**Blockchain in Higher Education: A Secure Traceability Architecture for Degree Verification**

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1. **Introduction**

Education plays a fundamental role in human life. We study in school, then university, and take other courses and take part in various projects throughout most of our careers to improve our skills, gain experience and become more valuable in our chosen field. Our education portfolio does not directly contain acquired knowledge, but paper certificates confirming that we have acquired specific skills, such as: diploma of higher education, certificates for participating in scholar competitions, certificates from education technology companies, like Udemy, Coursera. These documents allow employers to appraise employees' expertise and organizers of educational events to adapt to their student’s needs. We could say that these documents determine the course of our education and, more importantly, our careers. However, diplomas and certificates tend to be difficult, sometimes even impossible, to acquire, regardless of the amount of work and determination we put in our attempts. In consequence, many people resort to illegally falsifying them as an easier and more accessible, if costly, alternative, which makes paying sufficient attention to the authenticity of these documents a crucial part of a dean’s or an employer's job. Unfortunately, in our technologically advanced society, such acts of forgery are very common and increasingly more difficult to detect, thus rendering companies and institutions susceptible to hiring unqualified employees, which can generate problems at all levels of an institution.

**Blockchain Technology**

Blockchain is an advanced database system that allows transparent information, assets that tangible (a house, car, money, appliances) or intangible (patents, copyrights, branding, and intellectual property) to be easily shared and recorded within a business network.

Similar to doubly linked linear lists, each block keeps data, the address of the block itself, and the address of the previous block.

**Blockchain-based educational certificates**

The number of student records is limitless, and blockchain technology allows assets like attendance, courses, tuition payments, grades, coursework, and even diplomas and certificates to be added to a student's own blockchain record. Data security is guaranteed since these records cannot be removed. Additionally, it is the student's property, not the school's. With blockchain, once the data has been recorded, no person can alter it. If a record contains a mistake, a new record must be added to fix it, and both the incorrect and correct records will remain accessible.

1. **Digital Education Recognition**

Over the previous two decades, online education has grown significantly, especially during the two-year Covid pandemic in 2020. Statistics show that with an average annual growth rate of 20%, E-learning or online learning continues to see the quickest development in our society.

1. **European Digital Education Recognition vs other**

The European Blockchain Services Infrastructure (EBSI) program, which intends to encourage the implementation of blockchain technology in numerous industries, including education, was introduced in Europe by the European Blockchain Partnership (EBP). With the use of blockchain technology, the EBSI project has created the European Student eID, a digital wallet that enables students to safely keep and exchange their academic credentials. Additionally, the European Commission has started the European Student Card Initiative, which intends to give students a digital platform to manage their academic records, including transcripts, certificates, and diplomas, utilizing blockchain technology.

In comparison to other parts of the world, Europe is just as developed in terms of the usage of blockchain technology in digital education. For instance, the University of Texas in the US has introduced Blockcerts, a blockchain-based platform that enables students to securely save and distribute their academic credentials. Other colleges in the US and throughout the world have followed suit.

In Australia, the Australian government has launched a digital credentialing platform called My eQuals, which has been adopted by universities across Australia and New Zealand.

In Asia, Singapore has launched a digital credentialing platform called OpenCerts.

1. **Digital Education Recognition in Romania**

Romania has been progressively improving its recognition of digital education over the past decade as it works to modernize and align its educational system with global norm.

Although the use of digital credentials is still in its infancy in Romania, several initiatives are being carried out to encourage their usage. A system for issuing and certifying digital diplomas and certificates is being developed, for instance, by the National Agency for Quality Assurance in Pre-University Education (ARACIP), which will make it simpler for students to demonstrate their qualifications to companies or other educational institutions.

Massive Open Online Courses (MOOCs) are becoming more and more common in Romania, although traditional educational institutions are still slow to accept them. However, the Ministry of Education recently declared its intentions to create a framework for include MOOCs in the nation's system of continuing education.

Romania is slowly but surely increasing its acceptance of digital education as it works to update its educational system in conformity with international norms and encourage greater mobility and transparency in the educational system.

