

# Blockchain Applications in the European Higher Education Arena

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*This desk research will initiate an exploration of present and potential blockchain applications in the higher education sector of Europe. The aim of this research is to create a theoretical base for a further postgraduate research and analysis, so to create an effective model/framework to augment the integration of blockchain technology into existing organizational processes, initially in higher educational institutions, but which may be adaptable and generalizable to other specific uses. Due to the novelty of the topic, academic resources related to the research area are limited. Most studies seem to focus on blockchain-based applications in industries such as finance, healthcare, and supply chain management, and there is little evidence of the impact of blockchain technology on education. This paper discusses present and suggests some potential blockchain-based applications in education in Europe and beyond. This research provides a groundwork for education and academia stakeholders, policymakers and researchers to exploit the potential of blockchain in different functions of an education system.*

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## 1. Introduction

The world has witnessed several stages of the technological development. Currently, we are living in Industry 4.0 or the Fourth Industrial revolution, which includes technologies like AR/VR (augmented and virtual reality), AI (artificial intelligence), machine learning and blockchain technology. The world is developing too fast and these technological advancements bring deep changes into the nature of knowledge and skills required in the labor market. This in turn puts enormous pressure on traditional educational institutions and teaching and learning practices, calling for improved lifelong learning, skills development and recognition systems.

Improving the quality of life globally means investing in education. It improves social stability and long-term economic growth. Ensuring inclusive and equitable quality education and promoting lifelong learning opportunities for all is one of the top priority goals of the United Nations Sustainable Development Goals [1].

Technology has improved access to education for an increasing number of students. The COVID-19 pandemic was one of the factors that exposed educational challenges. It forced educational institutions to temporarily close their doors, which affected nearly 1.6 billion learners in more than 190 countries and all continents [2]. With the Russia-Ukraine war in place, Ukraine needed to shift to an emergency remote teaching and learning mode that has already been adopted in the past because of the pandemic. These two incidents underpinned the need for digital technologies in the education sector and a higher level of digital capacity and innovations in the education sector and a higher level of digital capacity and innovations [3].

In the 21st century, computers have become an integral part of nearly every facet of education. Blockchain technology has recently received significant attention from EU institutions, policymakers and government. It is poised to bring about a similar transformative impact in

the education sector. Blockchain technology holds tremendous potential for addressing various educational challenges and facilitating improved monitoring of learning outcomes for both educators and students. Blockchain has a significant impact on educational learning and teaching methods. This advancement brings both opportunities and challenges for universities, affecting internal processes and organizational structure. As the momentum for change builds, organizations and institutions that have laid the groundwork for adopting and utilizing blockchain technology will gain a competitive edge in their respective markets and regions.

This study will incorporate desk research and will focus on present and potential applications of blockchain technology in higher education sector. This desk research will explore scientific journals, government data and media reports. Specific points of interest include use-cases of blockchain technology in education sector in Europe and beyond.

This research paper is only a preliminary mapping exercise and in no way represents a comprehensive assessment or the final word on the current state of blockchain technology in education sector of Europe. This paper provides a groundwork for education and academia stakeholders, policymakers and researchers to exploit the potential of blockchain in different areas of an education system.

## 2. Background

### Blockchain technology

Blockchain technology has emerged as a groundbreaking phenomenon that hit the global world since the invention of the Internet [4; 5]. Several authors mentioned that blockchain represents the second era of the Internet [6; 7]. This technology cannot be touched or seen, therefore, its intangible nature presents a challenge in explaining it. Visually, it can be imagined as a chain of blocks, that are linked to each other [8; 9]. These blocks

contain information in them, which can be stored in any format (text, pictures or audio files).

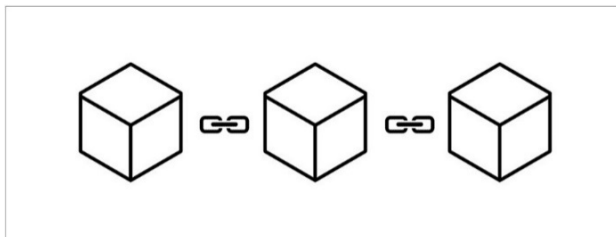


Fig. 1: Structure of Blockchain

Blockchain technology was initially described in the early 90s, as a tool to timestamp digital documents, so to eliminate the possibility of backdating or tampering with them. In this case, blockchain may be seen as a “digital notary”, digital notebook that lots of people can use and write in, with some special features that make it really secure and trustworthy.

