Proceedings in Manufacturing Systems, Volume 16, Issue 4, 2021, 143-149 ISSN 2067-9238

BLOCKCHAIN AND MACHINE LEARNING: SKILLS, COMPETENCES AND EDUCATIONAL LIMITATIONS

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Abstract: *As society progresses towards a digitalized means of handling daily aspects of society, ICT technology will have an even greater influence on how people carry out their tasks. In light of recent events that have forced society to adapt to a digital world by means of Work from Home or Study from Home decisions that have been implemented during the pandemic, society tries to find solutions in technologies that have had a restricted field of operation. Blockchain technology and machine learning have been more and more visible during this period, and have been used to help people achieve their daily tasks, from automation to educational models. But as these technologies have been brought into the limelight, some issues have been noticed in regards to how people perceive them and also that there is a lack of formal education or training in these fields, which translates into the lack of defined skills and competencies. As such, the purpose of this paper is to identify the fields in which these technologies have been used during the pandemic and also identify if there is a lack of a clear list of skills and competencies associated with these technologies.*

Key words: *blockchain, artificial intelligence, data science, machine learning, skills, competences.*

1. INTRODUCTION

As information and communications technology (ICT) continues to advance, more and more fields and domains are beginning to implement new technological advances in order to achieve their goals, some aspects regarding the lack of a formal framework for people that work in these fields have started to emerge. The focus of this paper will be on Machine Learning (ML) and on blockchain technology and how it has been used in the past years while trying to underline discoveries made in regards to training and education related to these aforementioned technologies. As such each technology will be discussed in general with its purpose, design, and use cases after which we shall go into the discoveries made by this current paper in regards to how training and education prepare people for their use of them in some states of the European Union. The last part of the paper will be focusing on how these technologies have affected education and training between early 2020 and late 2021 if there are any changes in their use cases and training requirements.

2. MACHINE LEARNING

Machine Learning, or ML, is defined as being "*... a system's ability to acquire, and integrate knowledge through large-scale observation*" [1] which has the capacity of learning or acquire new knowledge without it being programmed at a later period. Machine Learning can also be seen as a "*field of study that looks at using computational algorithms to turn empirical data into usable models*" [2]. There are many other definitions for Machine Learning, but the majority of them acknowledge that ML is a subfield of artificial intelligence, or Artificial Intelligence [3].

As such, there are a lot of domains that are related to machine learning such as:

- AI / Artificial Intelligence;
- Data science;
- Mathematics;
- Statistics;
- Computer science.

The list of domains that are related in one way or another to Machine Learning can go on depending on how strict the interpretation of that field/domain is.

During the period of time in which society as a whole has had to endure the lack of freedom to move or interact, certain fields or domains had to find a way to overcome the obstacles of various restrictions throughout the world. One way of overcoming issues that have risen was the use of machine learning in their fields. Medical fields, in the field of surgical education, have started experimenting with the use of Virtual Reality and the use of machine learning algorithms in order to improve their educational outcomes [4]. The authors mention that such endeavors in their field range from computational models for analyzing surgeon skills to measuring and evaluating surgeon performance. This is done through algorithms that are able to automatically classify surgeons, based on their use and skill with surgical robotic arms.

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Another approach is the use of Machine Learning in education is the use of ML in combination with Data Mining to achieve Educational Data Mining (EDM), which "*represents an application of major techniques like Data Mining, Machine Learning, and Statistical Techniques inside schooling and academics sector*" [5]. The authors of the aforementioned study discuss the possibility of using Machine Learning and Data mining in order to evaluate students. This refers to learning activities and other relevant activities in order to build an extensive and detailed set of data that will help educational institutions to get an insight on students learning habits/patterns with the end goal of helping these institutions with adding or removing subjects based of this data.

