BLOCKCHAIN APPLICATIONS FOR DIPLOMA VERIFICATION IN HIGHER EDUCATION INSTITUTIONS IN PORTUGAL – A MIXED METHODS STUDY

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Abstract

The increase in the number of international students, employers for qualified professionals, and the counterfeiting of diplomas made us want to study how an innovative solution can be used to address these situations. Blockchain, with its disruptive potential, aligned with its characteristics of transparency and trust, in a decentralized model, can contribute decisively to implement a model of verification of diplomas and certificates that eliminates the current problems (forgery, manual and time-consuming processes, difficulty in validating information, high costs which vary from case to case and from country to country, among others) with benefits for students, employers and universities. Our study aims to understand the current awareness of the blockchain solutions in Higher Education Institutions (HEIs) in Portugal and the perceived impacts and benefits for universities and students through a mixed research method. In the qualitative approach, we conducted six in-depth interviews with professionals from higher education institutions and research. Using thematic analysis, we identified four main themes: Awareness and Opportunities to use Blockchain in Higher Education, Impacts and Benefits of Blockchain applications in Higher Education, Adoption Barriers, and Adoption Suggestions. From the results, we concluded that awareness about blockchain in the academic community is still low, and therefore, it is necessary to continue the efforts to increase it. However, if applied, there is a perception that the technology can generate efficiency gains for those involved. Furthermore, the results showed the need to have at least one solution at the European level for a platform of this type to be interesting and consequently for the adoption to be successful. In the quantitative analysis, through an online survey, we collected 172 responses from members of the academic community. We used non-parametric tests – Kruskal-Wallis and Mann-Whitney U, for hypothesis testing to understand how the perceived benefits of using blockchain for degrees varied across gender, study cycle, and nationality. The result showed that there is a significant difference between national and international students. However, there are no significant differences between different genders or the study cycle. As an academic contribution, this is one of the first studies that sought to understand the level of awareness about the use of blockchain for Diplomas in Portugal in HEIs, and how the benefits of a potential solution are perceived among their various stakeholders. We also show some of the existing barriers to adoption and alternatives on how to overcome them and indicate avenues of future research. In addition, the work generated the publication of a scientific article in a European journal.

Keywords: Blockchain, Higher Education, Innovation, Diplomas

Resumo

O aumento do número de estudantes internacionais, empregadores para profissionais qualificados, e a falsificação de diplomas, fez-nos querer estudar como uma solução inovadora pode ser utilizada para resolver essas situações. "Blockchain", com seu potencial disruptivo, alinhado com as suas características de transparência e confiança, num modelo descentralizado, pode contribuir decisivamente para implementar um modelo de verificação de diplomas e certificados que elimina o problema atual (falsificação, processo manuais e morosos, dificuldades na validação de informações, custos elevados que variam caso a caso e de país a país, entre outros) com benefícios para estudantes, empregadores e universidades. O nosso estudo tem por objetivo compreender o nível de conscientização atual das soluções em "blockchain" para as Instituições de Ensino Superior em Portugal e os impactos, e benefícios percebidos por universidades e estudantes através de um método de investigação misto. Na abordagem qualitativa, realizámos seis entrevistas aprofundadas com profissionais de instituições de ensino superior e de investigação. Utilizando a análise temática, identificámos quatro temas principais: Sensibilização e Oportunidades de Utilização da "Blockchain" no Ensino Superior, Impactos e Benefícios das aplicações da "Blockchain" no Ensino Superior, Barreiras à Adoção, e Sugestões de Adoção. A partir dos resultados, concluímos que a conscientização na comunidade académica ainda é baixa, portanto, é necessário continuar os esforços nesse sentido. Contudo, se aplicada, há uma perceção de que a tecnologia pode gerar ganhos de eficiência para os envolvidos. Os resultados mostraram a necessidade de ter pelo menos uma solução a nível europeu para que uma plataforma deste tipo seja interessante e, consequentemente, para que a adoção seja bem sucedida. Na análise quantitativa, através de um inquérito eletrónico, recolhemos 172 respostas de membros da comunidade académica. Utilizamos testes não-paramétricos – Kruskal-Wallis e Mann-Whitney U, para os testes estatísticos de hipóteses, para compreender como os benefícios percebidos da utilização da "blockchain" na emissão de diplomas variavam consoante o género, o ciclo de estudos e a nacionalidade. O resultado mostrou que existe uma diferença significativa entre estudantes nacionais e internacionais. No entanto, não se indentificou diferenças significativas entre os diferentes géneros ou ciclo de estudos. Como contribuição académica, este é um dos primeiros estudos que procurou compreender o nível de consciência sobre a utilização da "blockchain" para Diplomas em Portugal nas IES, e como os benefícios de uma solução potencial são percebidos entre os seus vários intervenientes. Mostramos também algumas das barreiras existentes à adoção e alternativas

para ultrapassá-las e indicamos vias de investigação futura. Além disso, o trabalho gerou a publicação de um artigo científico numa revista europeia.

Palavras-chave: Blockchain, Ensino Superior, Inovação, Diplomas

Index

Index of Tables

Index of Figures

1. Introduction

The counterfeiting of diplomas, selling fraudulent certificates, and degree mills are not new issues. In the United States, evidence resembles from Civil War, where the market of fraudulent certificates was a common practice since 1730. However, recently, the issue is attracting more attention from education institutions, international organizations, and employers (Grolleau et al., 2008b, p. 689). According to data available at the Unesco Institute of Statistics, the number of students enrolled in tertiary education worldwide has grown more than 53% between 2006 and 2018. Moreover, the number of tertiary international students has grown steadily in the last 20 years, reaching 5.6 million in 2018 (OECD, 2020, p.201). Along with the mentioned expansion of international students in the past two decades looking to acquire higher education degrees abroad and applying for jobs worldwide, there is an increased pressure to ensure the legitimacy and authenticity of certifications, diplomas, and transcripts – and preferably without the current "hassle" (involving both time and money) of getting diplomas and other academic documents, like the transcripts, recognized by official entities.

The internationalization also happens in Portugal, where according to reports from the "Observatório das Migrações," in the last decade, there was a growth of almost three times in the number of international students in the country (Observatório das Migrações, 2020).

Indeed, nowadays, checking for a diploma or certification authenticity is a lengthy, manually intensive, and sometimes expensive process. For example, students applying for studying abroad may be required to do language translations and international authentications (e.g., Hague apostille or other forms of notary services) from their original documents as a way to prove their authenticity. It can be even a more complex task for students who have to recertify their foreign qualifications (e.g., Degrees and Diplomas) to have them valid in another country.

Refugees are also another community that suffers from having their prior education levels and degrees recognized. It is common for refugees not to have their documents and certificates taken with them when they leave their countries, creating difficulties and barriers to prove their education level. Not having their qualifications recognized has a severe impact on their ability to pursue qualified employment and positively impact their lives (Unesco, 2018).

The recent advances of technology with the development of Blockchain and Smart contracts, with their characteristics of immutability, decentralization, security, and traceability, and consensus, may be considered an excellent match to implement a robust and reliable anti-fraud solution to issue digital diplomas (Cheng et al., 2018) (Kamišalić et al., 2019). In turn, the digital diplomas and transcripts can be easily assessed and verified by any interested party worldwide, without the need for an intermediary or other certification agents. Furthermore, with the lockdown and other restrictions imposed by COVID-19, online activities are becoming crucial compared to presential ones. An inevitable push for the digitalization of several aspects of our lives is happening. Therefore, Higher Education Institutions (HEIs) need to be in the front-line of innovation by promoting disruptive technologies like Blockchain.

Although there is no consensus in the scientific community about what is a radical innovation, with different propositions over time, and with the type of industry studied (Dahlin & Behrens, 2005), we can perceive some common factors among these definitions, such as the degree of novelty of the technology and its impact on business models and process. Thus, a radical innovation involves applying a new technology in markets that do not exist or that profoundly change markets and end up being the basis of a whole new generation of products and businesses (McDermott & O'Connor, 2002). Moreover, they are innovations that change the way we live (Castro & Au-Yong-Oliveira, 2021). By contrast, an incremental innovation delivers minor improvements to a product or service through small advances in the technology (Chandy & Tellis, 1998). The first iPhone and Tesla cars are examples of radical innovations that create entirely new markets, displaced established competitors, provoked lifestyle changes, and created new consumer habits.

Moreover, blockchain is seen as fundamental in creating a more secure digital environment for European citizens and businesses, and several policies and advances are being promoted within the European Commission, including the development of a European Blockchain Services Infrastructure (EBSI) for public organizations in member countries to create their decentralized applications. The utilization for diplomas is one of the cases that are on the EBSI roadmap (European Commission, 2021a).

With all that in perspective, we consider the possibility to have the Higher Education Diplomas in blockchain as a radical innovation, so far as the resources it will save and the benefits -economics and social, for the academic community and society in general.

2. Literature review

2.1. Introduction

This section presents the literature review to understand how blockchain technology can be applied in Higher Education Institutions to manage diplomas, certificates, and academic transcripts. To reduce or eliminate forgery, increase trust, eliminate manual intensive activities, and consequently bring students to the center of the process and ownership of their academic information.

The literature review was conducted by searching the Scopus database for the following concepts: "blockchain", "diploma", and "higher education" and using a combination of the logical operators "AND" and "OR". The search considered the article's Title, Abstract, and Keywords, and it was conducted in January 2021 to identify the relevant literature.

The query and number of documents returned are in Table 1

Table 1 - Search Query in Scopus Database

Query	Documents Returned
TITLE-ABS-KEY (blockchain AND (diploma* OR "higher education"))	125

A brief bibliometric analysis was also performed to increase our understanding of the data. To support this activity, we choose to use the statistical tool R, executed through Rstudio (an Integrated Development Environment for R) in conjunction with bibliometrix library (Aria & Cuccurullo, 2017). A summary of results is presented in Table 2, Table 3, and Table 4.

Table 2 - Main data information

Information	Result
Period of Publication	From 2016 to 2021
Documents Returned	125
Average Years from publication	1,72

Table 3 - Number of documents per type

Document Types	Number of Documents
Conference Paper	62

Document Types	Number of Documents
Article	33
Conference Review	25
Book Chapter	1
Editorial	1
Review	1
Short Survey	1

Table 4 - Number of documents published per year

Annual Scientific Production	Number of Documents
2016	1
2017	4
2018	19
2019	44
2020	49
2021	8

From the analysis of information presented in aforementioned table, we confirm the literature is recent and has been gaining interest from researchers over the past few years, achieving the highest number of publications in 2020. The majority of articles were published between 2019 and 2020. In contrast, just one article was published in 2016. Almost half of the documents are Conference Papers, with 62 occurrences, followed by 33 Articles and 25 Conference Review documents.

Next, to select the documents for review, the results were downloaded in csv format, and further analysis was conducted in an Excel spreadsheet. Documents were then ranked by the number of citations, from highest to lowest, and had their titles and abstracts read to identify relevant literature.

Then, 31 documents were selected for a complete reading. After reading, seven documents were discarded as they did not bring additional relevant information to the research. Two additional documents were included in the review, were originated from other sources (through References found in other articles).

Figure 1 is a visual depiction of systematic literature review phases based on a Prisma flow diagram (Moher et al., 2009).

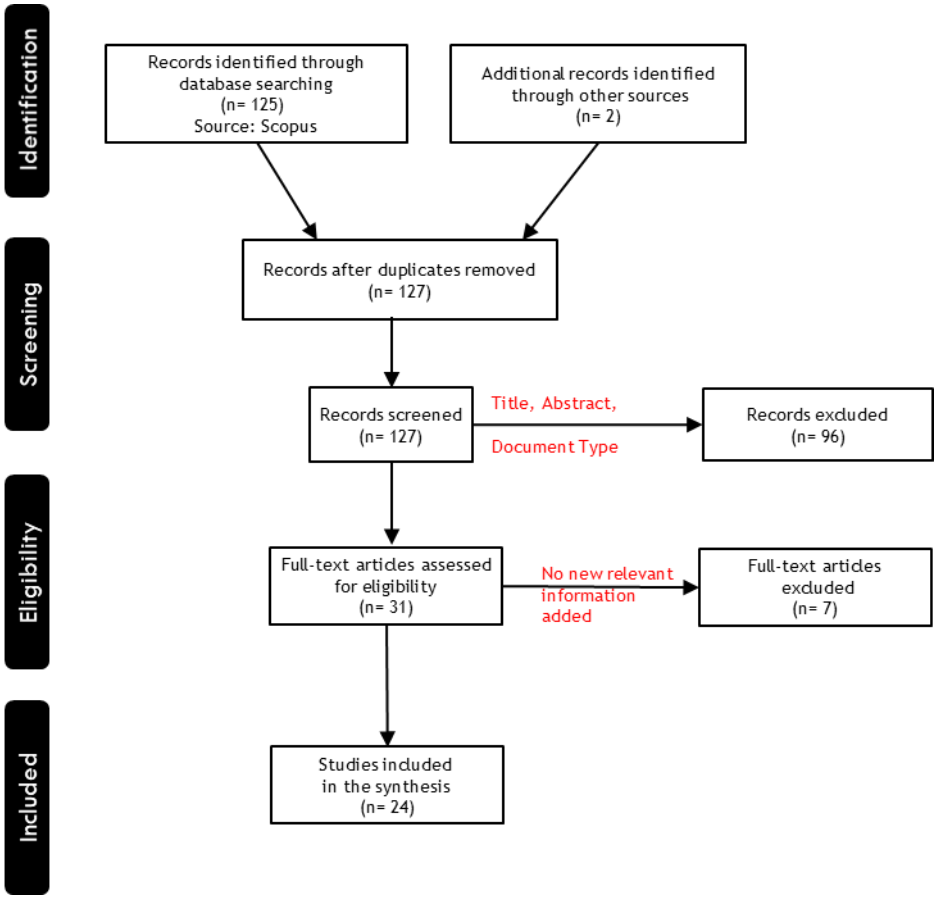

Figure 1 - Prisma flow diagram with steps of the literature review

2.2. Background concepts

2.2.1. Blockchain

Innovation is "a new or improved product or process (or combination thereof) that differs significantly from the unit's previous products or processes and that has been made available to potential users (product) or brought into use by the unit (process)" as defined by OECD/Eurostat (2018, p. 60). Blockchain can be seen as a product innovation (considering the novelty of the technology) that leads to process and business innovation in the form of new services and business offerings.

Blockchain is a radical innovation – that "involve substantially new technology" (Chandy & Tellis, 1998) - and an emerging technology that implements a digital distributed ledger deployed over a decentralized, self-trustful computer network that does not rely on a central trust party to ensure the validity of its transactions (Kamišalić et al., 2019). Therefore,

Blockchain guarantees transparency, security, traceability, and tamper-proof characteristics (Saberi et al., 2019). Blockchain was initially proposed to resolve the "double-spending" – "a situation where someone could try to use the same money be used to pay more than one transaction" - issue without the need of a trusted central authority to intermediate and ensure the validity of the transaction (Nakamoto, 2008).

From its inception, the technology was associated with cryptocurrencies like bitcoin; this phase is known as Blockchain 1.0. The introduction of smart-contracts represents the surge of Blockchain 2.0, with the development of a new set of applications in financial areas. With the growing interest of several other businesses and industries, mainly because of Blockchain's principal characteristics of decentralization, immutability, and transparency, many solutions are being developed. Thus, we enter the Blockchain 3.0 phase (Kamišalić et al., 2019).

Blockchain is a distributed ledger that can store transactions in a decentralized, transparent way, implemented as a peer-to-peer network. Transactions stored on it are immutable and rely on consensus protocol to ensure integrity in a decentralized and trustful way (Arndt & Guercio, 2020). In a simplified form, Blockchain is composed of cryptographic and timestamped information blocks. Each block also stores a hashed pointer information to its predecessor (the chain) (Christidis & Devetsikiotis, 2016).

The blockchain characteristics of immutability, decentralization, transparency, availability, and trust are genuinely distinctive, paving the way to disrupt several business models and industries. Higher Education is obviously one of them. Therefore, it is essential to understand and investigate their potential (Awaji et al., 2020).

2.2.2. Smart Contracts

Smart contracts were elaborated by (Szabo, 1997). According to his work, "Smart contracts combine protocols, user interfaces, and promises expressed via those interfaces, to formalize and secure relationships over public networks".

Despite being defined in the literature for such a long time, they only started to attract attention recently, after being introduced as a prominent feature by Ethereum blockchain (Chent et al., 2018). Therefore, they allowed a whole new set of applications to be developed, expanding blockchain usage far beyond cryptocurrency transactions. Smart contracts allowed a programmable blockchain, where smart contracts can be seen as an object with attributes,

states, and methods that can be executed to change its own state or from other smart contracts (Capece, 2020).

Use cases of blockchain and smart contracts are now found in several different applications and industries like Electronic Voting Systems, Electronic Medical Records, Identity Management Systems, Decentralized Notary (Di Francesco Maesa & Mori, 2020).

Moreover, there are several systems proposed for diploma and transcript management using smart contracts (Gresch et al., 2019; Nguyen et al., 2017; Meyliana et al., 2019).

2.2.3. Blockchain Initiatives in Higher Education

According to (Kamišalić et al., 2019, p.115), Blockchain is a "perfect match" for Higher Education. Besides, there is a growing interest in applying Blockchain in HEI, particularly issuing and verifying diplomas. Although the author does not intend to compile an extensive list of current initiatives but shed light on the current status of research on the topic, the literature review identified initiatives, ranging from proposals to prototypes and pilot programs spread worldwide. A summary of initiatives is given in Table 5.

Table 5 - Identified blockchain diploma verification initiatives

Institution	Country	Status	Underlying Technology
University of Rome "Tor Vergata"	Italy	Pilot	Bitcoin/Blockcerts
Southern Taiwan University of Science and Technology	Taiwan	Prototype	Ethereum
Xiangtan University	China	Pilot	Smart contracts
Bina Nusantara University	Indonesia	Conceptual Model	N/A
University of Zurich	Switzerland	Prototype	Ethereum
University of Lisbon	Portugal	Pilot	Ethereum
HCMC University of Technology	Vietnam	Prototype	Ethereum
University Fernando Pessoa	Portugal	Prototype	Blockcerts/Bitcoin/ Ethereum
South Ural State University	Russia	Prototype	Blockcerts
University of Maribor (EduCTX)	Slovenia	Pilot	Ethereum
University of Nicosia	Cyprus	Production	Bitcoin

2.2.4. Digital Diplomas and Transcritps in Blockchain

The initiatives for diploma management (from issuance to verification) using Blockchain are not circumscribed to a specific geographic location or group of researchers. It has spread from Asia (Cheng et al., 2018; Duan et al. 2017), Europe (Kamišalić et al., 2018; Gresch et al., 2019; Vidal et al., 2019), and to the Americas (Palma et al., 2019) as identified in the literature.