In 2008, blockchain was revealed in a paper called “Bitcoin: A Peer-to-Peer Electronic Cash System” by Satoshi Nakamoto (the pen name), so to create the digital cryptocurrency called Bitcoin. The initial idea behind blockchain is that it is a virtual database, which is used by Bitcoin and other cryptocurrencies for secure and anonymous transactions [10]. Since then, there was an emergence of other blockchain implementations, such as Ethereum and Hyperledger [11; 12]. Nowadays, blockchain technology is much more than just a tool to enable digital currencies, it is a platform, which has a nearly limitless amount of applications across almost every sector. It is a new global infrastructure that could transform many existing processes in business, governance and society [13].

### Blockchain Generations

Blockchain 1.0 is an initial version of blockchain, the concept of which was introduced by Satoshi Nakamoto in 2008. It is used for secure and transparent transactions flow on a Bitcoin blockchain. Nowadays, this version of blockchain is used not only for Bitcoin, but for other existing altcoins – all cryptocurrencies created after Bitcoin.

Second generation of blockchain is called Blockchain 2.0. It started in 2013 with an introduction of Ethereum [11]. Ethereum speeded up the development of decentralized finance (DeFi), decentralized autonomous organizations (DAOs), initial coin offerings (ICOs), and non-fungible tokens (NFTs). While Bitcoin has been created solely for operating as peer-to-peer digital cryptocurrency, Buterin developed Ethereum as a platform on which many cryptocurrencies, including its own – Ether – can operate. Blockchain 2.0 can be defined as the second generation of blockchain technology that is focused on smart contracts. Smart contracts refer to digital programmes stored on a blockchain that are automatically executed when predetermined terms and conditions are

met [14]. Smart contracts are exactly the same as contracts in the real-world, but they are digital.

Blockchain 3.0 generation refers to blockchain’s impact on economy and market. It is defined as an enterprise and institutional blockchain. During this stage engineers tried to enhance blockchain’s scalability and security features, allowing blockchains to interact with each other and to facilitate speedier cost-effective transactions. Blockchain 3.0 is an upgraded version of blockchain 2.0, which makes blockchain more capable for running DApps.

Blockchain 4.0 generation is all about industry applications. Blockchain 3.0 is fitted into Blockchain 4.0 and it is usable in real-life business scenarios by satisfying Industry 4.0 demands by making blockchain promises come to life. It is important to notice that there is still room for better enhancement and next generations of blockchain. For example, blockchain can be easily enjoyed by humans and business if it has a user-friendly interface.

Blockchain technology enables the creation of a decentralized environment, where transactions and data are not under the control of any third-party organizations [15]. Rather than having a central administrator like a traditional database, blockchain has a network of replicated databases synchronized via the Internet and visible to those via the network. Blockchain is an open, distributed ledger that can efficiently record transactions between two parties in a verifiable and permanent way without the need for a trusted third party [16].

For the purpose of this research, authors define blockchain as a decentralized distributed ledger, which allows peer to peer transactions secured by cryptographic rules. It is a registry or journal (ledger), which does not have a central authority to control the database (decentralized), which involves many participants who store information (distributed) and operates safely due to securing information from unauthorized access (cryptographic rules). Blockchain is a registry that is distributed among many participants with no central entity to control.

### Educational Challenges

**Skills Development and Recognition.** The European Union undergoes continual transformations, which result in evolution in the demand for relevant knowledge, skills and competencies. One of them is the recent spread of COVID-19 which has created an unprecedented global health pandemic, resulting in a global economic crisis. This crisis has impacted businesses and institutions of all sizes in different ways – from closure to struggling to stay afloat to changes in business models – resulting in job losses [17]. At the moment, 40% of employers cannot find people with the right skills to fill their vacancies [18]. To effectively navigate these changes, individuals must possess a set of fundamental competences, including literacy, numeracy and digital proficiency. Education and

training play a pivotal role in empowering young individuals, particularly by facilitating the development of these competences and providing them with an optimal foundation for their future endeavors. To identify and address the acquisition of necessary knowledge, skills and attitudes, while preventing the emergence of skills gaps and mismatches, it is essential to establish effective communication channels between the education and training sector and the needs of the EU economy.