1. **Methodology for collecting data**
2. This study seeks to determine the parameters within which blockchain technologies could be integrated in the educational institutions of Romania, by analysing the data collected from our surveys and deciding which approach would be more efficient.
3. Development of hypothesis vs questionnaires / interviews
4. We collected the data recorded in the questionnaires completed by the students and compiled it into a single document. Within it, we calculated the weighted average of every item on the sheets and selected the three highest ranking factors of every category, which will help us develop our hypothesis.
5. We rearranged all the answers from the experts into a single document in a more visible format, then color-coded and used them to synthesize a more compact answer for each question in order to furthermore develop our hypothesis.
6. **Analysis of data**
7. **Centralisation of data:**

See attached files: Questionnaires\_Summary.xlsx and Interviews\_Compilation.docx.

1. **Statistical and logical analysis**

**Questionnaires:**

* Most of the student have heard of the concept of blockchain technology in the year 2021.
* The majority of students have heard of the following terms and concepts: smart contracts, multi signatures, oracles, decentralized storage, private key, validation process, blockchain fork, hash power, PoW, PoS, block reward, wallets, public address, transaction fees, blockchain bloat, mining, cryptographic hash function, hashtable.
* The students have chosen “clear and transparent rules about who is responsible for payment of fees (8)” to be the most important aspect to be considered before including blockchain-technologies within the educational sector, followed closely by “basic information/education about blockchain-technologies for all people involved in the educational sector (9)” and “in-depth education about blockchain-technologies for IT-professionals and administrative-officers in the educational-sector (6)”.
* The students have reported that blockchain technologies are most suitable for “Fees and credits transfer (6)”, “Copyrights management (8)”, and “Certificates management (1)”.
* The students say that the profession which requires higher knowledge of blockchain technologies is Hardware/Software Specialist (7), while the profession which requires lower knowledge of blockchain technologies is Administrative Non-IT Officer (2).
* The students have decided that the top 3 benefits of adopting blockchain technologies in education are high security (9), better control of data access (6) and identity authentication (5).
* The top 3 challenges of adopting blockchain technologies in education are: Privacy & Security (3), Trust (2), and weakening traditional school credentials (1).

**Interviews:**

**What are the potential applications of blockchain in higher education?**

Blockchain technology can be used in higher education to improve record keeping and digital certificates, increase efficiency in administrative processes, support MOOC initiatives, and create a disruptive model for the education industry. It can also be used in research, knowledge and data sharing, and monetization.

Blockchain technologies are becoming increasingly popular in higher education, with applications ranging from bachelor to master and PhD programs. They can create a new revenue stream for researchers and institutions, keep track of student grades, and other professional information. Potential uses include verifiable credentials, intellectual property management, funding tracking, students' payments, grants management, pedagogical enhancement, and tokenization of learning.

**What relevant data or units of learning would be on the blockchain?**

Blockchain technology can retain relevant data such as certificates and diplomas, asset ledgers, transactions and smart contracts, e-learning platforms, academic records, research, research results and credentials, blockchain architecture, enterprise blockchain regulation and security. It can be used to store a hash of the information, verify it with a hash from the blockchain, and share data points related to a study.

**One of the most critical components of a block on the blockchain is the quality of data, what are the quality assurance standards to ensure that the data is accurate, verifiable, and meaningful?**

Blockchain technology guarantees the quality of data by sharing and synchronizing transactions across multiple nodes. Consensus is a key concept used to approve or reject new data, and quality standards must be discussed and agreed by all users. Interoperability of data must be ensured, and data protection from unauthorized use and disclosure must be ensured. There are multiple research studies, reports and standards for blockchain/DLT technologies.

**What are some compelling reasons for using blockchain in higher education? Are there any reasons NOT to use blockchain in higher education?**

The main benefits of blockchain technology are decentralization, security and transparency, data immutability and integrity, and cryptography.

It can be utilised in higher education to provide individuals with the right tools and knowledge to succeed in their future careers and push the boundaries of collective knowledge. The integration of blockchain in universities has different perspectives, such as creating research teams, developing study programs, and implementing decentralized applications. Its advantages include self-sovereignty, trust, transparency, and collaboration.

However, it has a downside, as the resources used for computational power and storage are high and may have a negative impact on the environment.

**What are the most significant hurdles that higher education will need to overcome before blockchain sees broad adoption?**

Higher education has a significant role in facilitating and accelerating the awareness, knowledge and integration of blockchain technology in different domains. However, the most important hurdles that need to be overcome are related to legislative reglementation, getting traction, and funding. Additionally, the EU's General Data Protection Regulation (GDPR) may impose limitations on how personal data is transacted on the blockchain, scalability, data privacy and security, market adoption, and innovation.