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The existing process is clearly identified as inefficient, time-consuming, manually intensive, and costly (Capece et al., 2020). All this inefficiency brings attention to the issue of certification forgery (Cheng et al., 2018), which is a significant flaw in the system and affects society in several ways (Serranito et al., 2020). Surveys indicate relevant numbers of quality issues with certification and diploma information presented in job applications (forgery or fraudulent information) (Gresch et al., 2019; Serranito et al., 2020).

Universities may offer some form of verification or rely on other services for this task to minimize the problem. Despite that, such initiatives suffer from a lack of standardization and unification (Vidal et al., 2019).

Blockchain is seen as a potential solution to improve the process, increase transparency, bring added efficiency, achieve decentralization, and consequently reduce diploma fraud. It can also be used to build a global (transnational) certificate validation ecosystem (Serranito et al., 2020). Its characteristic of immutability can enhance credibility and reduce the risk of information loss (Cheng et al., 2018).

From the Higher Education Institution's point of view, blockchain-based issuance and validation solutions may be beneficial, such as internationalization programs, joint-degrees, and international student applications, reducing administrative tasks and costly processes. On the other hand, from the students' point of view, such systems may simplify student tasks to validate received credentials and eliminate unnecessary intermediaries in the process (Kamišalić et al., 2019).

Although most initiatives are still under early development phases, as prototype or pilot implementations, a few applications surpassed that stage and evolved to commercial applications, even generating spin-offs. This is the case of the University of Nicosia, which since 2017 is issuing all diplomas on Bitcoin using its own developed open source solution (Turcu et al., 2018; Blockchain Certificates. ,n.d.).

2.2.5. Implementation Barriers

The research of Blockchain for Higher Education is recent and increasing in recent years. Most of the literature and researchers seek to demonstrate and emphasize the disruptive capabilities and benefits of the technology. Otherwise, there is not much discussion and attention to implementation challenges (Capece et al., 2020).

In the case of the University of Rome, presented by (Capece et al., 2020), most of the issues during the development of solutions arose from the novelty of the technology and its complexity. Moreover, in the same study, the authors highlight concerns about the immutability characteristics of the solution: "… the immutability nature of such credentials makes it even more important to carefully consider the long-term effects of this technology" (Capece et al., 2020, p. 7).

The immutability question is a big concern, and (Vidal et al., 2020) have dedicated one article to describe a proposal to overcome this situation when there is a need to revoke an issued diploma or credential.

(Turcu et al., 2018) explain that the research topic is still in the beginning, and standards and regulations would be necessary to expand utilization. This is confirmed by (Turkanović et al., 2018, p. 5113). Other limitations that need to be addressed include ensuring data privacy compliance (e.g., General Data Protection Regulation in Europe), and the latency of blockchain transactions and storage capacity is also indicated by (Turcu et al., 2018).

Operational costs and scalability are also considered implementation barriers (Nguyen et al., 2017).

Another critical factor to be considered is that human beings are naturally adverse to change, which is an additional barrier to implementing the solution globally.

2.2.6. Diffusion of Innovation

The diffusion of innovation theory formulated by Everet M. Rogers (Rogers, 2010) and reviewed in the context of the education field by Shain (2006 pp 14-23) shows five attributes that influence the adoption of an innovation or technology. The attributes are: relative advantage, compatibility, complexibility, trialability, observability. The higher their degrees, the higher the adoption rate, except complexibility, which works opposite. The lowest the complexity, the higher the adoption rate. Furthermore, in his research, Friedlmaier et al. (2018 p. 3524) deducted them to the Blockchain. The technical characteristics (decentralization, cryptography, immutability) of Blockchain made it difficult to understand, and therefore, the perceived complexibility is increased.

Therefore, to understand how a radical innovation like Blockchain can be introduced and adopted is essential to understand how stakeholders, users, and society perceive its value and contributions. In that sense, the same is expected to be evaluated to assess the potential of adopting blockchain technology by HEIs.

2.3 Synthesis

In this section, we present the synthesis of the literature review. The results are in the format of a table detailing document reference, contribution, additional considerations, and future research directions. See Table 27 in Annex.

As mentioned previously in Chapter 2, we performed a bibliometric analysis on the data resulting from the Scopus search - the query used is presented in Table 1 - and consequently identified the five keywords that appear most frequently in the results. The keywords and their respective frequency of occurrence are: Blockchain (in 61 documents), Higher Education (26 documents), Education (12 documents), Blockchain Technology (10 documents), and Smart Contracts (10 documents). Moreover, the research production is not circumscribed to one geographic location or region. Instead, we have authors from distinct parts of the world, as distinct as Albania, Brazil, China, Indonesia, Portugal, Slovenia, and the USA, to name a few.

2.4 Analysis

The literature review shows the existence of several initiatives and research looking to unleash the blockchain potential for the Higher Education sector worldwide. We see initiatives in almost every region, from Asia (Cheng et al., 2018), Europe (Kamišalić et al.,

2019), and the Americas (Palma et al., 2019). There are more mature initiatives like the case of the University of Nicosia that was the first university to accept bitcoins for tuition fee payments, and that since 2017 is issuing all diplomas in Blockchain (Fedorova & Skobleva, 2020) (Blockchain Certificates, n.d.) but this is not the norm. Notably, the literature shows two main groups of initiatives. In one group are the initiatives addressing the issue, management, and verification of diplomas and certificates. Another group of initiatives proposes broader solutions that encompass certificates and the whole academic life cycle, including transcripts and, to the extent, solutions that will support long-life learning.

The majority of the literature is focused on describing the prototypes and solutions proposed and, in some cases, the results achieved. The more technical documents also provide implementation details and excerpts from the programming code utilized and user interfaces for the solutions' main components. The literature is rich in examples and prototypes; the presented cases are, generally, specific to one university or a single location, addressing specific regulatory requirements or the university specifics. Ultimately, a holistic discussion is missing in indicating paths to promote such solutions' broader adoption.

On the other hand, there are just a few cases where the authors searched to understand the level of HEIs awareness and understanding of how blockchain technology can be beneficial to academia and society. We identified only two such research studies, one from Russia (Fedorova, E. P., & Skobleva, 2020) and another in Romania (Stoica et al., 2020), addressing this topic.

As identified by (Turcu et al., 2018), Blockchain in education is still not a priority in many locations. This situation is mostly caused by the lack of awareness of the main stakeholders about the potential of the technology.

Specific to Portugal, the existing literature focuses on prototype developments and how technical questions can be addressed by blockchain solutions (Vidal et al., 2019) (Vidal et al., 2020). Moreover, one author proposes a model to address the need to interchange information between HEIs in the context of the Erasmus program (an ever more popular and increasingly vital program to promote added cohesion in the European Union between member states) (Cardoso et al., 2020).

According to the study from (Awaji et al., 2020), the challenges are related to blockchain immutability, usability, privacy, cost of the transactions, scalability issues, lack of a standard design to store the data, select the right consensus algorithm, and lack of motivation from

stakeholders to change legacy applications. Moreover, due to the technology's novelty and increasing interest in the topic, further research is still needed (Awaji et al., 2020).

Besides the disruptive potential of Blockchain, the lack of knowledge and awareness about the technology and its potential by the key academic stakeholders (teachers, administrators, students, and employers) is one of the main challenges for increased adoption.

2.5 Conclusions

From the literature review conducted, it is clear that are missing studies (i.e., a gap in the literature exists) that approach the topic from a holistic perspective, looking for an expanded set of universities or a whole region or country to assess the current status of awareness and knowledge of the critical stakeholders about blockchain potential for HEIs in general. Moreover, the literature clearly indicates that the topic is in its infancy and further research is more than necessary. Therefore, we expect to contribute to the field with the survey to understand the current awareness of HEIs and students in Portugal about blockchain solutions for the Higher Education sector. Notably, for the topic of diploma and transcripts management, what are the particular challenges and benefits that can be expected for Portugal? We expect to evaluate how the academic community sees the potential advantages, the compatibility with existing administrative processes, and its complexity for adoption. Besides, we also expect to contribute by indicating future research avenues.

3. Methodology

3.1. Research Design

From the literature review, we could assess the current state of blockchain initiatives for Higher Education from a global perspective. Moreover, we were able to identify the academic community's level of awareness in two countries, namely, Russia and Romania. As a radical innovation, Blockchain can disrupt the current manually intensive, costly, and forgery-prone diploma and transcript management processes. Therefore, adopting a student-centric approach, these solutions can positively impact the students in an increasingly mobile and digitalized world, contributing decisively to increase the inflow of highly qualified students and professionals in Portugal.

The objective of the study is to understand: "What is the current state of the blockchain scenario in Portuguese Universities and Polytechnics, particularly for diploma and transcript management, and what are the future impacts for the students?".

From the objective, we propose two research questions:

> RQ1: What is the current awareness of blockchain-based solutions for diploma management, from issuance to verification, by HEIs and students in Portugal?
>
> RQ2: What are the perceived benefits and importance of blockchain-based solutions for diploma management, from issuance to verification, by HEIs and students in Portugal?

The study will use a mixed-method research approach to understand the research problem in a more complete way.

A qualitative study (involving interviews, based on an interview script) will be performed involving the main stakeholders (course directors, administrative staff, teachers, and researchers) from HEIs in Portugal to assess the current environment, the level of awareness about the solution, and comprehension of the benefits. The qualitative method is seen as adequate due to the research's exploratory nature. In this part of the research, we aim to understand the participants' views about the problem and the proposed solution. We will use a purposive sample, where participants will be chosen based on them being well informed and having the specific knowledge to contribute with rich information to the study (Acharya et al., 2013). Therefore, these homogeneous cultural samples can lead to high-quality results with a few interviews, varying from as low as four in this situation (Remenyi, 2013).

A quantitative survey will also be performed to gather the perspectives of those most impacted by such a system – the students themselves. Therefore, a quantitative approach is preferable to collect opinions from the large student population, who will benefit most from the solution, in principle. Descriptive and parametric/non-parametric tests (as needed, in case normality distribution of the data be violated) for hypothesis testing will be performed to find associations between the data variables.

In the quantitative study, the importance and perceived benefits will be evaluated under four components. First is the importance of Blockchain for a digital diploma, where students are requested to evaluate the importance attributed to having the possibility of receiving a digital diploma in Blockchain. The second component, to assess the importance of a decentralized platform, students are asked to evaluate the importance of sharing academic information without university intervention. The third and fourth components look to assess how students evaluate the importance of universities in Portugal and abroad to accept a digital version of the diploma. Figure 2 is a visual representation of the components that comprised the benefits for the students.

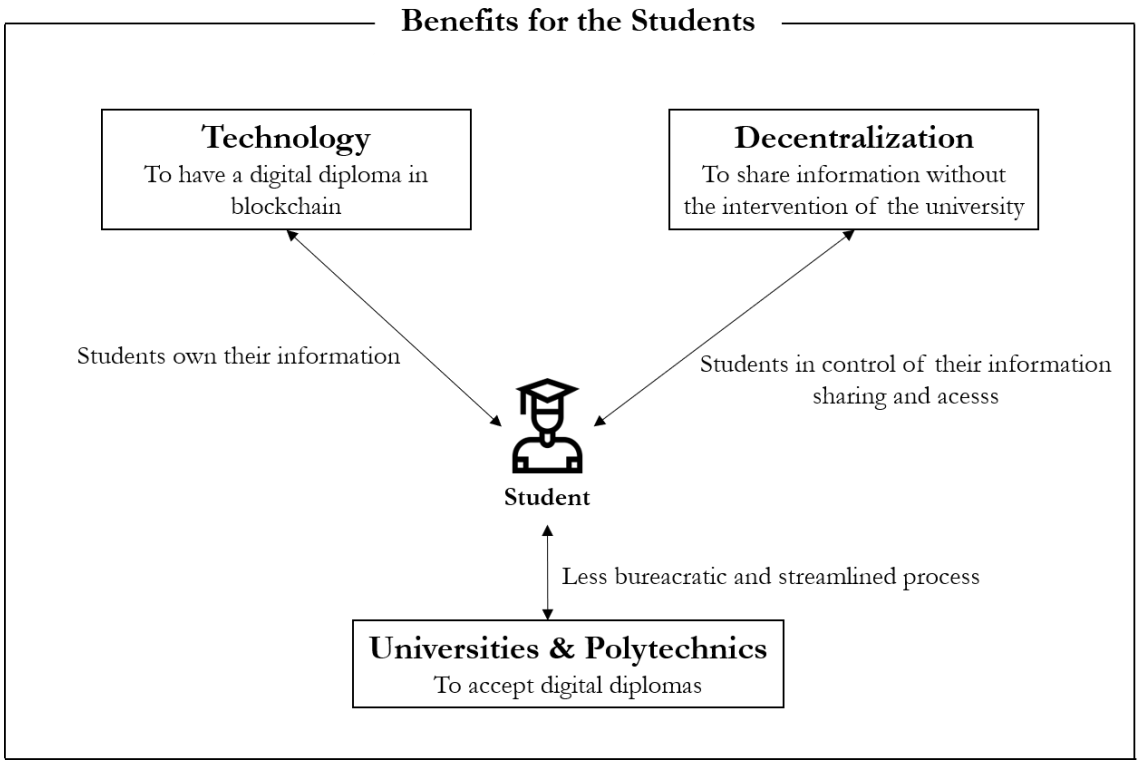

Figure 2 - Visual representation of benefits for the students

Then we will test the association of the four components with gender, study cycle (first, second or third), and between national and international students.

The null and alternative hypotheses are presented in the format of a table detailing the component (or perceived benefit), associated variable, and the respective null and alternative hypothesis. The null and alternative hypothesis for gender is given in Table 6, and the remaining hypothesis for the other variables are specified in Table 28 and Table 29 in the Annex.

Table 6 - Null and Alternative Hypothesis for Gender x Perceived Benefits

Component	Gender	
	Null Hypothesis	**Alternative Hypothesis**
1. The importance attributed by students in having the possibility of receiving a digital version of the diploma in Blockchain	**H0**: There is no association between gender and the importance attributed by students in having the possibility of receiving a digital version of the diploma in the Blockchain.	**H1**: There is an association between gender and the importance attributed by students in having the possibility of receiving a digital version of the diploma in the Blockchain.
2. The importance of being able to share their academic information without the need for university intervention	**H2**: There is no association between gender and the importance of being able to share this information without the need for university intervention.	**H3**: There is an association between gender and the importance of being able to share this information without the need for university intervention.
3. How important it would be for the students that universities in Portugal to accept digital diplomas	**H4**: There is no association between gender and how important it would be that universities in Portugal accept digital diplomas.	**H5:** There is an association between gender and how important it would be that universities in Portugal accept digital diplomas.
4. How important it would be for the students that universities abroad to accept digital diplomas	**H6:** There is no association between gender and how important it would be that universities abroad accept digital diplomas.	**H7**: There is an association between gender and how important it would be that abroad accept digital diplomas.

We shall aim for at least 100 answers to the survey – to provide us an accuracy of around plus or minus 10% (Saunders and Cooper, 1993). However, some statisticians state that, for example, 35 answers are enough for statistical analyses to be performed (Saunders & Cooper, 1993).

4. Quantitative Results - Students Awareness and Perceived Benefits

4.1. Introduction

The quantitative study was conducted in the form of an electronic survey sent through the University of Porto webmail on March 18th of 2021 to all students actively enrolled in any course level at the time. The communication was sent to 9009 recipients. The survey comprises 24 questions in the Portuguese and English languages. A total of 172 questionnaires were completed between March 18th through April 1st of 2021. Copy of email requests and survey questionnaires are found in the Annex section.

4.2. Student Community Awareness and Perceptions about Blockchain potential for Higher Education Diplomas

As students can be seen as the most impacted stakeholders with the introduction of digital diplomas in Blockchain, in this part of the study, our objective is to assess the level of awareness of the student's community about blockchain technology, its perceived benefits, and the potential advantages in such solution.

4.2.1 Sample Characterization

We have used descriptive statistics to characterize the sample and used IBM SPSS (version 26, release 26.0.0.0, 64-bit edition) for calculations. The confidence level used was 95% ($p > 0.05$).

Our sample has a total of 172 records (each record represents one individual response to our survey). The average age of the respondents is 24.54 years, the minimum age is 18 years, and the maximum age is 60 years. The majority of the respondents are male, with n=106 (61.6%). Female respondents account for 37.2% (n=64) of our sample and 1.2% (n=2) preferred not to inform their gender.

We have nine different nationalities represented in our sample. The Portuguese represent 82% of the respondents (n=141), followed by Brazilians with 13.4% (n=23). Complete information about the nationalities is in Table 30 in the Annex.

We have 168 responses from current students, but 4 identified themselves as not studying at the time of the survey. Moreover, people currently working represent 73.8% (n=127) of our sample. This information is presented in Table 7.

Table 7 - Distribution of Students and Workers

	Are you studying?	Are you working?
Yes	97.7% (n=168)	73.8% (n=127)
No	2.3% (n=4)	26.2% (n=45)

Master's students are most respondents with a 65.5% share (n=110), followed by undergraduate students with 22% (n=37). The complete data are in table 8 below.

Table 8 - Student's cycle

Study Level	Counts	% Total	Cumulative %
Master	110	64.0	64.0
Bachelor/Licenses	37	21.5	85.5
Not Studying	4	2.3	87.8
Doctorate	20	11.6	99.4
Continuous Education	1	0.6	100.0

4.2.2 Knowledge of Blockchain

As indicated by Rogers (2010) in his deduction of diffusion innovation theory and further deducted for Blockchain by Friedlmaier et al. (2018, p. 3524), as more complex the technology, the lower the adoption rate. Therefore, to assess the awareness and knowledge of Blockchain among Higher Education students, we asked respondents to classify their knowledge of the technology, the most known blockchain application, and the most crucial blockchain attribute in their opinions.

For the question ***"What is your level of knowledge about blockchain technology?",*** 55.2% of respondents (n = 95) classified their knowledge of Blockchain as Low or Very Low, and 15 responses indicated having no knowledge about it. This may not be seen as a surprise due to the nature of technology and its novelty but may indicate that adoption rates may still be affected until knowledge and understanding of technology expand. Table 9 shows the complete information.

Table 9 - Knowledge about blockchain technology

Knowledge Level	Frequency	Percentage (%)
Very Low	38	22.1
Low	42	24.6
Reasonable	51	29.7
High	20	11.6
Very High	6	3.5
None / I don't know	15	8.7
Total	172	100.0

Then, interviewees were given a list of blockchain applications and asked to indicate whether they were most familiar or had heard of before. As expected, Cryptocurrencies (e.g., Bitcoin) are the most known utilization of Blockchain, with 83.1% selection (n=143), followed by 7,0% of respondents informing not knowing any application of Blockchain. Complete set of answers and statistics are in Table 10

Table 10 - Blockchain Applications known

Application	Frequency	Percentage (%)
Cryptocurrencies (e.g. Bitcoin)	143	83.1
Degrees and electronic academic information	1	0.6
Electronic identity management	4	2.3
Intellectual property management	4	2.3
Electronic Medical Record	2	1.2
None / I don't know	12	7.0
Others*	6	3.5
Total	172	100

*Others enabled responses to be typed. Responses included occurrences like: "all of the above", "NFT" and "several others".