**Fraud Tampering.** In education systems certificates state that the achievements of the students and different activities are mostly issued on paper or other physical forms. Universities and institutions are responsible for the issuing and validation of academic certificates, such as diplomas. That requires educational institutions to be constantly available to perform this validation when requested by external entities, such as employers. Moreover, paper certificates are prone to tampering and forging. We still live in a paper-based economy of student records, which has a lot of problems, such as widespread fraud [6]. However, recent research showed that the counterfeit in diplomas involves not only lower-tier staff but also activists, governmental members, officials and university candidates [19].

Degree mills are one of the ways how to get a fake diploma. Degree mills are fraudulent providers of higher education and training, offering degrees and certificates that may be considered bogus and have no academic value [20]. Very often, degree mills look like usual colleges or university, with the website, publications, contact details and attractive logo. However, if we take a closer look, we will see that the logo has been “borrowed” from a real university and a bit modified, contact details will lead you to the post box or even fake address, and real address of the institution does not even exist. Nevertheless, their degrees can be purchased for much cheaper price than the tuition fee paid. Degree mills stop the efforts to assure quality in education. Fake degrees also have a negative impact on the students: because degree mills are unaccredited institutions, their diplomas or ECTS are not recognized, so students cannot continue their educational path. Moreover, employees, who tend to verify candidate’s diploma before making a job offer, very easily understand that it is a scam. It all has a negative impact on public educational institutions and legitimate service providers, as people start losing trust towards colleges and universities.

**Decrease in University Enrollment.** Educational sector all over the world experienced a decline in enrolment of students. There is a number of factors, which have influence on this indicator: rise in tuition fee, widely promoted massive open online courses, political situation in some regions (Ukraine, countries of the Middle East). There are many reasons why tuition fees are increasing globally. For example, increase in labour and supply costs in the USA was one of the factors that led to the increase in average tuition and fees up to 1.2 percent for

public universities in fall 2020 and 1.6 percent in fall 2021 [21]. High energy costs, alongside with the decline in real pay for university staff forced university vice-chancellors in England and Wales to call for an increase in tuition fees. It leads to the idea to cut the number of UK students universities take, but increase the number of international and postgraduate students, whose fees are not capped by the Government. Overall, tuition fees are a burden for many young students. As you can see from the Figure 2, tuition fee crisis has a negative impact on overall economy. People either enter the university and then leave it, because of an increase in tuition payments, or even do not apply for any study programme. It leads to the situation, when people avail of an opportunity of getting a fake degree (if they have money) or they end up with no degree at all. Of course, employers are not happy with that, as it has an impact on their businesses and overall economy.

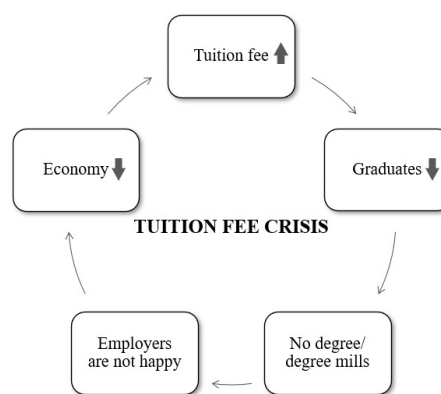


Fig. 2: Tuition Fee Crisis

There are many more challenges in education, which are discussed on the European level, such as digital transformation, which includes online learning and quality of higher education, integration and skills recognition of migrants and refugees, learning mobility of staff and students and lifelong learning.

Blockchain technology is becoming an increasingly popular tool to address these challenges in education sector.

### 3. Blockchain in Education

Let’s have a look at the Figure 3, which summarizes 10 blockchain use-cases in education, both present and potential applications.