**With every new tech adoption that has broad implications, there are “winners” and “losers” who falls into these categories; Who are the biggest winners and losers? Does the benefit to the winners outweigh the impact on the losers?**

Organizations that adopt blockchain technologies as early as possible will be the winners, as financial resources for salaries payment represent an important percent of the company's profit.

Most of the interviewed agree that these organisations are educational institutions, banks, and the health system.

Losers will be organizations that do not see a benefit in adopting the technologies, as the benefit to the winners outweighs the impact on the losers.

**Building on the previous question, there are potential equity, access, and accessibility implications, how do we ensure that blockchain doesn’t marginalize these populations?**

While some interviewed refrained from answering this question, the others say that Governments should have clear politics in this field to ensure equity, access, and accessibility.

Trend setters need to share their knowledge free and in a timely manner, so that partnerships between different institutions can mitigate risks.

Training, entrepreneurship, and digital entrepreneurship courses can be offered to people affected by job loss.

**Is blockchain in higher education just hype?**

All of the interviewed have agreed that blockchain technology is not a hype, as it has been found to be the most effective in the cryptocurrencies space and can be applied in higher education with important benefits. Higher education has a significant role in facilitating and accelerating the awareness, knowledge, and integration of this technology. It can also make things better, such as copyright protection, certificate and identity management, digital credentials, and lifelong learning. Blockchain is an important technology.

**Where do we go from here? Who needs a seat at the table?**

Blockchain technology presents two great opportunities: improved efficiency in education and taking advantage of its disruptive aspect as a source of new revenue. Organizations need to start and implement multiple use cases for blockchain, test them as prototypes, and come up with a carefully planned strategy to launch them. Additionally, a public-private partnership needs to be created so that both can benefit from the blockchain adoption.

**What are your observations about blockchain adoption in Romania / Czech Republic / Norway / Iceland in general and in the education field in particular?**

Romania has a growing number of experienced companies, innovative startups and projects, active accelerators, and numerous educational programs including blockchain. There is a national NGO agency that sponsors the adoption of blockchain, and students are learning about the concept in technical universities. However, there hasn't been much progress in terms of adoption. Romania has a growing interest in blockchain technology and has initiated projects such as "EBSI4RO: Connecting Romania through Blockchain", which aims to create a sustainable ecosystem for accelerating digitization and facilitating the knowledge and adoption of Blockchain technology. Romania is one of the pioneering countries to issue university diplomas and micro-credentials on the European Blockchain Services Infrastructure (EBSI).

Blockchain Romania Association is a non-governmental organization established in 2018 to popularize and inform people about blockchain technology, develop a legal framework, provide education and learning opportunities for safety, and highlight attributes of a blockchain crypto economy. Popular applications include cryptocurrencies and smart contracts.

**How do you intend to check the relevant skills / competences when recruiting for a dedicated project / job linked to blockchain application in higher education (in Romania / Czech Republic / Norway / Iceland)?**

The most important details for recruiting a Blockchain Developer are checking knowledge in the field, using some systems with blockchain technology, case studies, education, and previous experience. The most relevant skills are data structure, smart contracts, cryptography, encryption, decryption, critical cryptography, interoperability skills, node, block, chain, miners, interviews, portfolio of related work, research interests and results. The most relevant European project related to skills/competencies in blockchain is the CHAISE project.

1. **Synthesis of results vs hypothesis**

Blockchain technology guarantees data quality by sharing and synchronizing transactions across multiple nodes.

The interoperability and protection of the data must be guaranteed against unauthorized use and disclosure. Popular applications are cryptocurrencies and smart contracts.

However, the key hurdles to overcome relate to legal regulation, traction, and funding. The EU General Data Protection Regulation (GDPR) may impose restrictions on how personal data is processed on the blockchain, scalability, privacy and security, market adoption and innovation.

Organizations that adopt blockchain technologies as early as possible will be the winners as the financial resources used to pay salaries represent an important percentage of company profits. Most respondents agree that these organizations are educational institutions, banks and the healthcare system.

Romania has a growing number of experienced companies, innovative startups and projects, active accelerators, and numerous educational programs that are blockchain-based. Blockchain Romania Association disseminates and educates people about blockchain technology, develops a legal framework, provides education and learning opportunities for security, and highlights the attributes of a blockchain crypto economy.

For recruiting a Blockchain Developer, the most relevant skills are data structure, smart contracts, cryptography, encryption, decryption, critical cryptography, interoperability skills, node, block, chain, miner, interviews, portfolio of related work, research interests and results.