Furthermore, interviewees were asked to indicate the most important characteristic of Blockchain in their views. The five key blockchain features (Immutability, Decentralization, Disintermediation, Security, and Traceability) with a brief description were presented for selection.

Security was the most important characteristic in the opinion of the students, with n=71 (41.3%). Complete information is in Table 11.

Table 11 - Most important Blockchain features

Blockchain features	Frequency	Percentage (%)
Decentralization	34	19.8
Disintermediation	27	15.7
Immutability	26	15.1
Rastreability	14	8.1
Security	71	41.3
Total	172	100

The diffusion of innovation theory formulated by Everet M. Rogers (Rogers, 2010) and reviewed in the context of the education field by Shain (2006 pp 14-23) shows five attributes that influence the adoption of an innovation or technology. The attributes are: relative advantage, compatibility, complexibility, trialability, observability. The higher their degrees, the higher the adoption rate, except complexibility, which works in the opposite direction. The lowest the complexity, the higher the adoption rate. Furthermore, in his research, Friedlmaier et al. (2018 p. 3524) deducted them to the Blockchain. The technical characteristics (decentralization, cryptography, immutability) of Blockchain made it difficult to understand, and therefore, the perceived complexibility is increased.

4.2.3. Perceptions about the current model

To determine the level of student satisfaction with the current process of requesting and validating academic documents, respondents were asked to assign a score (on a scale of values from one to five, where one represents Not Satisfied at all and five indicates Very Satisfied) for the attributes: ease of the process, cost of the process, and time of the process. For better characterization, these questions were presented to respondents based on a previous filter question to select only those respondents that had already requested some academic document in the past (n=96).

Descriptive statistics are in Table 12.

Table 12 - Student's perception of the current process

Statistic	Easy of the Process	Cost of the Process	Time of the Process
N	96	96	96
Missing	0	0	0
Mean	3.09	2.68	2.53
Median	3.00	3.00	3.00
Standard deviation	1.19	1.35	1.11
Minimum	1.00	1.00	1.00
Maximum	5.00	5.00	5.00
Shapiro-Wilk p*	< 0.001	< 0.001	< 0.001

* A low p-value (<0.05) suggests a violation of the assumption of normality

As we could notice, satisfaction with the existing process has the lowest levels for time (mean = 2.53), followed by the cost (mean = 2.68). Easy of the process falls just a little above average with a mean rate of 3.09.

4.2.4 Perceived Benefits of Blockchain and Digital Diplomas

Blockchain and its features allow the issuance of digital diplomas, which can then be shared and verified in their authenticity and validity in an automatic and decentralized manner regardless of the institution that issued them. Therefore, such a platform can be highly beneficial for students once they acquire their degrees and throughout their lives. It will permit students to share their academic information in a simple, transparent, decentralized, and secure way with employers, other institutions, or in whatever other situation necessary. This section seeks to understand how students perceived these benefits of a diploma solution using blockchain technology by specific assessing four components:

- (1) The importance attributed by students in having the possibility of receiving a digital version of the diploma in Blockchain
- (2) The importance of being able to share their academic information without the need for university intervention,
- (3) How important it would be for the students that universities in Portugal to accept digital diplomas
- (4) How important it would be for the students that universities abroad to accept digital diplomas

Students were asked to score their perceptions using a scale of values from one to five, where one represents Not Important at All and five indicates Very Important. Descriptive statistics are depicted in Table 13.

Table 13 - Perceived benefits of Blockchain and Digital Diplomas in the student's evaluation

Statistic	(1)	(2)	(3)	(4)
N	172	172	172	172
Missing	0	0	0	0
Mean	3.63	3.85	4.10	4.17
Median	4.00	4.00	4.00	4.00
Standard deviation	1.23	1.12	0.953	0.949
Minimum	1.00	1.00	1.00	1.00
Maximum	5.00	5.00	5.00	5.00
Shapiro-Wilk p*	< 0.001	< 0.001	< 0.001	< 0.001

* A low p-value (<0.05) suggests a violation of the assumption of normality

Gender x Perceived Benefits

To understand if gender is a determinant for how students perceived the benefits of blockchain diplomas, descriptive and t-tests analysis to confirm or reject the null hypothesis.

For the importance attributed by students in to have the possibility of receiving a digital diploma in Blockchain, the null hypothesis is:

> H0: *There is no association between gender and the importance attributed by students in having the possibility of receiving a digital version of the diploma in the Blockchain.*

The alternative hypothesis would be:

> H1*: There is an association between gender and the importance attributed by students in having the possibility of receiving a digital version of the diploma in the Blockchain.*

The result and decisions are summarized in Table 14.

Table 14 – H0, H1 hypothesis tests result and decision

Gender	Mean	Std. Dev.	Test-statistics	Statistic	p	Null Hypothesis	Decision
Female	3.81	1.13	One-Way ANOVA Kruskal-Wallis	4.289*	0.117	H0	Retain null hypothesis
Male	3.56	1.27					
Prefer not to Say	2.00	1.41					

* Normality assumption violated for parametric testing. Kruskal-Wallis used as an alternative non-parametric test

In regards to the importance of being able to share their academic information without the need for university intervention, the null hypothesis is:

> H2: *There is no association between gender and the importance of being able to share this information without the need for university intervention.*

The alternative hypothesis would be:

> H3*: There is an association between gender and the importance of being able to share this information without the need for university intervention.*

The result and decisions are summarized in Table 15.

Table 15 – H2, H3 hypothesis tests result and decision

Gender	Mean	Std. Dev.	Test-statistics	Statistic	p	Null Hypothesis	Decision
Female	3.91	1.09	One-Way ANOVA Kruskal-Wallis	5.352*	0.069	H2	Retain null hypothesis
Male	3.87	1.10					
Prefer not to Say	1.50	0.707					

The null hypothesis for the importance attributed to having the possibility of Portuguese universities accept a digital diploma is:

H4: *There is no association between gender and how important it would be that universities in Portugal accept digital diplomas*.

The alternative hypothesis would be:

H5*: There is an association between gender and how important it would be that universities in Portugal accept digital diplomas*.

The result and decisions are summarized in Table 16.

Table 16 - H4, H5 hypothesis tests result and decision

Gender	Mean	Std. Dev.	Test-statistics	Statistic	p	Ho	Decision
Female	4.17	0.935	One-Way ANOVA Kruskal-Wallis	1.891*	0.389	H4	Retain null hypothesis
Male	4.07	0.969					
Prefer not to Say	3.50	0.707					

The fourth component assessed was the importance attributed to having the possibility of universities abroad accept a digital diploma. The null hypothesis is:

H6: *There is no association between gender and how important it would be that universities abroad accept digital diplomas*.

The alternative hypothesis would be:

H7: *There is an association between gender and how important it would be that abroad accept digital diplomas*.

The result and decisions are summarized in the following tables

Table 17 - H6, H7 hypothesis tests result and decision

Gender	Mean	Std. Dev.	Test-statistics	Statistic	p	Null Hypothesis	Decision
Female	4.22	1.000	One-Way ANOVA	2.277*	0.320	H6	Retain null hypothesis

Gender	Mean	Std. Dev.	Test-statistics	Statistic	p	Null Hypothesis	Decision
Male	4.15	0.924	Kruskal-Wallis				
Prefer not to Say	3.50	0.707					

Gender is not a determinant for how students perceived the benefits of blockchain diplomas from the results. The null hypothesis was retained for the four components of analysis.

Study Cycle x Perceived Benefits

To understand if the study cycle is a determinant for how students (respondents who are currently studying) perceived the benefits of blockchain diplomas, descriptive and t-tests analysis to confirm or reject the null hypothesis.

For the importance attributed by students in to have the possibility of receiving a digital diploma in Blockchain, the null hypothesis is:

> H8: *There is no association between the study cycle (1st, second or third) and the importance attributed by students in having the possibility of receiving a digital version of the diploma in the Blockchain.*

The alternative hypothesis would be:

> H9: *There is an association between the study cycle (1st, second or third) and the importance attributed by students in having the possibility of receiving a digital version of the diploma in the Blockchain.*

The result and decisions are summarized in Table 18.

Table 18 - H8, H9 hypothesis tests result and decision

Study Cycle*	Mean	Std. Dev.	Test-statistics	Statistic	p	Null Hypothesis	Decision
Bachelor/Licensee	3.70	1.08	One-Way ANOVA Kruskal-Wallis	0.293***	0.864	H8	Retain the null hypothesis
Master**	3.61	1.31					
Doctorate	3.85	1.04					

*Not considered responses from non-students (n=4) and one reported as Continuous Education (n=1)

**Master includes Masters and Integrated Master courses

**Normality assumption violated for parametric testing. Kruskal-Wallis used as an alternative non-parametric test.

In regards to the importance of being able to share their academic information without the need for university intervention, the null hypothesis is:

> H10: *There is no association between the study cycle (1st, second or third) and the importance of being able to share this information without the need for university intervention*.

The alternative hypothesis would be:

> H11*: There is an association between the study cycle (1st, second or third) and the importance of being able to share this information without the need for university intervention*.

The result and decisions are summarized in Table 19.

Table 19 H10, H11 hypothesis tests result and decision

Study Cycle*	Mean	Std. Dev.	Test-statistics	Statistic	p	Null Hypothesis	Decision
Bachelor/Licensee	4.03	0.866	One-Way ANOVA Kruskal-Wallis	0.705**	0.703	H10	Retain the null hypothesis
Master	3.83	1.16					
Doctorate	4.05	0.999					

*Not considered responses from non-students (n=4) and one reported as Continuous Education (n=1)

**Normality assumption violated for parametric testing. Kruskal-Wallis used as an alternative non-parametric test.

The null hypothesis for the importance attributed to having the possibility of Portuguese universities accept a digital diploma is:

> H12: *There is no association between the study cycle (1st, second or third) and how important it would be that universities in Portugal accept digital diplomas*.

The alternative hypothesis would be:

> H13*: There is an association between the study cycle (1st, second or third) and how important it would be that universities in Portugal accept digital diplomas*.

The result and decisions are summarized in Table 20.

Table 20 - H12, H13 hypothesis tests results and decision

Study Cycle*	Mean	Std. Dev.	Test-statistics	Statistic	p	Ho	Decision
Bachelor/Licensee	4.14	0.855	One-Way ANOVA	1.681**	0.432	H12	
Master	4.05	0.994					

Study Cycle*	Mean	Std. Dev.	Test-statistics	Statistic	p	Ho	Decision
Doctorate	4.40	0.681	Kruskal-Wallis				Retain the null hypothesis

*Not considered responses from non-students (n=4) and one reported as Continuous Education (n=1)

**Normality assumption violated for parametric testing. Kruskal-Wallis used as an alternative non-parametric test.

The last component assessed was the importance attributed to having the possibility of universities abroad accept a digital diploma. The null hypothesis is:

> H14: *There is no association between the study cycle (1st, second or third) and how important it would be that universities abroad accept digital diplomas.*

The alternative hypothesis would be:

> H15*: There is an association between the study cycle (1st, second or third) and how important it would be that abroad accept digital diplomas.*

The result and decisions are summarized in Table 21.

Table 21 - H14, H15 hypothesis tests results and decision

Study Cycle*	Mean	Std. Dev.	Test-statistics	Statistic	p	Ho	Decision
Bachelor/Licensee	4.11	0.875	One-Way ANOVA Kruskal-Wallis	2.711**	0.258	H14	Retain the null hypothesis
Master	4.15	0.979					
Doctorate	4.50	0.688					

*Not considered responses from non-students (n=4) and one reported as Continuous Education (n=1)

**Normality assumption violated for parametric testing. Kruskal-Wallis used as an alternative non-parametric test.

The study cycle is not a determinant for how students perceived the benefits of blockchain diplomas from the results. The null hypothesis was retained for the four components of analysis.

Nationality x Perceived Benefits

To understand if nationality is a determinant for how students perceived the benefits of blockchain diplomas, descriptive and t-tests analysis to confirm or reject the null hypothesis. Therefore, for the importance attributed by students in to have the possibility of receiving a digital diploma in Blockchain, the null hypothesis is:

H16: *There is no association between international and national (Portuguese) students the importance attributed by students in having the possibility of receiving a digital version of the diploma in the Blockchain.*

The alternative hypothesis would be:

H17: *There is an association between international and national (Portuguese) students the importance attributed by students in having the possibility of receiving a digital version of the diploma in the Blockchain.*

To perform the tests, we created a variable grouping all non-Portuguese nationalities. For the total of 172 responses, 82.0% (n= 141) are Portuguese, while 18% (n=31) are from other nationalities.

Results and decisions are summarized in the following tables.

Table 22 - H16, H17 hypothesis tests results and decision

Nationality	Mean	Std. Dev.	Test-statistics	Statistic	p	Null Hypothesis	Decision
Portuguese	3.54	1.234	Mann-Whitney U	1624.5*	0.020	H16	Reject the null hypothesis
Others	4.06	1.153					

* Normality assumption violated for parametric testing. Mann-Whitney U used as an alternative non-parametric test

In regards to the importance of being able to share their academic information without the need for university intervention, the null hypothesis is:

H18: *There is no association between the international and national (Portuguese) students and the importance of being able to share this information without the need for university intervention.*

The alternative hypothesis would be:

H19*: There is an association between the international and national (Portuguese) students and the importance of being able to share this information without the need for university intervention.*

The result and decisions are summarized in Table 23.

Table 23 - H18, H19 hypothesis tests results and decision

Nationality	Mean	Std. Dev.	Test-statistics	Statistic	p	Null Hypothesis	Decision
Portuguese	3.74	1.143	Mann-Whitney U	1511.0*	0.005	H18	Reject the null hypothesis
Others	4.35	0.839					

* Normality assumption violated for parametric testing. Mann-Whitney U used as an alternative non-parametric test

The null hypothesis for the importance attributed to having the possibility of Portuguese universities accept a digital diploma is:

> H20: *There is no association between the international and national (Portuguese) students and how important it would be that universities in Portugal accept digital diplomas.*

The alternative hypothesis would be:

> H21*: There is an association between the international and national (Portuguese) students and how important it would be that universities in Portugal accept digital diplomas.*

The result and decisions are summarized in Table 24.

Table 24 - H20, H21 hypothesis tests results and decision

Nationality	Mean	Std. Dev.	Test-statistics	Statistic	p	Null Hypothesis	Decision
Portuguese	3.74	0.963	Mann-Whitney U	1649.0*	0.023	H20	Reject the null hypothesis
Others	4.35	0.848					

* Normality assumption violated for parametric testing. Mann-Whitney U used as an alternative non-parametric test

The fourth component assessed was the importance attributed to having the possibility of universities abroad accept a digital diploma. The null hypothesis is:

> H22: *There is no association between the international and national (Portuguese) students and how important it would be that universities abroad accept digital diplomas.*

The alternative hypothesis would be:

> H23*: There is an association between the international and national (Portuguese) students and how important it would be that abroad accept digital diplomas.*

The result and decisions are summarized in the following tables

Table 25 - H22, H23 hypothesis tests results and decision

Nationality	Mean	Std. Dev.	Test-statistics	Statistic	p	Ho	Decision
Portuguese	4.09	0.960	Mann-Whitney U	1525.5*	0.005	H22	Reject the null hypothesis
Others	4.55	0.810					

* Normality assumption violated for parametric testing. Mann-Whitney U used as an alternative non-parametric test

From the results, we identified that the importance attributed to the four components analyzed has a significant difference between national and international students. In all cases, the null hypothesis was rejected, and therefore, nationality is a determinant for the perception of importance and benefits. International students attribute higher importance to the four factors of the research when compared to national students.

5. Qualitative Results - Academia Stakeholders Awareness and Perceived Benefits

5.1 Introduction

The qualitative study aimed to collect the views and opinions of academic stakeholders and influencers through in-depth personal interviews. The interviewees were selected among top Portuguese universities and research institutes with experience in blockchain research and development and involved with international student mobility and administrative roles to create a homogeneous sample of experts and specialists. Participants came from the University of Porto, the University Fernando Pessoa, and Inesc Tec.

From a list of 14 potential interviewees, we contacted them by email, introducing our study's research, topic, and objectives, and invited them to participate in our study. We had six positive responses, accepting to collaborate and be interviewed. Four accepted the online format, and two agreed to answer the questionnaires by email. The online model was chosen due to the circulation restrictions imposed by the Covid-19 pandemic, which were in place at the time of the study and prevented the interviews from being conducted in person. The online interviews were fully recorded and had an average time duration of 25 minutes, with the longest lasting 36 minutes and the shortest lasting 23 minutes.

We used Thematic Analysis (Braun & Clarke, 2006) alongside data triangulation techniques (accessing various sources of data – including visual feedback during the interviews as well as the reading of relevant background publications in the media and on the Internet) (Saunders et al., 2019) to analyze the findings and produce the results. Moreover, we achieve data saturation with the interviews performed (whereby additional data collection was seen not to reveal new data on the research topic) (Saunders et al., 2019). These results and findings were also further validated by the interviewees. In the remaining part of this section, our findings are presented.

5.2 Themes

Using Thematic Analysis over the interview transcripts, we were able to identify four main themes: **Awareness and Opportunities to use Blockchain in Higher Education**, **Impacts and Benefits of Blockchain applications in Higher Education**, **Adoption Barriers**, and **Adoption Suggestions**. In a further analysis within each theme, we were able to identify sub-themes to organize better and categorize the results. Table 26 depicts the mentioned organization.

5.3 Awareness and Opportunities to use Blockchain in Higher Education

In this theme, we assessed the level of awareness of academia about blockchain initiatives in Higher Education and what would the opportunities for application. Two sub-themes emerged from the data: **Higher Education Institutions Awareness** and **Opportunities to use in Higher Education**. The remaining of this section is dedicated to present the findings.