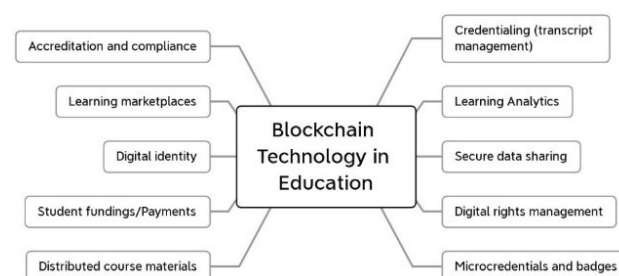


Fig. 3: Summary of Present and Potential Applications of Blockchain Technology in Education Sector

## Present Applications of Blockchain in Education

### Credentialing (Transcript Management)

One of the most famous and researched use-cases of blockchain technology in the field of education is called transcript management. Transcript management can be understood as a process of collecting, organizing and storing students' data, which includes, but is not limited to the documents confirming grades achieved, courses taken and degrees conferred. The idea behind introducing blockchain into the educational sector as a storage for academic credentials is in storing digital academic transcripts and issuing the degrees. This blockchain use-case has been widely researched by many authors [16; 19; 22]. It is also referred to the transformation of the traditional centralized record storage of students and staff to the distributed network. That eliminates the need for the third party to verify the details as well as using less resources (time and money). Moreover, blockchain technology provides people with 24/7 access to the information required. Blockchain technology provides a secure and innovative means of realizing the concept of the self-sovereignty [23]. Several authors considered that linking blockchain and higher education diplomas can positively impact students around the world [24]. Overall, the process itself becomes very simple, but more secure and transparent.

There are several existing applications of blockchain technology in this area in Europe and beyond:

**Blockcerts.** The Massachusetts Institute of Technology and the University of Nicosia, Cyprus are the pioneers of Blockcerts adoption. This open-source blockchain-based application allows students to quickly and easily get a verifiable, tamper-proof version of their diploma that they can share with employers, schools, family, and friends. To ensure the security of the diploma, the Blockcerts Wallet uses the same blockchain platform that powers the digital currency Bitcoin, which was built "on-top" of a blockchain and can also work with Ethereum or Hyperledger [19]. MIT use-case of blockchain technology is an example where learners have a full autonomy over their own records. Blockcerts is considered to be an internationally recognized standard for securing important digital records, however, it does not allow blockchain to be used in a global higher education credit and grading platform yet. Also, Blockcerts does not allow to upload bulk documents and has no well-developed revocation system [25]. As has been pointed out by several authors, who argued that the Blockchain protocol does not provide any strong mechanism for authenticating the issuing institution, since the issuer authentication is basically performed on the basis of an unauthenticated issuer profile available online and referenced from inside the certificate [26]. Simply speaking, it means that fake academic certificate issued by a fake educational institution can be put on the blockchain platform, but Blockcerts will not be able to recognize it.

There are several universities around the world that

have adopted Blockcerts for their academic credentialing systems and they are presented in the Table 1.

**Block.co.** Block.co platform has been developed by the University of Nicosia in 2014 and it is a pioneer in blockchain credentialing applications. Similar to Blockcerts, it also serves as a system to upload certificates on a blockchain. The advantage of using Block.co lies mainly in its cost reduction since it allows to upload multiple documents on the blockchain that will be hashed together [19]. Block.co platform allows to secure PDF documents from fraud without any intermediaries. The documents generated are entirely self-contained and self-verifiable, which means they include both the blockchain proof and data inside the document itself without requiring the installation of extra software or apps [27]. While both Block.co and Blockcerts use blockchain technology, they are not directly similar. Also, their specific implementations are different, with Block.co being more focused on enterprise blockchain solutions (hospitality, fashion and beauty, telecommunications industries), while Blockcerts is more focused on the education sector and digital credentialing.

Institution	Record Type	Year
Massachusetts Institute of Technology, USA	Degree/certificates	2017
University of Nicosia, Cyprus	Degree/certificates	2017
Pallavan School and Vasant Valley School, India	Leaving Certificates, Language Certificates, Character Certificates, Letters of Recommendation, and Five Areas of Development Mark Sheets	2019
Maryville University, USA	Degree/certificates	2019
Lehigh University, USA	Career Skills Certifications	2019
RCSI Bahrain, Bahrain	Degree/certificates	2021
The University of Rome "Tor Vergata", Italy	Degree/certificates	2018
University of Melbourne, Canada	Teaching certificate	2017
University of Milano-Bicocca, Italy	Degree/certificates	2019
University of Padova, Italy	Degree/certificates	2019
Central New Mexico Community College	Certificates	2017
Southern New Hampshire University	Degree/Certificates	2018
Singapore Management University	Degree/Certificates	2019

