (crecscitec@sussex.ac.uk). The project reference number is (ER/MA2026/1). If you would like to withdraw your data from this research, you will need to email this request to the researcher ma2026@sussex.ac.uk. The deadline for such withdrawal will be 2 weeks after the data collection date.

CONSENT

- I understand that by signing below I am agreeing to take part in the University of Sussex research described here, and that I have read and understood this information sheet.

- I understand that my participation is entirely voluntary, that I can choose not to participate in part or all of the study, and that I can withdraw at any stage without having to give a reason and without being penalised in any way (e.g., if I am a student, my decision whether or not to take part will not affect my grades).
- I understand I can request without penalty that my data be withdrawn and deleted even after the data collection is complete, any time up until the results are analysed ([May 2021]).
- I consent to the processing of my personal information for the purposes of this research study. I understand that such information will be treated as strictly confidential (subject to legal limitations) and handled in accordance with data protection legislation.
- I understand that my data including my personal information (e.g., name) will be stored safely. Electronic data will be stored securely on a University server, and hard-copies will be stored behind a locked door.
- I understand that my identity will remain confidential in any written reports of this research, and that no information I disclose will lead to the identification in those reports of any individual either by the researchers or by any other party, without first obtaining my written permission.
- I understand that my name and data will not be shared with any third party outside the research group, unless I later provide written permission.
- I understand the observation will be recorded and conducted on-line via the University of Sussex Microsoft Teams account Or the University of Sussex Zoom account. Privacy statements for each of these:

    The privacy statement for Zoom is: https://zoom.us/privacy
    The privacy statement for MS Teams is: https://privacy.microsoft.com/en-gb/privacystatement

- Please initial this box if you consent for us to share with other researchers or interested professional parties' images from the video of your participation. [ ]

______________________	______________	____________________
Name of Participant	Date	Signature

Researcher contact:

Mona Alshahrani

E-mail: ma2026@sussex.ac.uk

If you have any concern about the way in which the study has been conducted, please contact my supervisor and the ethics committee (C-REC):

Dr Natalia Beloff

E-mail: N.Beloff@sussex.ac.uk,
Phone: +44 (0) 1273 678919

Department of Informatics, University of Sussex, Falmer, Brighton BN1 9QJ

Ethics Committee (C-REC): crecscitec@sussex.ac.uk