Table 26 - Thematic Analysis results (Themes, Sub-Themes, and Citations)

Themes	Sub-Themes	Citations
Awareness and Opportunities to use Blockchain in Higher Education	Higher Education Institutions Awareness	“I don't know what the state of the art is, I have never equated, but I have discussed, finally, informal conversations among colleagues, the possibility of having, in fact, the diplomas and the grade embedded in a BC.”
		“From what I see, what I look at, and from the contacts I have, I don't think it is a concern or that it is a topic that is on the agenda.”
		"But I haven't seen it applied in a very specific way yet in the university question. I see it more in terms of theory."
		"I believe I even saw it. I don't know if it is in Italy, there are some. Some applications that are at the very beginning that are studying there how to do it...that is to be able to have the digital diploma.”
		"So far, I have seen absolutely nothing in the universities."
		"I am not aware of it."
		"So, I know that this project from Portugal existed with testing, also in prototype, but always in this sense, you know, the universities, for example, the Fernando Pessoa University, always testing, evaluating, but still far from using this as something within their processes. I think this is still very far away."
	Opportunities to use in Higher Education	“if there were a really credible, decentralized platform here, where you could verify that the person took the course they say they took, with the grade they say they took, at the time they say they took it ... It would be fantastic..."
		"I think that for the universities, it would also be interesting because it can escape from that logic of the paper, of the paper diploma, that worked very well a hundred years ago, but that today we can clearly find an alternative here.”

Themes	Sub-Themes	Citations
		"I even think that the main consumers of this will be the universities (...) And therefore, I think that the main consumers will be mostly them on the issue of the grade. "
		"Yeah, that was something that I believe would be important (...) especially in terms of Europe, isn't it, that there is a very big internationalization, because many times it is very centered on the physical, on paper, and the world today is digital."
Impacts and Benefits for Universities and Students	Efficiency Gains	"Digital diplomas would speed up all processes and minimize costs."
		"You would not even need to print the document. It would already decrease the cost for the university."
		"It would be optimization, even of time. You would not have to worry about authenticating the documents."
		"In terms of advantages, it seems clear to me: reduce entropy, increase the level of transparency, facilitate audits, facilitate the validation of information."
		"So it would solve that problem for me. I could look at the resumes I receive and validate that the grade is indeed the one the person says they took."
		"So on this side, the adoption of technology would facilitate both my work as a manager, in verifying these certificates, and the student himself, who would not have to submit that certificate again. It would just be a matter of looking at the keys that have already been issued, and the information would already be there."
		"If, in fact, there was a possibility for the universities on this side to at least verify that the person actually took that course there, without having to directly contact the Iranian university to prove it... that is three months...3 months generates immense inefficiency. This in this case, really hurt that project. Because I wanted that person, I could not hire that person."

Themes	Sub-Themes	Citations
		"Recently, I made the application for a Ph.D. I gave up because there were so many things that I will have to spend a whole semester gathering documents to make the application for a scholarship that I am not even sure if it will be accepted or not."
		"The application submission process would be facilitated. And the evaluation process of these FCT research grant applications would also be made easier through the adoption of the Blockchain. The validation would be simpler, and it would be easier to verify the authenticity of a set of documents that are required for the application."
		"I may even lose my scholarship simply because I could not validate a document that is theoretically simple to validate."
		"If it is already difficult to see in Portugal what the grade is, it is even more difficult to see foreign diplomas. I cannot. If they send a diploma from a university in Brazil, I do not know if that can even be fake. I cannot evaluate it. And I cannot send to all the universities all the curriculums that I receive to tell me if that course is true or not. It is impractical."
		"The ease of checking that someone got the grade they say they got in the course they say they got, I think that would already be a huge convenience. And, in this particular case, the Blockchain would facilitate that."
		"And then, a series of documents that you have to submit in order to get the course recognized. And then, you are right. If the Blockchain is implemented, it would be one less job for us. It would be an optimization, even of time. You would not have to worry so much about authenticating this document."
	Avoid Fraud	"You would save time and have a platform that would help you inhibit fraud practices."
		"It would save time and have a platform to help to inhibit fraud practices."

Themes	Sub-Themes	Citations
		"And so I think all of that can increase transparency and trust between the parties is good. From a social, economic point of view and to minimize academic fraud. That this is a very serious issue."
Adoption Barriers	Technological Barriers	"This would cause the owner of the certificate, the student, to have to store in an app, in a digital wallet indefinitely a set of credentials that at the end of a while would have to be revoked, because his public-private key pair would have to be revoked at the end of a while and this eventually would create more problems than solutions."
		"This also forces institutions to keep a key pair active indefinitely. This is also not possible because they have to be revoked every three years or every five years. And in this case of diplomas, we are talking about information for life."
		"I think all these technical issues end up being obstacles to widespread adoption of this type of technology."
		"Suddenly, other issues started to arise, for example, the question of the visualization of the certificate. There wasn't much of a standard, you know. There were tools that allowed you to view the certificate. Some of them were from the MIT itself, and others were developed by third parties. And it brought a different visualization of the certificate on the screen. Even though the validation was universal, but the visualization of the certificate was different...And then I started thinking: could this also be a problem, because who is evaluating does not know the technology underneath...we are fighting forgery, and I am bringing something that may be bringing some kind of distrust."
		"Then I also implemented Ehtereum because I started to realize that if I designed a solution with only one blockchain in mind, it would bring acceptance problems."
		"In a generation that was based on old databases, there is SQL, which is totally different, that does not talk with the Blockchain language, so it could be that this is also a problem for universities to implement these blockchain tools in the diploma."

Themes	Sub-Themes	Citations
		"But what I think, maybe, the universities, they are not yet getting into technology because there are still many technical points still, that still need to be solved."
		It is a challenge. I think that is the main challenge: someone who can coordinate this, coordinate this implementation."
	Institutional Barriers	"From the universities' point of view, I don't see them having much interest either because they will already have the additional work of putting the grades on this platform as well."
		"There is no urgent need to change the system because it is poorly functioning. So there is no such pressure, on the one hand."
		"From the point of view of the institutions and the entropy that these institutions have, I see that there are indeed some obstacles here."
		"So, I think that overcoming the barrier of institutions and their entropy was going to be complicated."
		"The universities each live in their own little yards and don't even care. It's irrelevant. And as such, I think that's going to be the big barrier, which is institutional adoption"
		"But for that to happen, there had to be universities with that will...universities are very heavy structures, very conservative. It's like a stone's throw from a stone's throw. It teaches others how to be innovative, but it itself is not innovative, and it has very heavy structures that react very slowly, that are zero innovative, and that are not very permeable."
		"…, because of the perception that there is not yet a latent problem, there is no thought of implementing this tool."
	Other Barriers	"Here, it is difficult to play with financial incentives. That is, it is difficult to have a company mobilize this because whom would the company charge?"

Themes	Sub-Themes	Citations
		"And. so I think people act on incentives...not always, not in all cases, not all, but in aggregate, clearly people react to incentives And so, if there are no incentives, it's hard to get those people on the same page."
		But the experience I have in Portugal, of this type of initiative, of technology-based innovation, is that they arrive ten years behind other countries."
		"We lack the will to take risks, to be disruptive, to want to do things differently, so we always follow very closely what others do. In a posture that is always very cautious."
		"I think we could be more disruptive, innovative. But yes, maybe I would say it's a more cultural characteristic."
		"So we come into a world where we manage risk. At the moment, we have, you see, it's a process where there are few stakeholders: we have the students, we have the issuing institution, and we have those who want to verify. We have three stakeholders. Now, these three actors can be perfectly well associated in a distributed server, nowadays we have the cloud, the servers being available or not. This question doesn't arise."
Adoption Suggestions	Transnational platform and standardized process	"But, if it is to do something that is transversal, several universities, I think it makes sense to have a decentralized transversal platform. And it doesn't make sense for each university to have its own little platform."
		"On the other hand, that would be to force a somewhat global blockchain. Although there may be interactions between blockchains, I would have to guarantee that a diploma in any country could be easily accessed by an app in Portugal and vice-versa"
		"Eventually, have a solution at the European level, transatlantic even, European plus the United States."
		"But it cannot work at the national level. It has to be at the supranational, transnational level."

Themes	Sub-Themes	Citations
		"And then I started thinking, and the solution has to work for any kind of Blockchain. So if the University wants to switch eventually, it's like switching a database."
		"There would have to be a specific service, specific procedures, and specific technology to handle the entire life cycle of this information. "
		"Standardization of information systems and process standardization"
	Increase Awareness	"First try to get it into people's heads, make people aware that this technology is important. That this technology will bring great benefits to universities and only then try to move on to the other aspects."
		"I think there needs to be an awareness that technology is necessary, that technology solves the problem, and to work on that point first."
		"It is necessary that the managers have a perception that these resources, which already exist, will bring an advantage to the institution. Otherwise, this will hardly happen. If this perception is not developed."
		"That is, it has to be clear to everyone that the platform makes sense, and therefore, I voluntarily want to be part of this platform. It should not be something imposed"
		"It's that thing. It is not just generating the innovation itself, but convincing people that that innovation solves some problem, and that it really matters."
		"First, I think it has to be aware that technology really solves a problem. I think that as long as institutions don't realize the need for it, that it really solves a problem. Technology is going to be kind of excluded."
		"I think there needs to be an awareness that technology is necessary, that technology solves the problem, and to work on that point first."
	Find Incentives for Adoption	"That's the question, is adoption. How do you put incentives in place so that parties want to use this."

Themes	Sub-Themes	Citations
		"What incentive do universities have to do that? Reputation? Do those who are on this platform get more reputation."
		"And create the financial incentives because there are no big financial incentives here. It is not clear who is going to pay for this. So that there are the right incentives for the parties to use the system."
		"I think that in the case of Portugal, it would make it easier, eventually, to have a clear direction here saying, let's use it. Let's implement this from now on."
		"Who is on this platform gains more reputation? For example, you need to have many good universities there so that being there is associated with creating a reputation. But the universities will only go there if they already have other universities to give that value, that credibility. Therefore, a network effect is generated here that is difficult to overcome."
		"This is like a social network growing up. You only want to be there if others are there. Thus, maybe, the university would really like others to implement that because then it makes it easier to validate from my side. (...) It has an initial kick-start effect here...which is to get a large group of universities together that are committed to doing this. There has to be an effort in this direction. "
		"In an isolated way, I don't think it has any motivation. If it is a national or European initiative, it has all the advantages of reducing bureaucracy and increasing mobility."

5.3.1 Higher Education Institutions Awareness

The group analysis shows that their knowledge of Blockchain and its applications is more associated with cryptocurrencies and supply-chain, intellectual property management, or a high-level understanding of technology and its potential business application in a more general way. More specific, the knowledge is still restricted to research and investigation projects and prototypes or high-level discussions

Moreover, concerning initiatives in Higher Education, the knowledge varies from superficial knowledge about the topic, addressed in informal conversations to not knowing any initiatives at all. The exception was one of the interviewees who were part of a research project on the subject at his university as a master's dissertation.

Regarding initiatives within Portuguese universities, they were almost unanimous in saying that they were not aware of any such initiatives.

The understanding is that the use of Blockchain is not a discussion topic or a priority for Portuguese universities, and the level of awareness about it is limited to specific research groups of professionals but is not yet widespread in the academic community. The low level of awareness found in our study was identified in other countries as well, as in the research by Fedorova and Skobleva (2020), which identified a low level of awareness and knowledge of Blockchain within the Russian academic community.

5.3.2 Opportunities to use in the Higher Education

The Diploma and academic transcripts issuance and verification are seen where significant opportunities for applying blockchain technology by Higher Education Institutions arise. There is a perception that universities have outdated processes and practices that create many difficulties for students when applying for financial support for studying or hiring by research projects and professional opportunities.

To improve the quality of information exchanged, reducing time and cost in the academic information verification by any interested party is crucial to bringing universities into the digital world. Besides, the technology can help reduce fraud and enhance transparency and confidence among the students, universities, employers, and other interested intervenients.

During the study, it became clear that despite the opportunities to use Blockchain by the Higher Education Institutions to reduce or eliminate bureaucracy and paper-based process, therefore be more efficient and even increase international reputation. However, despite that, it was consensus that this is not a priority for institutions.

Moreover, the institutions tend to do not to recognize this situation as a problem. Although several cases were presented where the existing practices and process has created real impacts on research projects, on the hiring of international research professionals, or scholarship funds be not accessible by students, the perception is that this is not a problem of the Higher Education Institutions.

5.4. Impacts and Benefits for Academia and Students

Another objective of our study is to assess how blockchain-based solutions for diploma management, from issuance to verification, can cause students and academia in Higher Education Institutions in Portugal. Also, the impacts for Portuguese students going to study abroad were assessed. Under this theme, two main sub-themes emerge from the study: **Efficiency Gains** and **Avoid Fraud.**

Efficiency Gains come from process simplification, particularly academic information verification, including degrees obtained in Portugal or abroad, to grades obtained by students. Reduction of bureaucracy, notarial process, and even reduced financial costs or simplified access to education grants are also noticed as potential benefits for students and universities. The study highlights that the current processes for verifying academic documents are bureaucratic and outdated and cause academic, professional, and financial impacts for everyone, from universities and research institutes to students and researchers. In this regard, the use of Blockchain can translate into a simpler and easier process for various applications, both in the university environment and at the level of foundations supporting science and research.

The existing processes make it unfeasible to hire foreign researchers, with real impacts on the projects developed in the country, as we can see in the following report.

Moreover, in this sense, a reliable, decentralized platform that allows for quick verification of credentials could bring benefits, such as increased transparency and reliability of the information, greater ease in validating this information, among other aspects.

We also have financial impacts, which can be translated into better use of funding and aid resources for students to achieve their academic and professional goals, avoiding cases such as the one reported, where the candidate gave up on seeking these resources due to the inefficiency of the processes.

The reduction of bureaucracy and redundant processes appears as another benefit that can be obtained by using Blockchain in the management and validation of academic information, as one of the interviewees commented, because of some existing procedures at his university.

It is worth noting that the benefits are considered more relevant in the case of international students and applicants, where the difficulty of validating the information provided is even more latent.

As a benefit, the processes would become more straightforward, safer, and more convenient.

The fight against academic fraud is also pointed out as a benefit, as we can see from the reports

The reduction of costs and time with the processes is seen as another benefit for universities and research institutes and students going abroad, particularly in Europe, increasing student internationalization.

5.5. Adoption Barriers

5.5.1 Technological Barriers

The technology is recent and still seen as complex and not yet thoroughly tested or widely adopted, except for cryptocurrencies, in the view of our group. Therefore, this study highlighted that this novelty, aligned with complexity, might create some adoption barriers by the Higher Education Institutions.

The complexity of the technology emerges as an implementation barrier and confirms what is found in the literature, as per the study by Friedlmaier et al. (2018 p. 3524).

Another barrier arises from the need to integrate existing systems in universities and a new blockchain solution that can be difficult. The difficulty comes from the architectural and structural differences between solutions based on a client-server model and relational database and a decentralized model in the Blockchain. The very novelty of the technology still causes some concerns. Questions have been raised about how this technology will evolve in the long term, how this information would be kept for a very long life cycle, for 20, 30, or 40 years.

Also, from a technological point of view, other barriers to adoption arise because there is still no technological standardization, with the various blockchains, such as bitcoin and ethereum, with different aspects, potentially leading to distinct solutions and interoperability

difficulties. It is pointed out that we need to have a solution that can work and coexist on different blockchains.

In line with the literature, where we see that there are several proofs of concepts because, as identified by the group, it is easy to create a prototype, the studies confirm the point made in Capece et al. (2020) of the little attention given to implementation barriers, in particular with the issue of the long life cycle of information.

5.5.2 Institutional Barriers

The Universities' lack of interest in changing is pointed out as a factor that hinders the adoption of an innovative technological solution. There is an apparent lack of interest in a solution that at the first moment can generate additional work, to include and maintain the information in a new platform. There is a perception that universities are not integrated and live each one to their reality and overcome the entropy of these institutions so that the adoption is facilitated. There is a perceived lack of interest from universities in change, mainly because they do not perceive or feel the problem. The study shows that the concerns and problems caused by the existing process of verifying academic information and the time and cost involved are not seen as a situation that needs to be solved by the universities. The universities do not perceive this as their problem since the impact is felt more by students and employers.

Consequently, there is no interest or perception of an urgent need for change. The issuing of digital diplomas is not perceived as something that brings clear and immediate value to the university. It is something more sensitive to the students, as much as the possibility of sharing this information. Even certificate and diploma fraud, which is seen in the literature as a driver to propose blockchain-based solutions into this process, is still not perceived as a significant problem and even considered a residual issue. Therefore, there is no pressure for an urgent change in the model.

People's natural resistance to change is also indicated as another barrier to overcome. Thus, there is a need to convince managers and other university stakeholders that there is a need to move from an old paradigm, over the paper-based and centralized process, to a complete electronic and decentralized world.

Moreover, Universities are seen as conservative and heavy structures that move very slowly and with little innovation. If we analyze this situation from the point of view of the theory

of diffusion of innovation (Rogers, 2010), it is possible to say that Universities may within between Late Majority and Laggards, and therefore the adoption of an innovation, such as the issuing of degrees and transcript management solutions in blockchain, still has a long way to go.

5.5.3 Other Barriers

Some other aspects that may consist of barriers to adoption were highlighted in our study and are presented in the following paragraphs.

The lack or the difficulty of finding the right incentives that facilitate the adoption by universities was found in the study. Barriers arise from the difficulties in making the universities realize the benefits of implementation and not only focusing on the cost and work necessary to implement such platforms. Like every technological change, there is a cost and investment that has to be done, but on the other hand, it is not clear how and by whom it would be paid. It seems challenging to find a way to turn it into a business to attract entrepreneurs' or private investors' attention because it seems to be difficult to charge for this service. On the one hand, the student, who is the one with a significant benefit, may not want to pay to use a platform to share their information.

On the other hand, the university may not want to finance such a solution, where it does not yet see an immediate benefit. So there is difficulty in selling the solution to interested parties. Another aspect raised is that because it is a process with few players, **u**niversities, students**,** and eventually employers who wish to validate academic information, this ends up being a barrier to adoption.

The group also placed as a barrier some cultural aspects of Portugal**,** where technology-based innovations arrive a few years later than in other countries. A risk-averse culture and cautious attitude towards innovation may be barriers that hinder the adoption of technology-based innovations**.**

5.6. Adoption Suggestions

The group studied indicated suggestions and possible ways to promote adoption. These recommendations were grouped under the following themes: **Technology Implementation, Increase Awareness,** and **Find Incentives for Adoption**.

In the **Technology Implementation** theme, the interviewees are unanimous in affirming the need for a solution that transcends the limits of Portugal. For the adoption to have a

better chance of happening successfully, one must have a solution adopted at the European level. However, a solution that, in addition to Europe, would also include universities in the United States and other countries is seen as the most appropriate. A solution that would only serve the purposes of Portugal is not seen as attractive either for universities or for students in a context of high internationalization of higher education. On the other hand, creating a transnational solution brings a coordination challenge also at the same level, and therefore must be considered an essential factor for the success of such an initiative.

Still, in the group's view, some technological issues need to be solved, such as the scalability of the solution over the years, like the increasing volume of stored information, processing times and updates of encryption keys, and interoperability between various blockchains. A multiplatform solution not tied to a single blockchain is an important factor in promoting adoption.