Table 1: Current users of Blockcerts for students' credentials

**BTCerts.** The BTCerts project was inspired by Blockcerts and developed by the University of Birmingham's IT Services department and the Centre for Doctoral Training in Cloud Computing for Big Data in collaboration with blockchain technology company Learning Machine. BTCerts uses blockchain technology to issue and verify academic credentials. It aims to create a secure and immutable platform for students to share their academic credentials, which can be verified by potential employers, universities and any other institutions. It also aims to solve several weaknesses found in Blockcerts, such as utilizing a multi-signature scheme to ameliorate the authentication of certificates; exerting a safe revocation mechanism to improve the reliability of certificates revocation; establishing a secure federated identification to confirm the identity of the issuing institution [28]. BTCerts uses the Blockcerts open standard and allows students to access their digital certificates through a secure web portal. The platform also enables students to share their certificates with employers and other institutions via a secure link, allowing for easy and secure verification of their academic achievements. BTCerts is currently being piloted with the University of Birmingham's CDT students and will be rolled out to the wider university in the future.

### Micro-credentials and badges

European Commission stated that the lack of digital solutions for the validation, recognition and storage of micro-credentials remains one of the obstacles to the further development and adoption of micro-credentials [29]. Badging was the initial response to online credentialing. Blockchain technology, in return, may support the issuance of digital badges. It provides education sector with security through validating academic certificates and credentials registered on blockchain. At the same time, blockchain provides an opportunity to verify the documents in real-time all around the world. Similar to blockchain use-cases in transcript management, it provides features like decentralization, immutability, security and availability, which are leveraged for the issuance of micro-credentials and digital badges. On the other side, views are mixed regarding the feasibility and potential risks of blockchain technology adoption. Some concerns are related to the significant investments in terms of an organizational strategy that can help to transform the internal processes and training of employees [30].

In 2019, the World Wide Web Consortium (W3C) created the Verifiable Credential Model 1.0 standard. This not only standardizes certification exchange at the national level, but also ensures that digital diplomas and electronic documents are recognized worldwide. Blockchain technology enables this standard to be implemented with a higher degree of security, trust, interoperability and robustness than any other solution that uses traditional technologies. Issuing micro-credentials and badges on the blockchain platform has been researched

and piloted by several institutions, organizations, researchers and developers. UK has developed Ethereum's Smart Contracts to document micro-credentials (badges) as an open source solution. Several authors proposed a system, where blockchain technology will be incorporated in the digital badge and in the examination app [31; 32]. One author explored the possibilities of extension eAsel, a competency web-based platform, to support blockchain micro-credential certificates [33].

The main purpose is to eradicate the problem of fake certificates/achievements. One researcher introduced a concept of Smart Badges for supporting lifelong learning [34]. In comparison to the traditional online or digital badges that just record a learning achievement, Smart Badges can also offer job or course recommendations based on a student's portfolio.

**Credentify.** Credentify is a decentralized blockchain-based cloud service which empowers students, educational staff and universities across Europe to issue and receive micro-credentials that can be summed up into ECTS. It allows accreditation of the traditional learning experience to be fast, safe, reliable and accountable. Main aim of this initiative is to ensure that micro-credentials are certified and mapped to the European qualifications frameworks and can be embedded into other forms of Higher Education [35].

Credentify is the first European free and open issuer of blockchain-secured stackable ECTS credentials that are university and student owned, and verifiable anywhere, anytime, thus in turn improves transfer and transparency of credentials. It is at present being piloted by five European universities: Duale Hochschule Baden-Württemberg, Germany; Vytauto Didziojo Universitetas, Lithuania; Tampere University, Finland; Fondazione Politecnico di Milano, Italy; Institut Jozef Stefan, Slovenia.

The development of Credentify has occurred in a context of increasing requests from graduate students to recognise learning achieved online and elsewhere. Credentify provides students the opportunity to get credentials from multiple universities recognised as part of their studies, and it supports portability and storage of digital student data [36]. One of the advantages of Credentify is that it offers a standard format for documenting micro-credentials in terms of ECTS, using existing recognition tools.

**BCdiploma.** BCdiploma is the first blockchain credentialing platform which allows to automatically issue forgery-proof credentials and micro-credentials once a passing grade has been determined. More than 170 institutions over 21 countries use blockchain to secure digital credentials.