1. **The Making of a Pilot Model**

Step-by-step guide on how to develop a pilot model using blockchain for record keeping of student degrees, certificates, and diplomas, along with a simulated case study:

1. **Defining the problem at hand.**

The first step is identifying the issue you're trying to solve, which is the difficulty in verifying the authenticity of the student degrees, certificates, and diplomas, as it can lead to significant fraud and misinterpretation.

1. **Selecting an appropriate platform.**

Choosing a blockchain platform that works for your use case is the next step. Some of the well-known ones are Ethereum, Hyperledger Fabric, and Corda, though there are many others available.

We will use Ethereum for this pilot model because it is a public blockchain platform that supports smart contracts, which will be helpful for implementing the record-keeping system.

1. **System architecture design.**

The design of the system architecture is the next step, which consists of the following elements:

* The front-end software, namely a website that lets users upload their diplomas, certificates, and degrees to the blockchain network.
* A smart contract - a piece of code that operates on the Ethereum network and keeps track of the records of diplomas, certificates, and degrees.
* And the Ethereum network, which is decentralized network that contains the data of diplomas, certificates, and degree records.

1. **Developing the front-end application.**

The next step is creating the front-end application.

Students can upload their diplomas, certificates, and degrees to the blockchain network using the front-end application.

Using the front-end application can also enable employers to confirm the authenticity of a degree by cross-referencing it with the blockchain network.

1. **Developing the smart contract.**

The next step is creating the smart contract, which will manage the diploma, certificate, and degree records. The following features will be included in the smart contract:

* Adding a degree: Students will be able to add their diplomas, certificates, and degrees to the blockchain network using this feature.
* Getting a degree: Employers will be able to confirm the validity of a degree using this function by checking it against the blockchain network.
* Revoking a degree: Using this feature, students can remove their diplomas, certificates, and degrees from the blockchain network at any time.

1. **Deploying the smart contract.**

The next step is deploying the smart contract on the Ethereum network. This requires using Solidity, the programming language used to create smart contracts on the Ethereum network.

1. **Verification.**

The final step is to test the system to ensure that it is working correctly. To make sure they are operating as intended, the front-end application and the smart contract will need to be tested.

**Case Study Simulation**

Let's assume for the purposes of our case study that X is a student who has graduated from UPB with a bachelor's degree in computer science. To guarantee the safety and immutability of X's degree data, the university wants to create a record for him on the blockchain platform.

The university logs into the blockchain system's web-based interface and adds a new record for X. The record contains X's name, degree information, the date it was issued, and the name of the issuing institution (UPB). The university then uses a smart contract to store this record on the blockchain.

Now, let's fast forward a few years. After earning his degree from UPB, X is currently seeking employment. He submits an application to a software development company that demands a computer science bachelor's degree. X's credentials must be confirmed by the company before he is hired.

The company logs into the web-based interface of the blockchain system and searches for X's record using both his name and the name of the university that issued the record (UPB). X's record, which contains all the necessary details about his degree, is returned by the system. The organization doesn't need to get in touch with UPB in order to confirm the legitimacy of X's degree.

The employer is pleased with X's qualifications and decides to hire him. The organization can then access X's blockchain record to confirm his academic credentials at any time.

In this case study, we can see how using a blockchain-based pilot model for the documentation of student degrees, certificates, and diplomas can offer a safe, open, and practical method of credential verification. The system makes the records easily accessible to authorized parties while also guaranteeing their security and immutability.

1. **Conclusions**

With the use of the distributed ledger technology known as blockchain, transactions may be recorded securely and openly without the use of intermediaries. The way we communicate and retain information, particularly academic records, could be completely revolutionized by this.

A common framework of a European Digital Education Recognition solution built on blockchain could offer numerous benefits. It could provide a secure and tamper-proof platform for storing and sharing educational records, making it easier for students to transfer their qualifications across different countries and educational institutions. This would also help to combat fraud and ensure the integrity of educational records.

Additionally, a blockchain-based digital education recognition solution could potentially reduce administrative burdens and costs associated with traditional paper-based systems. It could also enhance the efficiency and accuracy of the recognition process, making it faster and more reliable.

Overall, blockchain technology has the potential to transform the way we manage and share educational records, offering greater transparency, security, and efficiency. Its implementation as a common framework for a European Digital Education Recognition solution would represent a significant step towards a more connected and accessible European education system.

1. **References**

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