Besides that, they understand that the platform must be developed initially and then made available for universities to adopt. The development of this platform should also be led by a group or consortium responsible for maintenance and technological evolution.

Also, the creation and establishment of standard procedures and practices for the various processes, such as issuing, verification and revocation of credentials and certificates, as well as resolving issues of universities ceasing to exist, or undergoing incorporation and other changes over time, and how the platform and processes will support these occurrences.

Within the theme **Increase Awareness**, the study highlighted the importance of developing the perception of the academic community and their managers about the problems that exist with the current process of verifying and validating curricular information. It is essential to develop awareness about how blockchain technology can benefit the university and shift focus from implementation costs. Also, it is essential to eliminate the perception of increased work due to adding a new software component in the process. Deconstruct the current process paradigm and the view that the current process works, and therefore does not need to be changed, making the need for adoption perceived. As much as students are seen as the biggest beneficiaries, everyone agrees that implementing a blockchain-based solution would greatly benefit universities by reducing bureaucracy, achieve administrative efficiency, and even have a differentiated and innovative positioning that could increase interest from potential students. However, it is necessary to develop this perception and vision in university managers and decision-makers, as they would primarily be responsible for making the change happen. The students are seen as influential in the process. However, without the

power of decision, we conclude that it is essential to develop the awareness of university managers about the need for these changes.

The third theme identified, **Find Correct Incentives**, shows the need to find the right motivators for each group involved so that the adoption can happen. Financial incentives to support the necessary investments to adopt new technology solutions and integrations required are crucial for universities. An institutional direction, at least in Portugal, is understood as a motivating factor. Another aspect would be a reputational incentive, where a university would be encouraged to participate in a solution that already participated in other universities with high reputations inserted. Here we would have a network effect, like a social incentive that would promote adoption without the need for a top-down imposition. Besides, it can be challenging to promote the initial adoption for a group that would establish the initial network reputation. Then, it could lead to more institutions joining the net and expanding the adoption in a second moment.

6. Conclusions

Blockchain can be considered a radical innovation (Beck & Müller-Bloch, 2017; Holotiuk et al., 2019). Due to its intrinsic characteristics of immutability, decentralization, security, and traceability, in recent years, it is sparking interest from diverse businesses, industries, and researchers beyond cryptocurrencies and finance applications. These features combined can be used by Higher Education Institutions and be an excellent opportunity to solve problems such as a lack of trust in information provided by third parties, the elimination of intermediaries in data and information verification and authentication processes, and the elimination of curricular fraud.

The use of blockchain for higher education degrees and other academic information has proven to be an area that has seen a recent increase in research and investigation globally, as noted in our literature review. Also, the development of EBSI, a common European blockchain infrastructure, with diplomas as one of the use cases is significant. Also, the development of EBSI, a common European blockchain infrastructure that has utilization for diplomas in the roadmap, is another confirmation of the importance of our discussion.

Another fact that corroborates the importance of our investigation is that the process of digitalization of information is becoming increasingly important in Europe. The European Commission recently proposed creating a digital identity framework that should be adopted by all member states and thereby provide citizens and residents with the possibility of possessing a digital identity card, with proof of other attributes such as driving licenses, diplomas, for example (European Commission, 2021b).

The research work also generated an article co-authored with the supervisor (Castro & Au-Yong-Oliveira, 2021), where we show the lack of coordinated initiatives in Europe and whereby only individualized initiatives exist in some universities. Furthermore, in the mentioned work, we also raised the question of the impacts on student mobility due to the costs and time involved. For example, a student coming from Brazil who needs to have his diploma recognized may have to spend more than 500 Euros and 3 to 6 months until the whole process is concluded. Therefore, we have proposed using blockchain in the higher education diploma and certificates to achieve a better, simplified, trustful and transparent process of academic information verification and confirmation with positive impacts for students, universities, employers, and society.

Like any radical innovation, which implies profound changes in the technological aspect and the behavioral and procedural aspects of the various agents involved, the use by Higher Education Institutions is no different. However, for agents that teach and promote innovation, it should be expected that universities assume the protagonism and be a place where knowledge of the potential benefits arising from technology should be explored and adopted.

However, as a recent area of research, where the focus so far has been on prototyping and proof of concept, in order to further explore the potential and feasibility of the technology for issuing and verifying academic credentials, little attention has yet been paid to trying to understand how much the academic community (decision-makers, influencers, and users) know and are aware of these possibilities and initiatives.

Our study sought to compose a panorama of the current degree of knowledge within the academic community in Portugal, using a mixed-methods approach (interviews and a survey), to understand how Higher Education Institutions and their students perceive the technology and its benefits.

Based on other cases in the literature, the results confirm an expectation that knowledge of the inherent potential is still deficient and restricted to specific groups or research. Although there are already several initiatives in several European universities, including universities in Portugal, this is virtually unknown to the group as a whole. However, the study showed that technology could be a decisive factor for changing and improving administrative processes, described as bureaucratic, dense, and inefficient by students and other academy members. Moreover, we noticed the existence of a perception that the problems caused by these processes, which negatively affect both professionals and students, are not seen or understood as a problem for universities or that they are responsible for changing this situation.

Because it is a process with few players and there exists a difficulty in finding financial incentives and ways to monetize the process as a service, there is an understanding that it will be challenging to transform the activity into a business that companies can develop. Therefore, a coordination effort with governments and universities may be necessary in order to promote adoption.

Our study highlights that adoption will have more chances of success if a transnational approach with a multi-country platform is developed and adopted. It should not be restricted to initiatives from individual universities or circumscribed to a small region or country. It

will be necessary to create a network of Higher Education Institutions that allows the system to be adopted and, consequently, promoted jointly so that the benefits materialize, generating a social-network effect that will encourage other universities to join the solution. Financial support for the development of the necessary platforms and integrations should be considered as a way to encourage adoption.

Standardization of information, processes, and technology is also seen as a significant factor in promoting adoption.

The research showed that the knowledge about the technology is still low among students. A total of 55.2% of those surveyed reported having a low, very low, or no knowledge at all about blockchain. Therefore, it will require significant effort to raise awareness about the benefits of such solutions and a search for ways to simplify and facilitate the comprehension of the technology to promote adoption. The study identified that students are not yet aware of the initiatives to implement digital diplomas. On the other hand, they are not satisfied with the current process to manage their academic information and certificates. The time and cost of the current process were rated, respectively, at 2.53 and 2.68 (on a scale of values from 1 to 5) on average. In the context of Portugal, which was the object of our study, there is a difference in the perception of the benefits and advantages that the solutions can bring between national and international students. Although our study did not aim to understand why this difference in perception exists, we perceive it is possible to think that international students have already experienced difficulties with the management of their academic information when making their applications, and how they will still have to deal with the use of their credentials obtained in Portugal when returning to their home countries. Exploring this issue may be a research point for future researchers.

Additional future research avenues may include solving technological issues, such as, for example, how should the treatment and evolution be guaranteed to ensure that the information can be verified in the long term, in 20, 30 years, since a diploma, unlike other information, is something perennial and that accompanies the person throughout his or her life and can be used at any point in time.

Still, future research may seek to find ways to establish financial, social, and other incentives for educational institutions to adopt a blockchain-based digital diploma solution.

A final remark, from the point of view of adopting a solution that serves the higher education institutions of Portugal, we consider it to be of paramount importance to continue investing in the efforts to increase the awareness about the technology and its benefits in the academic

community, as well as explore opportunities for collaboration at the European level and search for incentives and financial resources in a coordinated way among various European institutions and actors. The creation of an international platform and the establishment of an initial set of early adopters is another essential factor to be considered in order to promote the technology and lay the foundations for a new process based on decentralization, transparency, and security, and therefore directing the efforts of governments, universities and research institutes in this direction should also be considered.

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Annex

Literature Review Synthesis

Table 27 - Literature review synthesis, ordered by number of citations in Scopus

Reference	Citations in Scopus	Contribution	Considerations & Future Research
(Turkanović et al., 2018)	122	By proposing an open global decentralized credit grading system based on ECTS, invite HEIs to join the network. This can promote awareness and adoption. From students, the platform may facilitate information sharing, in particular among European universities	Prototype only in Slovenia. Plans to test real-life environment and assess acceptance for other HEIs. Aims to be global, but it is ECTS-based that is only a European standard
(Cheng et al., 2018)	29	To solve diploma fraud issues through the use of blockchain. Developed a system for issuing and validating certificates in the article, using blockchain and smart contracts (based on Ethereum).	Concludes that data security is one of the essential features of blockchain and, therefore, the use of the proposed system reduces the risk of fraud with certificates. No evidence of concept testing in a real academic situation.
(Duan et al., 2018)	18	Proposes a specific application of a learning outcome blockchain. Developed a prototype and executed proof of concept for a group of students at Xiangtan University in 2017.	Using the proposed system, the students will have a diploma and a rich set of information about the course's capacity at the end of the course.
(Rahardja et al., 2019)	11	This indicates that blockchain in education still not on the global agenda, and education stakeholders not well informed of	Indonesia only; Limited exploratory resource; no statistical evidence; proposed framework may not represent a

Reference	Citations in Scopus	Contribution	Considerations & Future Research
		the potential of the technology; Design framework for the HE system in Indonesia using BC	holistic approach for education
(Kamišalić et al., 2019)	10	Analyzes and categorizes existing blockchain initiatives for Higher Education. Identification, categorization of initiatives, and their comparison to EduCTX.	Presents a discussion about the implementation challenges that can be useful for other researchers and initiatives.
(Gresch et al., 2019)	8	It proposes a blockchain/smart-contracts based system to issue and verify diplomas for the University of Zurich A simplified model for interacting with, reducing complexity compared to other implementations.	A customized solution for the University of Zurich. There is a need for additional effort to comply with internal rules and to add other Universities.
(Palma et al., 2019)	7	Benchmarks costs per student for their solution;	Prototype only; Did not present pilot or real case utilization; Follows Brazil HEI regulatory requirements;
(Vidal et al., 2019)	4	A proposed blockchain/blockcerts based system to issue and verify at University Fernando Pessoa. A prototype and metrics about transaction times and costs (per diploma issued) on Bitcoin blockchain.	Additional research work related implementation barriers due to blockchain's immutability and lack of standards.
(Juričič et al., 2019)	3	Trough a theoretical approach explains some advantages that a BC-based solution for credits and certificate	Theoretical proposal only

Reference	Citations in Scopus	Contribution	Considerations & Future Research
		management could bring to students.	
(Meyliana et al., 2019)	2	A proposal for a blockchain model for integrating the university value chain. An integrated model to achieve enhanced data-quality (accurate, verified, validated).	Research focuses on Indonesia's universities' value chain.
(Nguyen et al., 2017)	2	Proposes a Blockchain/smart-contract to support Certificate Management. A prototype and metrics about transaction times and costs (per diploma issued) on Ethereum blockchain.	Solution-focused on Vietnamese needs. Further implementation in other blockchains other than Ethereum is indicated.
(Vidal et al., 2020)	2	To present an approach to execute corrective actions on the blockchain to revoke credentials.A model to revoke digital diplomas that do not depend on the actions of third-parties.	Look for further standardization and in-depth review of the Verifiable Credentials model proposed by the World Wide Web Consortium.
(Arndt & Guercio, 2020)	1	Propose a BC solution for students' transcript storage/management using a NoSQL database. Therefore can streamline the transfer of student transcript information between HEIs.	Prototype only
(Awaji et al., 2020)	1	Following a systematic literature review presents the current status of blockchain research for education. It shows the main research topics and the	From the challenges, we can highlight blockchain solutions' usability due to technical complexities and novelty; Also lack of motivation from HEIs to change traditional

Reference	Citations in Scopus	Contribution	Considerations & Future Research
		main challenges for researchers.	applications already in use.
(Fedorova & Skobleva, 2020)	1	Identifies the Russian academic community still not well informed of the technology and its applications in Higher Education. Over 50% are unaware of BC technology.`	Study only considering Russian HEIs
(Nikolskaia et al., 2019)	1	Develop a prototype for diploma validation using blockcerts. Set of instructions and diagrams to develop using blockcerts.	No testing in a live situation.
(Taufiq et al. ,2019)	1	Propose a crypto-governance model for handling student documents and diplomas. A proposal model to implement a crypto-governance model, involving several actors, using a private blockchain network.	Focus on a private university case. Based on a private blockchain network, other initiatives use public ledgers.
(Abreu et al., 2020)	0	Develop a prototype to certificate management; assess technical and user views; uses interviews combined with a ten-step path approach and comparison with the current model	User validation with only two university administrative staff
(Capece et al., 2020)	0	Describe technical aspects of the pilot Blockchain/blockcerts solution at the	Further investigation on smart contracts potential and standards like Certificate

Reference	Citations in Scopus	Contribution	Considerations & Future Research
		University of "Tor Vergata." Compares issuing and verification for existing and pilot solutions and discusses how blockchain can increase trust and efficiency in the process.	Transparency* https://www.certificate-transparency.org/
(Cardoso et al., 2020)	0	Propose a model to enable interchange information in the context of the Erasmus program	A prototype to be developed further
(Ceke & Kunosic, 2020)	0	Presents estimate costs to certificate issuing on Ethereum. Therefore, helps to assess the cost impact for the Universities	Still, prototype with a limited set of transactions, priced on Ethereum test environment
(San et al., 2019)	0	Proposes blockchain issue & verification credential method to achieve increased data privacy. A digital certification validation method based on a Merkle Tree to increase data privacy.	Proof of concept or prototype not developed.
(Serranito et al., 2020)	0	Proposes a prototype of blockchain/smart-contract ecosystem of Higher Education Institutions for certificate validation. Describes their unique proposal to enable a consortium of Institutions in a decentralized manner and testing results achieved.	Further investigation and development to enhance decentralization, either on technical or governance aspects.

Reference	Citations in Scopus	Contribution	Considerations & Future Research
(Stoica et al., 2020)	0	Benchmarks current BC adoption/usage in Romania	
(Friedlmaier et al., 2016)	Not in Scopus	An overview of the current blockchain industry and evaluate the technology using Diffusion Innovation theory	The study focuses on the Venture Capital perspective and Financial sector analysis. Further research to see how to overcome low degrees of compatibility and observability
(Sahin, 2006)	Not in Scopus	Review Diffusion Innovation theory in the context of higher education innovations adoption	Presented cases are related to using/introducing computers for instructional purposes. Older cases (beginning of 2000)

Null and Alternative Hypothesis

Table 28 - Null and Alternative hypothesis for study cycle

Component	Study Cycle	
	Null Hypothesis	**Alternative Hypothesis**
5. The importance attributed by students in having the possibility of receiving a digital version of the diploma in Blockchain	**H8**: There is no association between the study cycle (1st, second or third) and the importance attributed by students in having the possibility of receiving a digital version of the diploma in the blockchain.	**H9:** There is an association between the study cycle (1st, second or third) and the importance attributed by students in having the possibility of receiving a digital version of the diploma in the blockchain
6. The importance of being able to share their academic information without the need for university intervention	**H10**: There is no association between the study cycle (1st, second or third) and the importance of being able to share this information without the need for university intervention.	**H11**: There is an association between the study cycle (1st, second or third) and the importance of being able to share this information without the need for university intervention.
7. How important it would be for the students that	**H12**: There is no association between the	**H13**: There is an association between the

Component	Study Cycle	
	Null Hypothesis	**Alternative Hypothesis**
universities in Portugal to accept digital diplomas	study cycle (1st, second or third) and how important it would be that universities in Portugal accept digital diplomas.	study cycle (1st, second or third) and how important it would be that universities in Portugal accept digital diplomas.
8. How important it would be for the students that universities abroad to accept digital diplomas	**H14**: There is no association between the study cycle (1st, second or third) and how important it would be that universities abroad accept digital diplomas.	**H15**: There is an association between the study cycle (1st, second or third) and how important it would be that abroad accept digital diplomas.

Table 29 - Null and Alternative hypothesis for nationality

Component	Nationality (Portuguese x Other nationalities)	
	Null Hypothesis	**Alternative Hypothesis**
9. The importance attributed by students in having the possibility of receiving a digital version of the diploma in Blockchain	**H16**: There is no association between international and national (Portuguese) students the importance attributed by students in having the possibility of receiving a digital version of the diploma in the blockchain.	**H17**: There is an association between international and national (Portuguese) students the importance attributed by students in having the possibility of receiving a digital version of the diploma in the blockchain.
10. The importance of being able to share their academic information without the need for university intervention	**H18**: There is no association between the international and national (Portuguese) students and the importance of being able to share this information without the need for university intervention.	**H19**: There is an association between the international and national (Portuguese) students and the importance of being able to share this information without the need for university intervention.
11. How important it would be for the students that universities in Portugal to accept digital diplomas	**H20**: There is no association between the international and national (Portuguese) students and how important it would be that universities in Portugal accept digital diplomas.	**H21**: There is an association between the international and national (Portuguese) students and how important it would be that universities in Portugal accept digital diplomas.

Component	Nationality (Portuguese x Other nationalities)	
	Null Hypothesis	**Alternative Hypothesis**
12. How important it would be for the students that universities abroad to accept digital diplomas	**H22**: There is no association between the international and national (Portuguese) students and how important it would be that universities abroad accept digital diplomas.	**H23**: There is an association between the international and national (Portuguese) students and how important it would be that abroad accept digital diplomas.

Table 30 - Student's nationalities

Nationality	Counts	% Total
Brazilian	23	13.4
Capeverdean	1	0.6
Iranian	2	1.2
Mozambican	1	0.6
Nigerian	1	0.6
Portuguese	141	82.0
Russian	1	0.6
Sao Tome and Principe	1	0.6
South Korea	1	0.6
Total	172	100.0

Published Paper

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European Journal of
Investigation in Health, Psychology and Education

MDPI

Review

Blockchain and Higher Education Diplomas

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Abstract: Due to added mobility and the increase in international students worldwide, as well as the current problem regarding the counterfeiting of diplomas and the selling of fraudulent certificates, we propose a technological solution. Namely, to ally blockchain technology to higher education certificates and diplomas, to make the process of checking for academic qualifications more facilitated and transparent. Employers of graduates, as well as higher education institutions which evaluate course applicants, would benefit. Perhaps equally as important, students applying for international degree programs would have their lives simplified. There is an increased pressure to ensure the legitimacy and authenticity of certifications and diplomas—and preferably without the current "hassle" of getting diplomas recognized by official entities. New technological advances, with the development of blockchain and smart contracts, with their characteristics of immutability, decentralization, security, traceability, and consensus, may be considered an excellent match to implement a robust and reliable anti-fraud solution to issue digital diplomas. Radical innovations, such as linking blockchain and higher education diplomas, involve significant change and novelty. Linking blockchain and higher education diplomas could potentially positively impact and benefit millions of people worldwide, especially the younger generations. This study involved a literature review and the searching of the Scopus database (refereed publications) for the following concepts: *blockchain* and *diploma*. Existing literature is recent, with most articles (25) published between 2019 and 2020, with 4 in 2018 and only 1 in 2017. This was aligned with our expectations since the development of blockchain utilization outside financial and crypto-assets industries is recent, and it is known as "Blockchain 3.0". We can additionally affirm that the topic is attracting attention and efforts from researchers worldwide and that some higher education institutions have already implemented ad hoc solutions. As it is, the sector lacks a unified response to the problem of automatic and reliable higher education diploma certification.