Machine Learning has also been present in K-12 education [6], though at a less impactful level than the other fields including academic fields, medical fields, ITC, and other technical fields. This is due to the fact that there were not many ways of enabling children to interact with machines without using code, but as technology progressed and AI also progressed, it is now possible for children to familiarize themselves with AI technologies through the use of natural language and technologies based around vision/image recognition. The authors cite Google's Teachable Machine as being easy for children to use, allowing them to train a Machine Learning Model using signs, body and facial expressions [6].

Taking into account that Machine Learning is related to technical fields/domains, the required skills and competencies should match or overlap most of those fields and domains that have been mentioned earlier. As it stands though, throughout the EU, especially in Romania [4], there is a mismatch of skills and competencies in the field of Machine Learning and/or ICT in general, resulting in no clear list, which can relate to this field.

In regards to the skills and competencies that a person should attain in order to be able to obtain a job in Machine Learning, the list is dictated by the labor market and is lengthy if it would be compiled by combining various job postings. The following is a list of what employers look for in their future Machine Learning employees:

- Data analysis and engineering;
- Concepts of computer science and software engineering;
- Math;
- Statistics;
- Robotics;
- Cognitive Science;
- Mathematical Models;
- Physics;
- Neural Network Architectures;
- Data Modeling;
- Machine Learning Algorithms and Libraries
- Domain Knowledge;
- Communication Skills;
- Problem-solving skills;
- Time management.

The list of required skills and competencies goes on but these are the ones that will come up with the highest frequency when a person does documentation about what is required by the labor market in order to obtain a job in this field. As such, it can be stated that there is no clear notion of what skills and competencies a person needs in order to acquire a job in this field because most skills that are mentioned by employers are not actual skills but rather knowledge about a certain type of technology/programming language.

As CEDEFOP defines it in their Glossary [5], knowledge refers to the "*Outcome of assimilation of information through learning. Knowledge is the body of facts, principles, theories, and practices related to a field of study or work*" whereas a skill represents the "*ability to perform tasks and solve problems*". With these terms defined in can therefore be understood that there is an issue in regards to what skills a person should have in order to match the "skills" that the labor market requires of them. Most of the elements that were mentioned in the list of skills required are fields that offer their own sets of learning outcomes, of what a person should know after finishing their studies in that specific field/domain. A learning outcome is comprised of more skills and competencies.

As previously mentioned Machine Learning has been used in various fields and has helped improve educational outcomes and overall performance for the parties involved, be it for people that have used it or for institutions that were involved in implementing it.

Taking these aspects into account, the use of Machine Learning, how it is implemented, and the labor market requirements for future professionals, the authors consider that there is a need for developing a tool that can first shed light on what learning outcomes a person should have if they intend to work in this field.

This tool can be either a program that develops the required skills and competencies for future professionals, and such work is already in place through European-funded projects such as MACHINA, as stated on their website [9]. The purpose of this project is to design a joint VET curriculum in Machine Learning, in order to empower professionals with technical / non-technical skills in this domain, or it can be a legal initiative to define the minimum learning outcomes a person should have in this domain.

Having these elements clearly defined will benefit every stakeholder involved by:

- Defining a clear way of integrating and recognizing formal and informal competencies;
- Developing flexible programs for professionals in order to not succumb to poorly updated curricula [4];
- Improve the labor market's knowledge about required skills and competencies in Machine Learning fields;
- Develop a tool based on Machine Learning algorithms in order to assess the skill levels of trainees;

The list of benefits can be further developed as long as the basic steps that have been mentioned above will be initiated or implemented.

3. BLOCKCHAIN

There are many definitions of what blockchain represents, from being "… *a technology that is developed*

using a combination of (…) *mathematics, algorithms, cryptography, economic models…*" [10] to representing a "*... decentralized architecture with built-in security …*" [11] through which elements that are related to transactions, such as security and integrity are improved.