The French governmental project within the European Blockchain Partnership, fr.EBSI, launched in 2021, is a response to the new standard introduced by the W3C – the “verifiable credentials”. The University of Lille is a leader

of this project, BCdiploma is the technical operator. The University of Lille is one of the first educational institutions to achieve a real digital transformation of its academic department. In its White Paper, published in 2023, it explained the way it is issuing its students a digital certificate of completion of their degree or certificate issued on a low-energy blockchain [37]. The University of Lille aims at issuing diplomas in the European Blockchain Service Infrastructure - blockchain ecosystem. This infrastructure, deployed by the European Commission and the European Blockchain Partnership, provides a blockchain and trusted digital environment to support cross-border applications such as “track and trace”, “verifiable credentials”, “trusted data exchange” and IP management [38].

The University of Lille has issued over 32 000 blockchain credentials since 2021, and student satisfaction rate of using the digital certificate was at 76%, what confirms the project’s success [37]. One of the advantages of this project is low-energy consumption. Lille University decided to issue academic certificates on the Avalanche blockchain, which operates on a Proof-of-Stake protocol. Based on the latest Ethereum research, it can be estimated that the emission of a digital certificate by the Lille University is about 0.025 g of CO<sub>2</sub>, compared to an average of 4 g of CO<sub>2</sub> for an email without an attachment [39].

Academic certificates are designed not only for websites, but also for smartphones, thus making it easier to share it via social media networks. It is also possible to share documents by sending a link to the recipient or through scanning a QR Code directly.

**XenEd.** The XenEd is an innovative technology, which is used as a platform for the delivery of MOOCs. This platform provides functionalities to better monitor and track learner progress and provides a seamless and flexible online learning experience to learners. University of Mauritius in a partnership with a software engineering products and services company the Crystal Delta Pty Ltd launched iLearn – a MOOC platform based on the concept of open learning and micro-credentials based on Ethereum blockchain. This platform provides learners with the possibility to earn micro-credits that can be accumulated and transferred into recognized university credits. The XenEd platform provides functionalities for iLearn, so to better monitor and track learner progress and to provide a flexible online learning experience. The University of Mauritius is a pioneering institution in the development of education technology in an academic field and in innovation in teaching and learning through technology [40].

**University of Hawaii at Manoa.** Institution performed qualitative research in their own blockchain-based micro-credential management system and found that qualitative evaluation reveals that such systems can decrease the overall cost and administrative workload [41].

**Hyland Credentials.** Hyland Credentials started as Learning Machine, which developed Blockcerts open standard with the MIT Media Lab. Currently, company positions itself as a global leader in blockchain-based digital credentials and the only records provider in the world with a product in market for multi-chain issuing and self-sovereign identity [42]. Hyland Credentials provides its services to the government, healthcare and education sectors. Its education products and services relate to diplomas and certificates, transcripts, examinations, photo ID’s and Open Badge. Company supports the importance of micro-credentials and recognition of specific skills and achievements.

### Student Funding/Payment

The original concept behind the invention of blockchain technology is its possibility to be used as a platform for recording, sharing and storing financial transactions. In education environment blockchain technology helps universities to keep a clear digital record of payments for each student while using cryptocurrency as tuition payment. It can also be used to create a secure and transparent platform for managing student funding, such as scholarships or grants. This type of blockchain application saves money and time not only for educational institutions, but also for individual learners [43]. Blockchain can be used as an efficient manner to exchange information and eliminate the need of such third or intermediary parties based on its high security level [44].

Nowadays, there are some pioneer schools who are already accepting tuition fees in cryptocurrency and tutors graduates on digital currencies. The widespread adoption of blockchain technology and digital assets has encouraged universities to plan for the future and accept cryptocurrency payments. On the one side, bitcoin adoption allows universities to stay ahead in the “blockchain race”, while sensitizing students on the market trends. On the other side, cryptocurrency payments may be used to ease the burden on international students who spends extra fees on transaction, as well as make it more efficient for everyone.