Keywords: blockchain; higher education; diplomas; certificates; fraud; international students; radical innovation; refugees

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1. Introduction

The aim of this research is to facilitate access to higher education academic qualifications, including to their quality, in a more transparent fashion. This could be due to the need to eradicate fraudulent practices, or to provide an outlet for individuals without the possibility to transport documentation (e.g., refugees), to be able to capitalize on previous qualifications via the use of a decentralized technological system and platform.

The counterfeiting of diplomas, the selling of fraudulent certificates, and degree mills (organizations that commercialize false diplomas without an associated educational experience) are not a new issue. In the United States, evidence goes back to the Civil War, where the market of fraudulent certificates was a common practice, since 1730. However, recently, the issue is attracting more attention from education institutions, international organizations, and employers [1]. The number of students enrolled in tertiary education

Figure 3 - Published Paper "Blockchain and Higher Education Diplomas"

worldwide has grown more than 53% between 2006 and 2018, according to data made available by the UNESCO Institute of Statistics. Moreover, the number of tertiary international students has grown steadily in the last 20 years, reaching 5.6 million in 2018 [2] (p. 201). Along with the mentioned expansion of international students in the past two decades looking to acquire higher education degrees abroad and applying for jobs worldwide, there is an increased pressure to ensure the legitimacy and authenticity of certifications and diplomas—and preferably without the current "hassle" (involving both time and money) of getting diplomas recognized by official entities.

Indeed, nowadays, checking for diploma or certification authenticity is a lengthy, manually intensive, and sometimes expensive process. For example, students applying to study abroad may be required to do language translations and international authentications/legalizations (e.g., Hague apostille or other forms of notary services) regarding their original documents as a way to prove their authenticity.

The recent advances of technology with the development of blockchain and smart contracts, with their characteristics of immutability, decentralization, security, traceability, and consensus, may be considered an excellent match to implement a robust and reliable anti-fraud solution to issue digital diplomas [3,4]. In turn, the digital diplomas can be easily assessed and verified by any interested party worldwide, without the need for an intermediary and other certification agents. We consider this possibility to be a radical innovation, in so far as the resources it will save.

Radical innovations—which go "beyond the present technology cycle" [5] (p. 1)—rather than staying "within a technology life cycle" [5] (p. 1), such as linking blockchain and higher education diplomas, involve significant change and novelty. Radical innovations change how we live or go about our day-to-day lives, with a new concept (e.g., the appearance of the Internet), as compared to incremental innovations, which only supply minor improvements to existing products and services (e.g., the Apple iPhone 12 versus the Apple iPhone 11). Linking blockchain and higher education diplomas could potentially positively impact and benefit millions of people worldwide. Additionally, the people most affected will tend to be the younger generations, a segment of the population which are more sensitive to the financial issues involved with official certifications of diplomas.

Another issue which is also relevant is the quality of the diplomas attained. Higher education institutions, and their courses/degrees, receive certifications and are integral parts of a number of national and international rankings. This information should also be automatically appended to the blockchain process, as employers and higher education institutions will want to know: (1) what qualifications applicants have; and (2) how good those qualifications are (relative to other applicants and institutions which concede academic certificates). Additionally, ethical issues may also be added to the process, as this is an increasing concern in society and in the education sector, including in undergraduate medical ethics education [6] and in other such related spheres where the humane component needs to be very present.

In this study, we intend to perform a systematic review of the existing literature regarding blockchain use by educational institutions to understand the current status, especially in the management and issuance of diplomas and certificates, while identifying literature gaps, and pointing out potential future research avenues. One such research avenue regards refugees, who are caught up in "humanitarian crisis settings", e.g., Jordan and Rwanda—conflict-induced refugee settings [7]. As refugees lack important documentation, which would be essential to their latter well-being and quality of life, we perceive that allying blockchain technology to higher education diplomas in this case will be especially useful, thus perhaps leading to additional global equality. The main issue is well-being, including youth refugee well-being [8].

2. Methods

An integrative literature review was conducted by searching the Scopus database (refereed publications) for the following concepts—*blockchain* and *diploma**—to identify relevant

Figure 3 - Published Paper "Blockchain and Higher Education Diplomas" (cont.)

literature during December 2020. The search included keywords, titles, and abstracts. The query and summary of results are in Table 1.

Table 1. Initial search query in Scopus.

Query	Documents Returned	Period of Publications
TITLE-ABS-KEY ("blockchain" AND "diploma*")	30	From 2017 to 2020

Existing literature is recent, with most articles (25) published between 2019 and 2020, with 4 in 2018 and only 1 in 2017. This was aligned with our expectations since the development of blockchain utilization outside financial and crypto-assets industries is recent, and it is known as "Blockchain 3.0" [3,9]. In its majority, the documents were conference papers, with 23 documents, followed by five journal articles and one conference review, and one short survey. English written documents were dominant with 29 occurrences. The remaining document was written in Spanish. The Institute of Electrical and Electronics Engineers was the main publisher with 12 documents identified.

Next, to select the documents for review, the query results were downloaded in csv format for further analysis in an Excel spreadsheet. Following this, documents were ranked in descending order by the number of citations and had their titles and abstracts read to identify relevant literature. After that step, a total of 15 documents (two journal articles and thirteen conference papers) remained and were considered for a complete reading.

3. Literature Review

This section will present our integrative literature review, which synthesizes and presents a summary of articles read and the main concepts and contributions. We identified authors from distinct parts of the world and different nationalities, such as China, Taiwan, Vietnam, Portugal, Switzerland, Italy, and others. Therefore, we can affirm that the subject is attracting attention and efforts from researchers worldwide. Moreover, we aimed to indicate the current state of the research for implementing blockchain in diploma issuing and verification. Three documents were discarded after reading.

Figure 1 shows a visual depiction of the research topic. The benefits of uniting blockchain technology with higher education diplomas are represented in Figure 1. The foundations of the future of this system are also portrayed in Figure 1.

The benefits of the suggested system—linking blockchain and higher education diplomas, as shown in the center of Figure 1—are listed at the top of Figure 1: less diploma counterfeiting and fraud (due to decentralized management); save time and money—especially true for the more fragile younger generations; added meritocracy in academia and in the job market (as real qualifications are accessed for processing by higher education institutions and firms). Figure 1 goes on to list what is involved, namely: a system for issuing and validating certificates, using blockchain and smart contracts; added data security reduces the risk of fraud; enhanced decentralization and data quality (accurate, verified, and validated data); note, however, that the concept needs testing to become mainstream; standardization and implementation challenges exist.

A bibliometric analysis was performed with the results obtained (including a total of 30 articles, from the Scopus database search, in the timeframe 2017–2020—please see Appendix A). In this paper we adopted the statistical tool R, executed through RStudio (an integrated development environment for R) and using the bibliometrix [10] package to analyze the information. An interesting analysis is to see how the keywords presented in the article are evolving over time. Table 2 shows the top three keywords and their number of occurrences in each year.

Figure 3 - Published Paper "Blockchain and Higher Education Diplomas" (cont.)

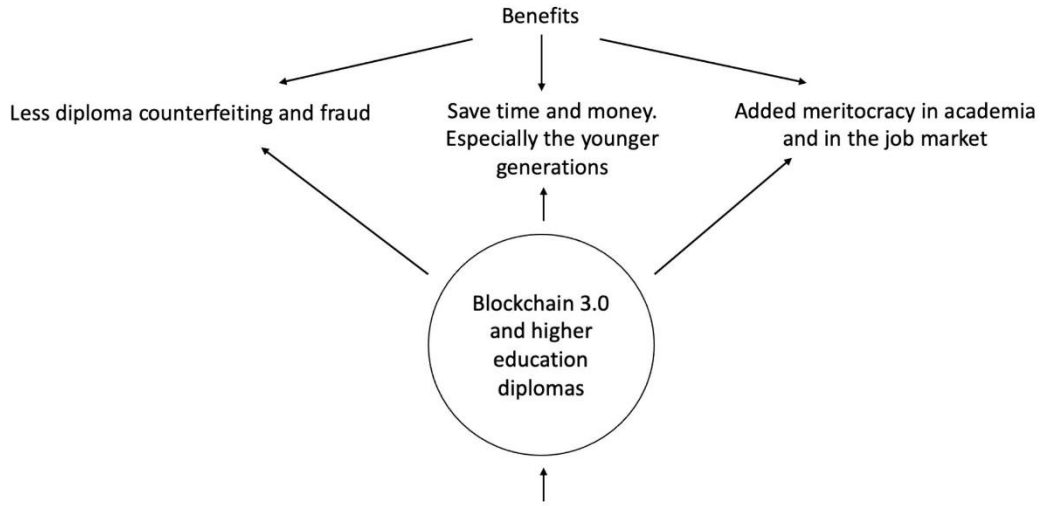

Figure 1. A visual depiction of the research topic.

Table 2. Top 3 keyword occurrences by year, obtained with the KeywordGrowth function.

Keyword	2017	2018	2019	2020
Blockchain	1	5	15	20
Higher Education	0	0	2	4
Students	0	1	4	4

The reviewed articles and papers are summarized and presented in Table 3 (including main objective, contribution, and considerations).

Figure 3 - Published Paper "Blockchain and Higher Education Diplomas" (cont.)

Table 3. Reviewed documents including main objective, contribution, and considerations.

Reference	Location	Objective	Contribution	Considerations
Cheng, J. C., Lee, N. Y., Chi, C., and Chen, Y. H (2018) [3]	Taiwan	To solve diploma fraud issues through the use of blockchain.	Developed a system for issuing and validating certificates in the article, using blockchain and smart contracts (based on Ethereum). Solution is built around 3 entities (schools or certification units that issue the documents, students and companies that inquire for a certificate, and service provider responsible for system maintenance and operation). Students are granted an e-certificate (QR code) and information that can be used to assess data.	Authors' proposed design is very simple, and they do not make any considerations of how schools and certification units will join the network, or how to make sure they are valid institutions allowed to issue certificates. Furthermore, authors did not consider how errors and revokes should be done in their design. This is one of the main questions in the area, as once a transaction is recorded in the chain it cannot be updated. Authors conclude that due to the intrinsic characteristics of blockchain, such solutions can bring trust and reduce issues with certificate forgery.
Kamišalić, A., Turkanović, M., Mrdović, S., and Heričko, M. (2019) [4]	Slovenia, Bosnia, and Herzegovina	Analyzes and categorizes existing blockchain initiatives for Higher Education.	Identification, categorization of initiatives, and their comparison to EduCTX.	The authors are responsible for one of the most referred and daring proposals, the EduCTX that aims to be a global platform for managing "digital micro-credentials", which makes reading their work worthy. The work lists a good number of initiatives, allowing a good overview of the current state of research development, and the authors perform a useful categorization of those initiatives using two different approaches. In addition, a good description of the EduCTX platform is given along with a discussion about the implementation challenges based on their experience. In our view, it is important to have authors discussing implementation challenges and other aspects besides technical attributes. We understand this is essential to increase awareness of decision makers and increase adoption of blockchain solutions.
Duan, B., Zhong, Y., and Liu, D. (2018) [11]	China	Proposes a specific application of a learning outcome blockchain.	Developed a prototype and executed proof of concept to a group of students at Xiangtan University in 2017.	The article brings a different perspective, by modeling a system for outcome-based learning using blockchain, and how the technology can contribute to creating an open learning environment, involving teachers, students, and even employers, and thereby promote continuous improvement of the curriculum and create greater student involvement. It is interesting in so far as it proposes that the student's approval does not depend only on the teacher, but is based on a consensus algorithm. By using the proposed system, at the end of the course, the students will have a diploma and a rich set of information about the capacity acquired during the course. For researchers interested in the topic of education learning outcome, and how technology can be used in it, we understand it is an important piece of work, well worthy of being read.
Gresch, J., Rodrigues, B., Scheid, E., Kanhere, S. S., & Stiller, B. (2019) [12]	Switzerland	Proposes a blockchain/smart-contracts based system to issue and verify diplomas for the University of Zurich	A customized solution for the University of Zurich. With a simplified model for interacting with, reducing complexity, when compared to other implementations.	Despite being a specific solution, based on the University requirements some of them can be easily generalized to other locations. Important to notice the authors expressed the need to increase awareness of such solution, so employeers could verify the diplomas by themselves. In our view this is a crucial point for any proposed solution to be widely accepted, but this is not explored further in the paper.
Vidal, F., Gouveia, F., and Soares, C. (2019) [13]	Portugal	A proposed blockchain/Blockcerts-based system to issue and verify at University Fernando Pessoa.	A prototype and metrics about transaction times and costs (per diploma issued) on bitcoin blockchain.	It is interesting to notice that the authors decided to estimate some costs associated with issuing diplomas in a bitcoin/Blockcert solution. Having such numbers is important to help decision makers to compare with the existing process. As there is an expectation that the whole process will be more efficient and cheaper, in particular for students, it is relevant to have research including the cost component.

Table 3. *Cont.*

Reference	Location	Objective	Contribution	Considerations
San, A. M., N. Chotikakamthorn, and C. Sathitwiriyawong (2019) [14]	Indonesia	Proposes a blockchain issue and verification credential method to achieve increased data privacy.	A digital certification validation method based on a Merkle Tree to increase data privacy.	The article brings an interesting perspective by proposing a (theoretical) model for credential management and verification at a very granular and modular level. By sharing a credential, the owner can choose which components they want to be included. The model differs from others (e.g., Open Badge) by the use of a Merkle Tree to build the data model of credentials (courses, learning activities, etc.). Moreover, the model is general enough to accommodate different types of credentials in addition to academic degrees. On the other hand, as it is still a theoretical model, we understand that further development is needed, with proofs of concept and how it would be implemented in a simple and intuitive way.
Nikolskaia, K., Snegireva, D., and Minbaleev, A. (2019) [15]	Russia	Develop a prototype blockchain/Blockcerts for diploma validation.	Set of instructions and diagrams to develop using Blockcerts.	Another prototype implementation of diploma verification application built upon Blockcerts. It is focused more on the technical aspects with diagrams and code excerpts. Worthy to note that the authors made available the source code in github, which can be of interest for some researchers.
Serranito, D., Vasconcelos, A., Guerreiro, S., and Correia, M. (2020) [16]	Portugal	Proposes a prototype of a blockchain/smart-contract ecosystem of Higher Education Institutions for certificate validation.	Describes in detail their unique proposal to enable a consortium of institutions in a decentralized manner and testing results achieved.	Besides technical aspects, the work is useful to shed light on various decentralization aspects that need to be considered in similar solutions. As per the authors, this is not an easy task as "Decentralization is hard because it is not natural for today's system architects and programmers". We agree with the authors, because even though blockchain is decentralized by default, a poorly designed solution will compromise the full benefit realization. An additional note is that the solution is being developed in the context of a larger initiative named QualiChain (https://qualichain-project.eu/)The source code in github is available, which can be of interest to some researchers.
Capece, G., Ghiron, N. L., and Pasquale, F. (2020) [17]	Italy	Describe technical aspects of the pilot blockchain/Blockcerts solution at the University of "Tor Vergata".	Compares issuing and verification for existing and pilot solutions and discusses how blockchain can increase trust and efficiency in the process.	Most challenges were technical, due to the complexity and novelty of blockchain. This can be considered as an essential point for further development—the training of technical resources (like developers, researchers) to work with blockchain. Furthermore, the work confirmed that students are willing to accept such innovation.
Meyliana, Chandra, Y. U., Cassandra, C., Surjandy, Eka Widjaja, H. A., Fernando, E., Prabowo, H., and Joseph, C. (2019) [18]	Indonesia	A proposal for a blockchain model for integrating the university value chain.	An integrated model to achieve enhanced data quality (accurate, verified, validated) for Indonesian universities.	Research focuses on Indonesia's universities' value chain to propose a conceptual model to manage full student learning paths until certification. The work does not indicate potential issues, like scalability of the solution, how information will be shared, and data-privacy concerns, among others.
Vidal, F. R., Gouveia, F., and Soares, C. (2020) [19]	Portugal	To present an approach to execute corrective actions on the blockchain to revoke credentials.	A model to revoke digital diplomas that do not depend on actions of third-parties.	The work is useful as it presents a good overview of existing approaches and solutions to deal with certificate revoking. This is an important topic for research because due to the immutability feature of blockchain, any need to change data recorded poses a big challenge. Furthermore, by proposing an alternative model that aims to be blockchain agnostic, it opens research avenues for interoperability and the compatibility of solutions.
Taufiq, R., Trisetyarso, A., Meyliana, Kosala, R., Ranti, B., Supangkat, S., and Abdurachman, E. (2019) [20]	Indonesia	Propose a crypto-governance model for handling student documents and diplomas.	A proposal model to implement a crypto-governance model, involving several actors, using a private blockchain network.	The authors bring an additional perspective to the process, involving multiple stakeholders in the university involved in diploma issuance. On the other hand, it is a customized solution for the Indonesian education system that may be not directly applicable to other jurisdictions. As a note, the solution is built on a private blockchain (IBM Hyperledger), in opposition to the majority of other initiatives that are based on public chains (e.g., bitcoin and Ethereum).

Figure 3 - Published Paper "Blockchain and Higher Education Diplomas" (cont.)

We noticed a recent and growing interest in the topic of Blockchain for Higher Education in recent years, therefore confirming the relevance of the discussion.

A descriptive analysis obtained through the bibliometrix *summary* function is given in Appendix A, for further information.

In addition, we searched for authors' (nationality and) cross-country collaboration (according to the bibliometric analysis) to understand what the current level of research integration regarding the topic is. The results indicate almost no cross-country collaboration except for studies from Indonesia–Singapore, Portugal–Brazil, Switzerland–Australia, and Canada–Spain. Figure 2 shows a graphical representation of the country collaboration network.