The key aspects of this architecture are:

- *Decentralization* – it uses a distributed ledger in order to reduce latency and eliminate points of failure. This is in opposition to centralized architectures that have issues with scalability and points of failure;
- *Efficiency* – blockchain, when compared to classical centralized architecture, is more efficient in terms of cost, speed, and risk management [12].
- *Security* – blockchain provides better security because it uses a public key type of infrastructure that facilitates protection against malicious actions towards data changes. Users in a blockchain network rely on a consensus mechanism;
- *Transparency* – By sharing transaction details across all participating users involved in those transactions, blockchain provides a high level of transparency. There is no need for a third party in a blockchain setting, which increases business friendliness and ensures a trusted workflow.
- *Immutability* – Because each block in the distributed ledger is linked to the preceding block in a chain of blocks, the blocks in blockchain technology are permanently recorded and never modified as long as the network is maintained by the user [13].

These features can be summarized as shown in Fig. 1.

Blockchain can also be divided into three categories, as shown in Fig. 2, and detailed below:

Fig 1. Blockchain characteristics [13].

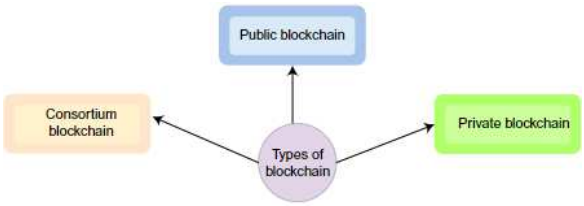

Fig 2. Types of blockchain [14].

- *Public blockchain* – In this blockchain system, all records are broadcasted, and everyone is involved in the process of confirming and validating transactions;
- *Private blockchain* – This type of network is also known as a centralized network because the entire network is managed by a single organization and only its members participate in consensus-building;
- *Consortium blockchain* – This blockchain system is partially decentralized, as a small pre-chosen set of nodes would be selected to participate in the decision-making process. It is controlled and governed by multiple agencies.

Blockchain also works based on a consensus model. This refers to a set of protocols that must manage the consistency of the public ledger's dispersed nodes. A blockchain-based structure's dependability and functionality can only be as good as its consensus algorithm [14]. Thus, there are a number of consensus models, such as:

- *Proof-of-work model* – PoW is a consensus algorithm utilized by Ethereum (now known as Homestead) and bitcoin. By requiring a set of work from the service requester, Proof-of-Work deters denial of service (DoS) and other abuses/attacks. This approach is used to verify transactions in blockchains and generate new blocks for the chain;
- *Proof-of-stake model* – PoS algorithms were developed largely to address the inefficiencies of PoW algorithms regarding high energy use during mining operations. The standard mining operation of the PoW algorithm is replaced by an alternate method employing the virtual currency holdings of user;
- *Proof-of-elapsed time model* – The PoET paradigm employs both permissionless and permissioned blockchains for the finality of probabilistic transactions. Participation is free and it is extremely scalable. Each node in the blockchain waits for an arbitrary amount of time, and the first node to reach its conclusion becomes the new leader. PoET uses this random leader election methodology based on SGXs to determine the next leader to finish the blocks.

Having determined the core elements of blockchain, by defining it and detailing the characteristics, types, and some of the consensus models which form the core of this technology, an incursion can be made into what and how this technology can be used in various educational domains.

The applicability of blockchain in education has been discussed in scientific papers since 2008 when blockchain has been considered an emerging technology. And, as such, an extensive systematic review has been written [15] in order to analyze the advantages and disadvantages of using blockchain technologies in education. The research was based on well-defined searches on scientific platforms such as: ACM, IEEE Xplore, SAGE Journals, ScienceDirect, Proquest, Web of Science, Springer, and Taylor & Francis Online. The authors also included articles from Google Scholar. A total of 2536 articles were found in the research's initial searches, but after exclusion and duplicate checks, a number of 47 articles were left for full-text reading.