**University of Nicosia.** University of Nicosia is the first accredited educational institution worldwide to accept cryptocurrency for tuition payments [45]. University of Nicosia expected that the initial adoption of blockchain will come from the students in Africa. In 2017 a new student from the South Africa made a payment of 1 BTC (at that time the equivalent of 670 EUR) toward tuition for an online Master of Business degree programme. From that moment Bitcoin was accepted throughout the entire University of Nicosia system, which includes online programmes and affiliated schools. Those students who wished to use Bitcoin for tuition fees could pay at the university’s finance office or through an online merchant processing service – BitPay Payment Gateway. University of Nicosia was willing to receive Bitcoin as a payment for the study programmes, but due to its volatility, the university promptly converted the cryptocurrency into

EUR. As per today (15 May 2023), for unknown reasons this payment option is currently unavailable.

**IEBS.** Innovation and Entrepreneur Business School in Spain (IEBS), an educational provider of the online courses, was the first digital business school to accept Bitcoin payment. Compared to the University of Nicosia, the Spanish college addressed the volatility of Bitcoin by providing international students with a stable exchange rate.

Since then, other international schools have followed the same example. In 2014, King's College in New York became the first accredited US institution to grant digital currency payments (in a partnership with a bitcoin trading company "Coin.co") and even donations [46]. The University of Cumbria, UK became the first public institution to accept Bitcoin as a form of tuition payment. However, it offered this opportunity exclusively to the students who were enrolled in Master degree programmes related to cryptocurrencies. Two years later, the European School of Management and Technology in Germany (ESMT) started accepting Bitcoin cryptocurrency for any degree or executive education [47]. ESMT was the German university that recognized the importance and need of cryptocurrency transactions, due to the fast clearance (in around 10 minutes), compared to weeks or months offered by the traditional payment systems. It started accepting Bitcoin as a tuition fee payment and then included to dash, ethereum and litecoin cryptocurrencies as possible options. Currently, universities have not set up a financial infrastructure that would process crypto payments, therefore educational institutions have to partner with the crypto merchant companies, start-ups and other institutions to handle transactions.

## **Potential Applications of Blockchain in Education**

### **Digital rights management**

The idea behind introducing blockchain technology into digital rights management lies into a possibility of managing and protecting digital content, such as textbooks and course materials, music and videos, ensuring that copyright owners are properly compensated and that content is not illegally shared. This blockchain use-case may be of a great value for students and learners from the creative industries (such as musicians, artists, video-makers), as it may enable students to create and share digital portfolios of their work. The application of blockchain technology as a digital rights management tool also enables copyright owners (students in this case) to track the usage of their digital assets. With the help of blockchain technology, digital rights management can be set up to automatically restrict access to a digital asset if needed. At the moment, companies across blockchains are starting to use NFTs, which are used to verify unique items and digital assets, which also may be of a potential application in education sector.

### **Learning Analytics**

Blockchain technology can be used to track and analyse student data for a better student learning experience. Also, blockchain can help lecturers and education stakeholders to understand students' hard and soft skills, strengths and weaknesses and provide learners with a personalised learning features and experience. One researcher proposed a blockchain based approach for connecting learning data across different Learning Management Systems (LMS), Learning Record Stores (LRS), institutions and organizations [48].

### **Secure data sharing**

Blockchain technology can be used to securely share student data in any educational ecosystem between students, lecturers, institutions and many more, ensuring that the data remains private and secure.

### **Distributed course materials**

Blockchain technology can be used to create decentralized platforms for sharing and distributing course materials, enabling lecturers to share resources with their peers and collaborate more effectively.

### **Digital Identity**

Blockchain technology can be used to create secure and verifiable digital identities for students and educators, enabling them to securely access online resources and verify their identity for exams and other activities.

### **Learning Marketplaces**

Blockchain technology can be used to create peer-to-peer learning marketplaces, where students can connect with tutors and other educators to access personalized learning opportunities.

### **Accreditation and compliance**

Blockchain technology can be used to create secure and transparent systems for accrediting educational programs and ensuring compliance with regulatory requirements.

### **Conclusion**

The research trend indicates that there is an increasing interest in applying blockchain in the education sector. However, present blockchain-based applications in education are limited to the areas of tuition fee payments, academic transcripts and micro-credentials. Considering the importance and potential of introducing blockchain technology in education sector of Europe, additional research should be conducted on potential use-cases of blockchain technology in education, which may allow to create an effective framework to augment the integration of blockchain technology into existing organizational processes in higher educational institutions of Europe.



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