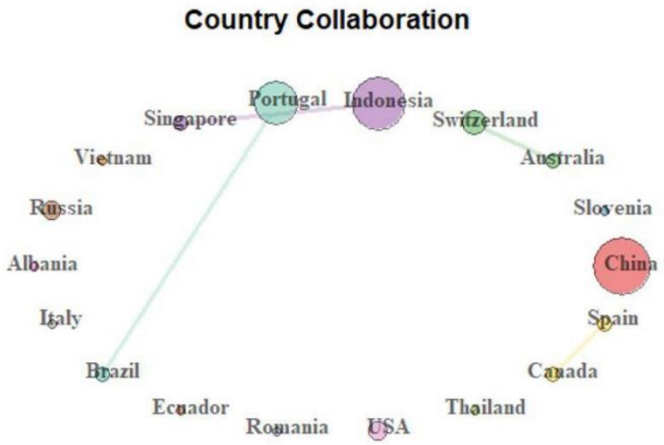

Figure 2. Country collaboration network representation among researchers.

In Figure 2, we may see different-sized and different-colored circles, according to the existing country collaborations. There are also (the same) colored lines linking and indicating collaborations. For example, Indonesia and Singapore collaborate (purple circles and a purple line), as does Portugal with Brazil (pink circles and a pink line); again, Switzerland and Australia also collaborate (green circles and a green line); and, finally, Spain collaborates with Canada (pink circles and a pink line). Additionally, China has a large red circle indicating that a number of researchers from China are collaborating together on the topic.

3.1. Main Concepts/Contributions

The following description aims to set the scene for the case. One of the authors works at a major Portuguese university and was, until very recently, a committee member on one of the doctoral programs, which required candidates to submit a Hague apostille certification (a form of certificate of authenticity that ensures a public document was issued by an authorized institution, therefore abolishing the need of legalization of such documents abroad) upon application. Of note is that a significant number of international candidates did not know what this was and thus failed to submit it and subsequently were not admitted to the doctoral degree. Moreover, this was a great disappointment, and in some cases, plans had been made for international study and travel. An alternative, decentralized, "watertight" (in so far as intermediate suppliers of information would not be allowed to tamper with the automatically appended information) blockchain solution would make the Hague apostille unnecessary and thus save time, resources, and even a lot of "heartbreak".

Additional concerns are with fraud. To understand the extent of the problem, the global market size of certificate fraud is estimated at 2 billion USD, according to National Student Clearinghouse, a non-profit organization based in the United States [21]. The costs

Figure 3 - Published Paper "Blockchain and Higher Education Diplomas" (cont.)

of fraudulent diplomas may range from USD 350 for a higher education degree to more than USD 4000 for a doctoral degree [22].

Blockchain and its characteristics, in particular the immutability of the transactions, can be seen as being pivotal to the implementation of digital certificates and diplomas in a secure, decentralized, and anti-forgery environment. Thus, it may provide a decisive contribution to the eradication of the existing problems.

3.1.1. Blockchain

Blockchain is a radical innovation that has its origins associated with bitcoin cryptocurrency and the underlying technology proposed by Satoshi Nakamoto in 2008 [23,24]. From the beginning, the technology was associated with crypto currencies; this is what is known as Blockchain 1.0. The introduction of smart contracts represents the surge of Blockchain 2.0, with the development of a new set of applications in financial areas. With the growing interest of several other businesses and industries, mainly because of blockchain's essential characteristics of decentralization, immutability, and transparency, many solutions are being developed, and we thus enter the Blockchain 3.0 phase [4].

Among the industries that may benefit from the novel technology, Higher Education is one that has tremendous opportunities, where the need for document authenticity, transparency, and trust, encounter in blockchain characteristics a great match [4].

In simple and straightforward terms, blockchain can be understood as a distributed database connected in a decentralized manner [3,15]. It is composed of blocks grouped in a transaction. The blocks are cryptographed and linked together to form the blockchain. Each block holds a hash pointing to its predecessor. Using a consensus mechanism, new blocks are validated and linked to the chain [3].

There are three types of blockchain—public, private, or consortium-based [15]—and its access can be permissioned (e.g., an entity regulates the access) or permissionless (where anyone can join) [16].

Smart contracts can be defined as clauses that can be described using a programming language and executed by a computer and were initially proposed in the 1990s. Ethereum introduced smart contracts in its core, making blockchain programmable and, therefore, allowing developers to write a diverse set of applications [3]. Additionally, smart contracts can be seen as an object with the state, attributes, and functions or methods that can be invoked to change states, call other functions or other smart contracts [17].

3.1.2. Blockcerts or Smart Contracts

Blockcerts was designed by Massachusetts Institute of Technology (MIT) Media Lab and further developed by Learning Machine, and now Hyland Credentials. It comprises open-source libraries, components, and applications to issue and verify credentials and build on the bitcoin blockchain [24]. It is considered the first significant case of storing hash certificates and aims to be an open standard for credential management on blockchain [12].

Blockcerts offer a simple way to issue a certificate with the required information and are signed using the issuer's private key. A hash is generated from a private key and certificate and stored in blockchain informing to whom it was issued. Certificates can be generated in batch for efficiency reasons [15].

Using a mobile app, the Blockcerts Wallet, the receiver (e.g., the student), can easily access his/her certificates and share with whomever necessary. Blockcerts transaction sizes are fixed, and costs to issue certificates are a function of the transaction fee, that is by default 0.0006 bitcoins (approximately 12 EUR, at the time this article was written) [16].

Blockcerts first appearance was in 2017 in a pilot with 111 cohort graduates of MIT [25]. Since then, it has been proposed, tested, and used in several other initiatives, like in South Ural State University [15], University of Rome "Tor Vergata" [17], and University Fernando Pessoa [13].

Nevertheless, Blockcerts is not the only promising open-source solution. For example, in the case of the University of Nicosia, it has developed its own solution based on bitcoin

Figure 3 - Published Paper "Blockchain and Higher Education Diplomas" (cont.)

and it was the first university to accept tuition fees in cryptocurrency and issue certificates in blockchain [4,26,27].

On other research fronts, there are the proposals and solutions based on Ethereum and smart contracts, like the ones developed at University of Zurich [12], University of Lisbon [16], and Ho Chi Minh City (HCMC) University of Technology in Vietnam [28].

Like bitcoin, Ethereum provides the same characteristics of transparency, security, immutability, and decentralization, albeit with the additional capacity to be programmable through the use of smart contracts.

On the other hand, advocates of the use of bitcoin claim this is a more mature, tested, and due to the higher financial investment spent, may be the better choice [17].

3.1.3. Digital Diploma Issuing and Verification

The initiatives for diploma management (from issuance to verification) using blockchain are not circumscribed to a specific geographic location or group of researchers. It has spread from Asia [3,11,14,15,28], Europe [4,12,13,16,17], and to the Americas [24] as identified in the literature.

The existing process is clearly identified as inefficient, time-consuming, manually intensive, and costly [17]. All this inefficiency brings attention to the issue of certification forgery [3], which is a significant flaw in the system and affects society in several ways [16]. Surveys indicate relevant numbers of quality issues with certification and diploma information presented in job applications (forgery or fraudulent information) [12,16].

Universities may offer some form of verification or rely on other services for this task to minimize the problem. Despite that, such initiatives suffer from a lack of standardization and unification [12].

Blockchain is seen as a potential solution to improve the process, increase transparency, bring added efficiency, achieve decentralization, and consequently reduce diploma fraud. It can also be used to build a global (transnational) certificate validation ecosystem [16]. Its characteristic of immutability can enhance credibility and reduce the risk of information loss [3].

From the Higher Education Institution (HEI) point of view, blockchain issuance and validation solutions may be beneficial, for example, in internationalization programs, joint-degrees, and international student applications, reducing administrative tasks and costly processes. On the other hand, from the students' point of view, such systems may simplify student tasks to validate received credentials and eliminate unnecessary intermediaries in the process [4].

As it is, the majority of initiatives are still in early phases of development, as prototype or pilot implementations, and there are only a few applications that surpass that stage and have evolved into commercial applications, even generating spin-offs. This is the case of the University of Nicosia, that, since 2017, has been issuing all diplomas on bitcoin using its own developed open source solution [27,29–31].

3.1.4. Initiatives

There is a growing interest in applying blockchain in HEI, with particular attention to issuing and verifying diplomas. Although the authors do not intend to compile an extensive list of current initiatives but shed light on the current status of research on the topic, the literature review identified initiatives, ranging from proposals to prototypes and pilot programs spread worldwide. A summary of initiatives is given in Table 4.

Figure 3 - Published Paper "Blockchain and Higher Education Diplomas" (cont.)

Table 4. Identified blockchain diploma verification initiatives.

Institution	Country	Status	Underlying Technology
University of Rome "Tor Vergata"	Italy	Pilot	Bitcoin/Blockcerts
Southern Taiwan University of Science and Technology	Taiwan	Prototype	Ethereum
Xiangtan University	China	Pilot	Smart contracts
Bina Nusantara University	Indonesia	Conceptual Model	N/A
University of Zurich	Switzerland	Prototype	Ethereum
University of Lisbon	Portugal	Pilot	Ethereum
HCMC University of Technology	Vietnam	Prototype	Ethereum
University Fernando Pessoa	Portugal	Prototype	Blockcerts/Bitcoin/Ethereum
South Ural State University	Russia	Prototype	Blockcerts
University of Maribor (EduCTX)	Slovenia	Pilot	Ethereum
University of Nicosia	Cyprus	Production	Bitcoin

3.1.5. Implementation Challenges/Barriers

To fully deploy the benefits proposed by blockchain solutions in diploma management, implementation barriers must be overcome. Reducing technical complexities to operate the system is crucial and needs to be considered in the solutions [12], such as eliminating the need to deal with public-private key-pair generation [17].

Another challenge originates from the immutability characteristic of blockchain, and it relates to an eventual need to correct information, with special attention to the ability to revoke diplomas and credentials [19].

Data privacy and data protection rules (e.g., the General Data Protection Regulation) must be considered for a successful solution. Again, data immutability in the blockchain may impose barriers to comply with, for example, with the "right to be forgotten" [12].

Solutions must also consider social and organizational aspects, and integrate with existing technological solutions, and deal with previously issued certificates and data storage [12].

4. Discussion

In this review, we were able to identify the increased interest in blockchain in the educational environment, especially in solutions for the issuance and verification of diplomas and digital certificates. With its characteristics of transparency, decentralization, and immutability, blockchain finds a perfect alignment with students' needs, educational institutions, and the labor market in general to minimize the problem of forgery of diplomas. Additionally, it allows for the establishing of a reliable and decentralized process, where those who need to validate the veracity of a diploma dispense with intermediaries, with the process occurring in an efficient and low-cost way. However, like any radical innovation, blockchain still needs to overcome some implementation barriers of a technical nature (complexity of the operation, scalability, correction of errors) and lack of "*de facto*" standards and others of a cultural and social nature (with new business models, regulatory issues, resistance to change). Therefore, investment in research in these areas is still necessary.

In regard to applications in academia and in HEI, with the increase in globalization and with evermore students aiming to study abroad, namely also in Portugal, such a system linking academic diplomas to blockchain might even serve as a catalyst for additional travel regarding higher education studies. With aging populations in Europe, more international students being ready and interested in studying abroad (in a facilitated blockchain-aided process) would make up for the diminishing local student populations (European women, as in all developed countries, are having children at increasingly older ages and are also having less children, quite understandably due to the cost and time involved with the rearing of children) and would thus boost a market otherwise condemned to stagnation (or, in the longer term, condemned to a definitive decrease in market size). This issue is thus of paramount importance and standards and other such related processes need to be addressed for the process to become widespread and mainstream, and not only implemented on an ad hoc basis at a few universities worldwide.

Figure 3 - Published Paper "Blockchain and Higher Education Diplomas" (cont.)

Finally, at a time where good jobs are hard to come by, and where the job market is increasingly more competitive as time passes, the system described herein could be a "game changer", limiting fraud and providing for a genuinely meritocratic environment concerning academic qualifications. People with the best qualifications would be employed, rather than those able to bypass a system which, at present, is in need of radical improvement.

5. Conclusion

We have presented an integrative literature review, summarizing articles read, along with the main concepts and contributions. We have shown how distinct parts of the world and different nationalities, such as from China, Taiwan, Vietnam, Portugal, Switzerland, Italy, and others, have been attracted to the subject. We did a bibliometric analysis using R/bibliometrix. In Appendix A, the commands used are included and part of the result of the summary function. A recent and growing interest is noticeable on the topic of Blockchain for Higher Education, therefore confirming the relevance of the discussion, which is seen to be very timely.

Due to the added mobility of citizens—including the increase in international students worldwide, but also regarding the refugee problem—as well as concerning the counterfeiting of diplomas and the selling of fraudulent certificates—we propose to ally blockchain technology to higher education certificates and diplomas. The result would be to make the process of checking for academic qualifications more facilitated, transparent, and reliable—possibly helping students in more domains than initially predicted and even sparing student burnout [32] (due to the uncertainty involved in the current process). In the case of refugees, this actually might present itself as the only option open to them in the absence of documentation and belongings in conflict-induced/war scenarios. Thus, the benefits accrued to this decentralized process would be up and above the simple adding up of the formal certification process and of the costs saved to job and higher education applicants. The real benefit could be immeasurably higher—providing for a more just and equitable world, where harsh turns of events may mean that technology may be the only solution, as in other scenarios [33], with social support provided by higher education being essential [34].

Our contribution lies also in shedding light on the (lack of a) coordinated approach, in Europe, or involving a group of universities, to solve the problem. We have verified the existence of isolated initiatives of each research group, which look only to the specificities of the countries/universities which they are in, with the exception of EduCTX, which speaks of establishing a global platform for European Credit Transfer and Accumulation System (ECTS), since its conception.

By mentioning the refugee problem, we are calling attention to yet another delicate situation.

Additionally, we leave open the issue of mobility from a more global perspective. We have noted that the initiatives tend to be very local or regional (e.g., Europe) in nature. Concerning international mobility, for example in Portugal, with the increase in the number of Brazilian citizens here (as Brazil has close ties and was a former colony of Portugal, where they also speak Portuguese), who depend on notary processes, the recognition of a Brazilian diploma is not automatic, when compared to a European diploma, which makes the discussion of this topic even more appealing. To recognize a single Brazilian diploma may cost as much as 500 EUR and take 3–6 months. For a refugee without a diploma, things are that much more complicated and with a very significant impact. It is time to unite forces, for a better world. Additionally, is anything more important than our education?

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Figure 3 - Published Paper "Blockchain and Higher Education Diplomas" (cont.)

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Conflicts of Interest: The authors declare no conflict of interest.

Appendix A

To obtain a summary of the bibliometric analysis, the following commands were executed using the RStudio console:

```
library(dplyr); library(stringr); library(bibliometrix)
my_scopus <- convert2df("scopus.bib", dbsource="scopus",format="bibtex");
results <- biblioAnalysis(my_scopus)
summary(results, k=10, pause=F, width=130)
```

The main results obtained from the summary command are as follows:

```
MAIN INFORMATION ABOUT DATA
    Timespan                                 2017 : 2020
    Sources (Journals, Books, etc.)          28
    Documents                                30
    Average years from publication           1.8
    Average citations per documents          2.533
    Average citations per year per doc       0.73
    References                               645
DOCUMENT TYPES
    article                 5
    conference paper        23
    conference review       1
    short survey            1
AUTHORS
    Authors                                  96
    Author Appearances                       107
    Authors of single-authored documents     2
    Authors of multi-authored documents      94
AUTHORS' COLLABORATION
    Single-authored documents       2
    Documents per Author            0.312
    Authors per Document            3.2
    Co-Authors per Documents        3.57
    Collaboration Index             3.36
Annual Scientific Production
    Year        Articles
    2017        1
    2018        4
    2019        13
    2020        12
Annual Percentage Growth Rate 128.9428
```

Bibliometrix functions used to obtain the top three keywords' occurrence and their year distribution:

```
KeywordGrowth(my_scopus, Tag = "ID", sep = ";", top = 3, cdf = TRUE)
```

Bibliometrix functions used to obtain the authors' country collaboration network and plot it.

```
M <- metaTagExtraction(my_scopus, Field = "AU_CO", sep = ";")
NetMatrix <- biblioNetwork(M, analysis = "collaboration", network = "countries", sep = ";")
```

Figure 3 - Published Paper "Blockchain and Higher Education Diplomas" (cont.)

```
net=networkPlot(NetMatrix, n = dim(NetMatrix) [1], Title = "Country Collaboration",
type = "circle", size=TRUE, remove.multiple=FALSE,labelsize=1.0)
```

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Figure 3 - Published Paper "Blockchain and Higher Education Diplomas" (cont.)

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Figure 3 - Published Paper "Blockchain and Higher Education Diplomas" (cont.)