Based on these articles that were reviewed, the authors [15] concluded that the main benefits, in order of importance, of using blockchain in education are the following:

1. *Security* – this is a benefit that derives from how data is handled in blockchain architectures. Data is considered to be protected in all aspects, such as privacy and integrity;
2. *Data access* – this derives from the fact that blockchain architecture is built in a way that allows transparency over who is accessing data and when it is accessed;
3. *Accountability* – taking into account that everything is transparent and secure from external tampering, participants can be held accountable for their decisions;
4. *Educational trust* – using blockchain in education raises the level of trust in the entire process of learning/teaching due to the high level of security and transparency this architecture provides;
5. *Cost efficiency* – blockchain can be used to lower costs related to transactions and data storage;

The authors concluded that there are more benefits to using blockchain technologies in education, based on their reviews, but the rest of them are variations on these 5 benefits and the general characteristics that blockchain has.

As such it can be considered that these are the most important benefits when discussing the use of blockchain. In addition to the benefits that have been previously identified, some of the benefits of classic online teaching technologies that can be added alongside these, such as time efficiency and portability should also be taken into consideration.

Of course, there are also downsides or, better named, challenges when it comes to implementing blockchain technology in education such as:

- *Scalability* – the concern is that there will be an increase in block sizes which will lead to increased latency for transactions;
- *Privacy* – although blockchain is considered to be one of the most secure ways of handling data, there still is the risk of malicious attacks and data leakage depending on the consensus model used;
- *Adopting costs* – due to the fact that this technology has not been the standard in online education or education in general, there is a concern in regards to initial costs of implementation such as computing power required, infrastructure changes, and cost management associated with the amount of data, etc.;
- *Immutability* – this challenge derives from how data is treated and how blockchain functions as an architecture. Immutability, for educational institutions, means that there is a rigid aspect to the technology and little to no room for mistakes, which are hard to correct;

As with the case of benefits, these challenges are what the authors considered to be important when discussing the use of blockchain technologies in education. The benefits and challenges of blockchain technology in education are illustrated in Fig. 3.

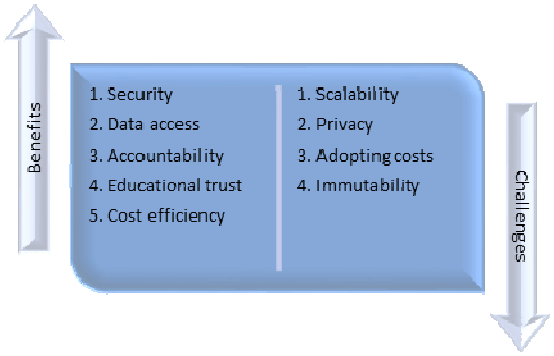

Fig. 3. Blockchain education benefits and challenges.

Considering the benefits and challenges that are visible in Fig. 3, one can analyze what application could be considered viable for this technology if it is used for educational purposes or fields.

First and foremost, blockchain technology can be used as a means to handle certificates. This relates to elements such as student certificates, academic credentials, or any form of formal recognition that requires a document to be issued. At a European level, digital certificates, digital credentials [16], micro-credentials, and other such elements have been discussed and are starting to be developed in order to allow different stakeholders to interact with issued documents. Digital credentials, for example, can be used in order to store and then validate learning achievements that a person has had throughout their educational journey, which in turn can then be directly used by other educational institutions or employers.

This shortens the time needed to verify study documents between different countries which in turn allows end-users to have a seamless transition between different jobs or learning opportunities that are offered in the European Union.

These types of credentials will have to be secure, and the entire process of handling the information that is stored for these elements needs to be encrypted. This is where blockchain technology could come into action, by providing an architecture that does not allow data to be tampered with. This data will include, alongside other elements, information regarding *age, full name, address, contact data, studies, and diploma information* (*place of study, educational provider, skills, competencies, grades, etc.*).

Thus, due to the *immutability* of blockchain architecture, using this architecture will add another layer of security in regard to such sensitive information that is being stored.