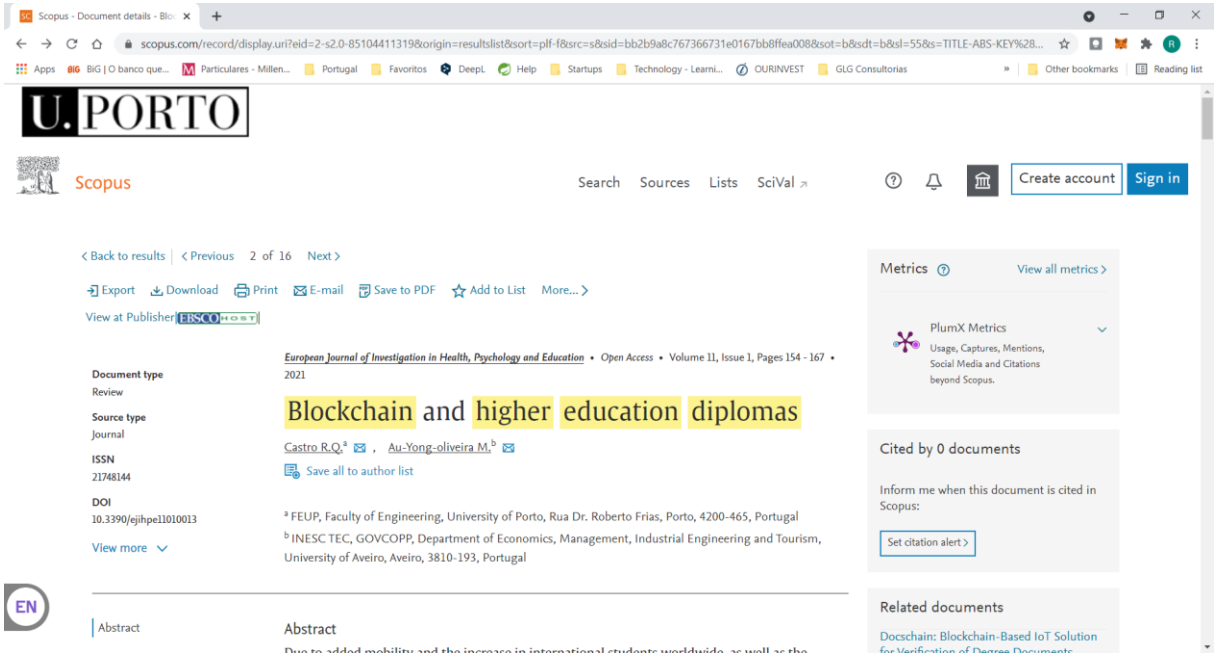
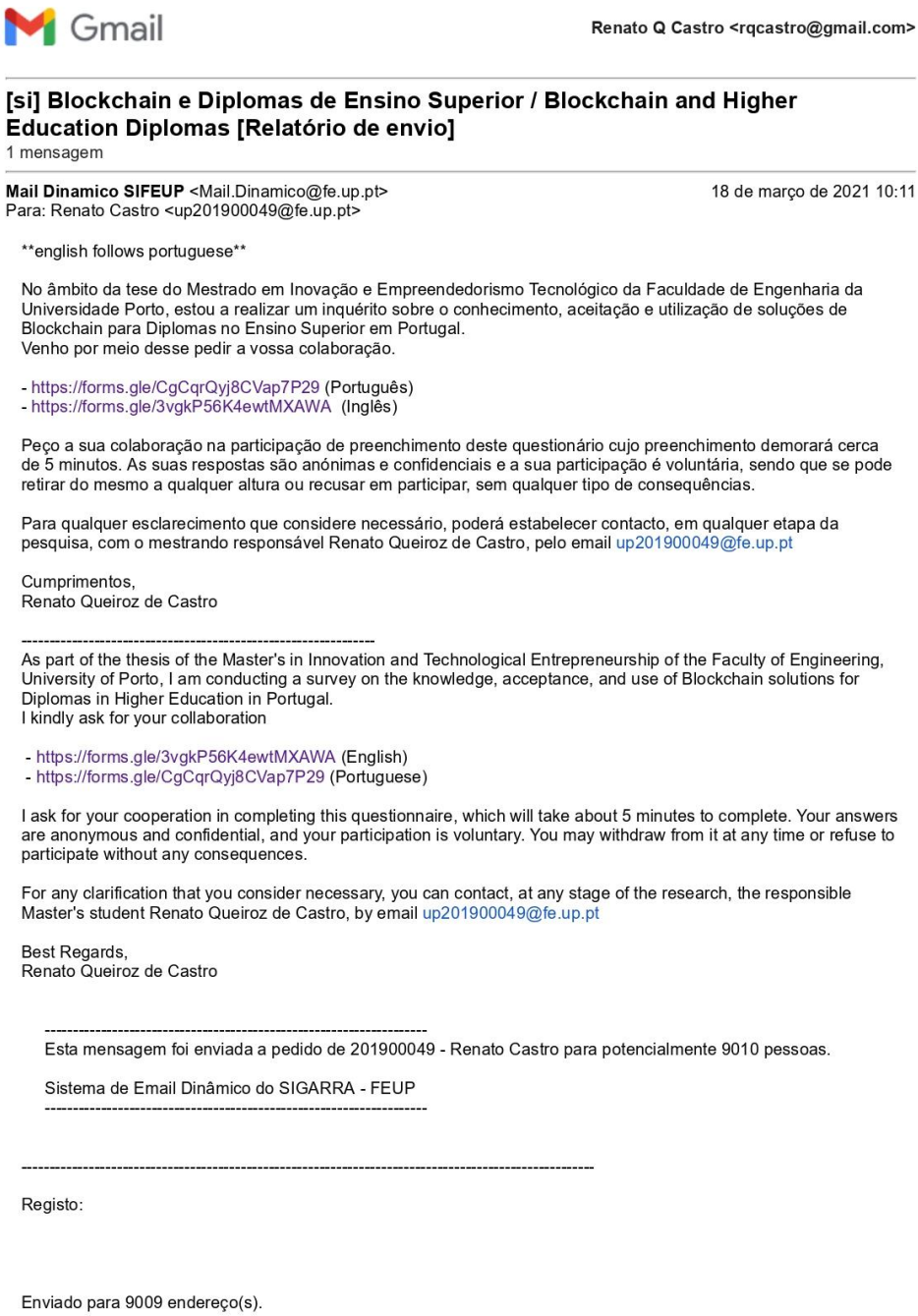


Figure 4 - Scopus result with the published article

Figure 5 - Certificate of Publication issued by the journal

Students survey request email

Print of email sent through SIFEUP's dynamic email to all enrolled students at the Faculty of Engineering of the University of Porto. Email sent on March, 18th 2021.



Gmail

Renato Q Castro <rqcastro@gmail.com>

[si] Blockchain e Diplomas de Ensino Superior / Blockchain and Higher Education Diplomas [Relatório de envio]

1 mensagem

Mail Dinamico SIFEUP <Mail.Dinamico@fe.up.pt> 18 de março de 2021 10:11
Para: Renato Castro <up201900049@fe.up.pt>

english follows portuguese

No âmbito da tese do Mestrado em Inovação e Empreendedorismo Tecnológico da Faculdade de Engenharia da Universidade Porto, estou a realizar um inquérito sobre o conhecimento, aceitação e utilização de soluções de Blockchain para Diplomas no Ensino Superior em Portugal.
Venho por meio desse pedir a vossa colaboração.

- https://forms.gle/CgCqrQyj8CVap7P29 (Português)
- https://forms.gle/3vgkP56K4ewtMXAWA (Inglês)

Peço a sua colaboração na participação de preenchimento deste questionário cujo preenchimento demorará cerca de 5 minutos. As suas respostas são anónimas e confidenciais e a sua participação é voluntária, sendo que se pode retirar do mesmo a qualquer altura ou recusar em participar, sem qualquer tipo de consequências.

Para qualquer esclarecimento que considere necessário, poderá estabelecer contacto, em qualquer etapa da pesquisa, com o mestrando responsável Renato Queiroz de Castro, pelo email up201900049@fe.up.pt

Cumprimentos,
Renato Queiroz de Castro

As part of the thesis of the Master's in Innovation and Technological Entrepreneurship of the Faculty of Engineering, University of Porto, I am conducting a survey on the knowledge, acceptance, and use of Blockchain solutions for Diplomas in Higher Education in Portugal.
I kindly ask for your collaboration

- https://forms.gle/3vgkP56K4ewtMXAWA (English)
- https://forms.gle/CgCqrQyj8CVap7P29 (Portuguese)

I ask for your cooperation in completing this questionnaire, which will take about 5 minutes to complete. Your answers are anonymous and confidential, and your participation is voluntary. You may withdraw from it at any time or refuse to participate without any consequences.

For any clarification that you consider necessary, you can contact, at any stage of the research, the responsible Master's student Renato Queiroz de Castro, by email up201900049@fe.up.pt

Best Regards,
Renato Queiroz de Castro

Esta mensagem foi enviada a pedido de 201900049 - Renato Castro para potencialmente 9010 pessoas.

Sistema de Email Dinâmico do SIGARRA - FEUP

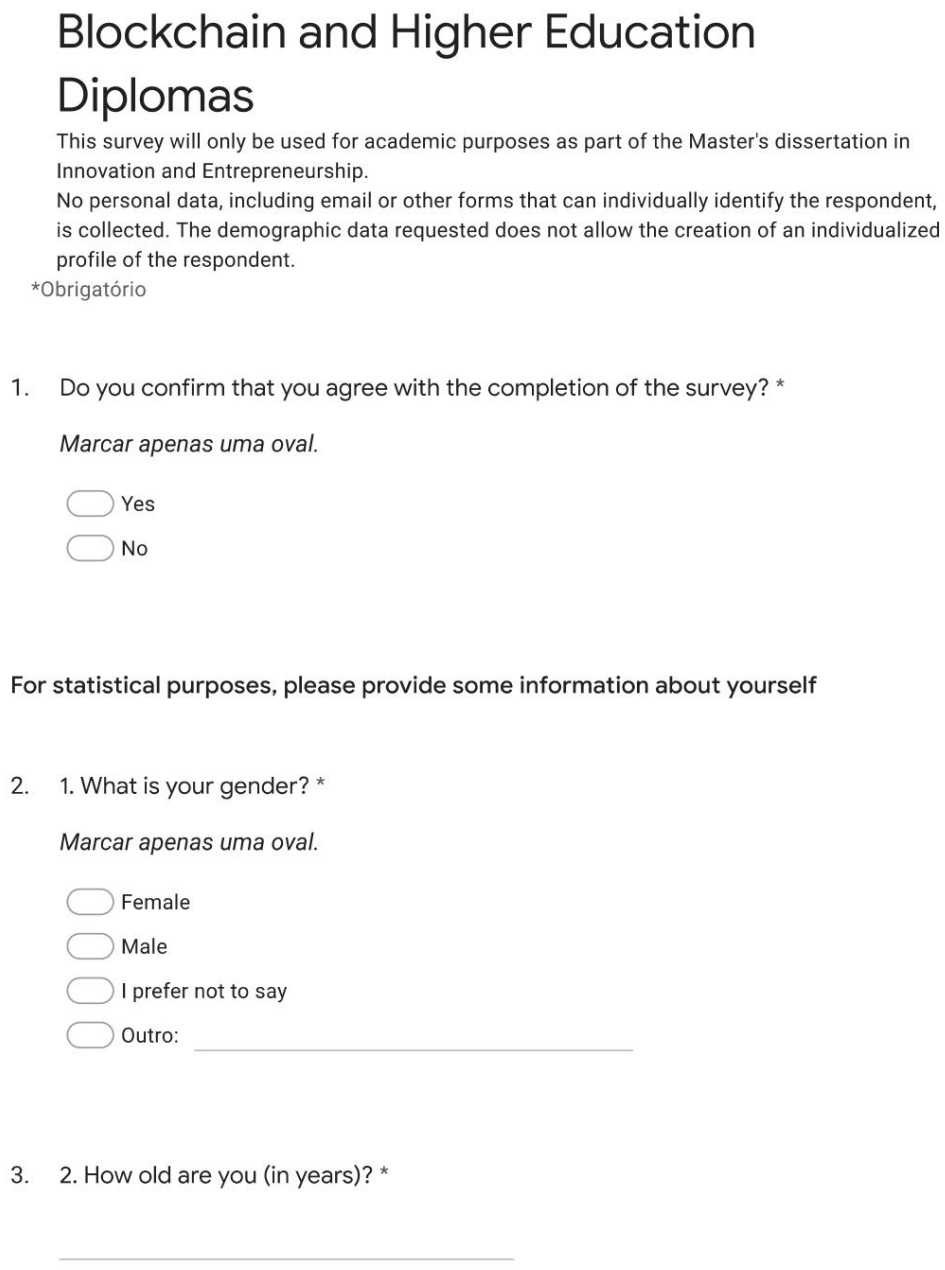
Registo:

Enviado para 9009 endereço(s).

Figure 6 - Print screen of survey submission email

Student's Survey

The print of the English version of the questionnaire was utilized in the survey with students. The questionnaire was created in Google Forms



Blockchain and Higher Education Diplomas

This survey will only be used for academic purposes as part of the Master's dissertation in Innovation and Entrepreneurship.
No personal data, including email or other forms that can individually identify the respondent, is collected. The demographic data requested does not allow the creation of an individualized profile of the respondent.

*Obrigatório

1. Do you confirm that you agree with the completion of the survey? *

Marcar apenas uma oval.

- Yes
- No

For statistical purposes, please provide some information about yourself

2. 1. What is your gender? *

Marcar apenas uma oval.

- Female
- Male
- I prefer not to say
- Outro: _____

3. 2. How old are you (in years)? *

_____

Figure 7 - Student's survey questionnaire - English

4. 3. What is your educational level? *

Marcar apenas uma oval.

- ◯ High School
- ◯ Bachelor
- ◯ Master
- ◯ Doctorate
- ◯ Post-doctorate
- ◯ Outro: _____

5. 4. What is your nationality? *

Marcar apenas uma oval.

- ◯ Portuguese
- ◯ Outro: _____

6. 5. Are you currently working? *

Marcar apenas uma oval.

- ◯ Yes
- ◯ No

7. 6. Are you currently studying? *

Marcar apenas uma oval.

- ◯ Yes *Pular para a pergunta 8*
- ◯ No *Pular para a pergunta 12*

Academic Context

Figure 7- Student's survey questionnaire – English (cont.)

8. 7. What university do you attend? *

9. 8. What is the course level? *

Marcar apenas uma oval.

- ◯ Bachelor
- ◯ Licensee
- ◯ Master
- ◯ Doctorate
- ◯ Post-doctorate
- ◯ Outro: _____

10. 9. Are you a mobility student? *

Marcar apenas uma oval.

- ◯ Yes
- ◯ No

11. 10. Are you a Erasmus student? *

Marcar apenas uma oval.

- ◯ Yes
- ◯ No

Figure 7- Student's survey questionnaire – English (cont.)

Blockchain Knowledge

Blockchain is a technology that has a number of intrinsic characteristics that provide the creation of innovative solutions in the most diverse business areas (financial, logistics, medical, educational, etc.).

12. 11. What is your level of knowledge about blockchain technology? *

Marcar apenas uma oval.

- ◯ Very Low
- ◯ Low
- ◯ Reasonable
- ◯ High
- ◯ Very High
- ◯ None/I don't know

13. 12. Which of the following applications (or uses) of blockchain are you most familiar with or have you heard of? *

Marcar apenas uma oval.

- ◯ Cryptocurrencies (e.g. Bitcoin)
- ◯ Degrees and electronic academic information
- ◯ Electronic identity management
- ◯ Intellectual property management
- ◯ Electronic Medical Record
- ◯ I don't know any application
- ◯ Outro: _____

Figure 7- Student's survey questionnaire – English (cont.)

14. 13. The following are the main features of blockchain. In your opinion, which is the most important? *

Marcar apenas uma oval.

- ◯ Immutability - Prevents the stored information from being altered
- ◯ Decentralization - Information is stored (replicated) in multiple locations
- ◯ Disintermediation - No need for a central authority to guarantee the authenticity of the information
- ◯ Security - Information is stored securely and encrypted.
- ◯ Traceability - Allows the traceability of the information, throughout its sequence of events

Academic Information Retrieval

15. 14. Have you ever needed to request your academic information (diploma, transcript) on any occasion (e.g. apply for studies, job opportunities)? *

Marcar apenas uma oval.

- ◯ Yes
- ◯ No *Pular para a pergunta 19*

Think about your experience in requesting your academic information, such as copies of diplomas, transcripts, and certificates. Please indicate your level of satisfaction with each of the elements indicated

16. 15. Ease of the process *

Marcar apenas uma oval.

	1	2	3	4	5	
Not at all satisfied	◯	◯	◯	◯	◯	Very satisfied

Figure 7- Student's survey questionnaire – English (cont.)

17. 16. Cost of the process *

Marcar apenas uma oval.

	1	2	3	4	5	
Not at all satisfied	◯	◯	◯	◯	◯	Very satisfied

18. 17. The duration of the process *

Marcar apenas uma oval.

	1	2	3	4	5	
Not at all satisfied	◯	◯	◯	◯	◯	Very satisfied

Digital Diploma in Blockchain

19. 18. Is there any initiative, at your current university, to issue diplomas in electronic (digital) format using blockchain? *

Marcar apenas uma oval.

- ◯ Yes
- ◯ No
- ◯ I don't know

Figure 7- Student's survey questionnaire – English (cont.)

20. 19. How important is it for you to be able to receive a digital version of your academic information (diplomas, academic transcripts, etc.) in an application using blockchain? *

Marcar apenas uma oval.

	1	2	3	4	5	
Not at all important	◯	◯	◯	◯	◯	Very Important

21. 20. In your opinion, what is the biggest benefit that a digital version of your academic information in an application using blockchain can bring? *

Marcar apenas uma oval.

- ◯ Agility in the process of obtaining and validating academic information
- ◯ Information Security
- ◯ Transparency of the process as a whole
- ◯ Lower cost for obtaining and validating academic information
- ◯ None
- ◯ I don't know
- ◯ Outro: _____

22. 21. How important is it for you to be able to share a digital version of your academic information (diplomas, transcripts and others) without the need for intervention from your university? *

Marcar apenas uma oval.

	1	2	3	4	5	
Not at all important	◯	◯	◯	◯	◯	Very important

Figure 7- Student's survey questionnaire – English (cont.)

20. 19. How important is it for you to be able to receive a digital version of your academic information (diplomas, academic transcripts, etc.) in an application using blockchain? *

Marcar apenas uma oval.

	1	2	3	4	5	
Not at all important	◯	◯	◯	◯	◯	Very Important

21. 20. In your opinion, what is the biggest benefit that a digital version of your academic information in an application using blockchain can bring? *

Marcar apenas uma oval.

- ◯ Agility in the process of obtaining and validating academic information
- ◯ Information Security
- ◯ Transparency of the process as a whole
- ◯ Lower cost for obtaining and validating academic information
- ◯ None
- ◯ I don't know
- ◯ Outro: _____

22. 21. How important is it for you to be able to share a digital version of your academic information (diplomas, transcripts and others) without the need for intervention from your university? *

Marcar apenas uma oval.

	1	2	3	4	5	
Not at all important	◯	◯	◯	◯	◯	Very important

Figure 7- Student's survey questionnaire – English (cont.)

23. 22. How important is it to you that a university, other institutions such as government agencies, employers in Portugal, would accept a digital version of your academic information that can be authenticated/validated independently from the home university? *

Marcar apenas uma oval.

	1	2	3	4	5	
Not at all important	◯	◯	◯	◯	◯	Very Important

24. 23. How important is it for you that a university, other institutions such as government agencies, employers OUTSIDE Portugal, would accept a digital version of your academic information that can be authenticated/validated independently from the home university? *

Marcar apenas uma oval.

	1	2	3	4	5	
Not at all important	◯	◯	◯	◯	◯	Very Important

25. 24. How do you see the future of higher education? Gaining more and more importance to get a good job? *

Marcar apenas uma oval.

	1	2	3	4	5	
Totally disagree	◯	◯	◯	◯	◯	Totally agree

Figure 7- Student's survey questionnaire – English (cont.)

23. 22. How important is it to you that a university, other institutions such as government agencies, employers in Portugal, would accept a digital version of your academic information that can be authenticated/validated independently from the home university? *

Marcar apenas uma oval.

	1	2	3	4	5	
Not at all important	◯	◯	◯	◯	◯	Very Important

24. 23. How important is it for you that a university, other institutions such as government agencies, employers OUTSIDE Portugal, would accept a digital version of your academic information that can be authenticated/validated independently from the home university? *

Marcar apenas uma oval.

	1	2	3	4	5	
Not at all important	◯	◯	◯	◯	◯	Very Important

25. 24. How do you see the future of higher education? Gaining more and more importance to get a good job? *

Marcar apenas uma oval.

	1	2	3	4	5	
Totally disagree	◯	◯	◯	◯	◯	Totally agree

Figure 7- Student's survey questionnaire – English (cont.)