Taking into account the fact that only certain organizations are allowed to issue study documents and certificates, the issue of *immutability* that has been considered a challenge in literature can be avoided. This adds a level of trust for all parties involved, starting from the end-user who knows that his data is accurate and is stored in one place, and ending with employers who do not need to check with authorities if the diplomas are authentic or not.

This application of blockchain can be observed in Fig. 4.

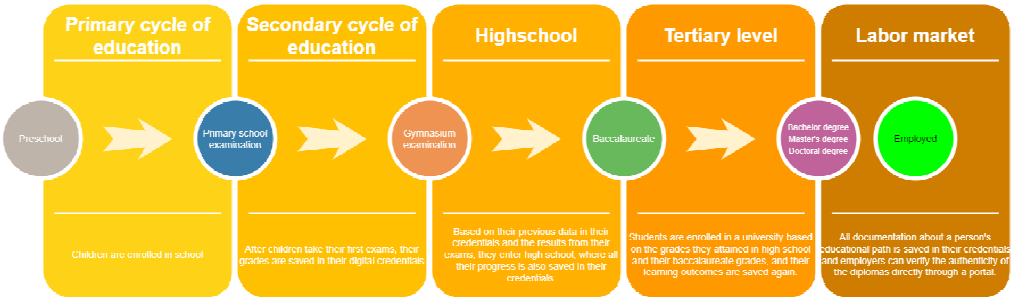

Fig. 4. Usage of digital credentials throughout the educational path.

Other use-cases for blockchain technologies include the possibility of implementing systems for managing grades, competencies, and learning outcomes. It can be considered that this is a valid use case that can work together with digital credentials. Through the use of applications to manage skills and competencies, be it at a local level or a national level, these can later be centralized and included in the data that is required for digital credentials to function. As a result, if there are two different elements that work in the data collection of information required to validate a person's educational path, taking into account that this is based on blockchain data verification and security this would lead to a secure and accurate record of skills and competences, learning outcomes that a person has gathered.

As in the case of Machine Learning technologies that have been discussed in the previous chapter, there is also an issue in regards to skills and competencies required for blockchain professionals. The same problems have been noticed through studies done by researchers in a European funded project named CHAISE, which has an objective, among others, to institutionally validate the European Blockchain Skills Strategy which will allow the creation of a framework for cooperation and the outline of actions to address skill shortages and mismatches in regards to Blockchain technologies [17]. In a document presented on their project website, their researchers tried to identify the fields in which persons that have been employed in blockchain jobs are working and what skills are required for these employees [18].

After an analysis of this document and other data presented on the project's website, in corroboration with elements that are common with Machine Learning, such as skills and competencies, the authors consider that the blockchain domain also is affected by a lack of skills and competencies framework through which stakeholders can understand the requirements of qualifications in this domain. In the same manner, as in the case of Machine Learning, developing a tool or an application would greatly improve the general perception the labor market has on what learning outcomes should a future employee have.

4. USING BLOCKCHAIN AND MACHINE LEARNING FOR EDUCATION

As it can be noticed by analyzing both types of technologies that were presented, in regards to their structure, characteristics, advantages and disadvantages, combining them will give better results. These results will have an improved outcome for educational or non-educational institutions which desire to implement intelligent tools. Tools that cater to their students, their entities, on a national or international level, which can be used to make a more efficient and transparent learning or teaching process.

The use of these technologies can be seen as a symbiosis, through the following process:

1. Developing Machine Learning based algorithms that allow the possibility of identifying what fields of interest are better suited for a certain student in order to give them better possibilities at choosing their curricula. Of course, this has to take into account if the educational system of the implementing body country allows for such elements to be modified based on the student's preference. In the case of a rigid educational system, the fields in which the student is discovered to excel can be added as optional curricula programs.
2. Gathering data and storing it in a blockchain model that can be either based on digital credentials, e-identity (educational electronic identity), or digital educational profile on a national level or on an international level. This data will be gathered and stored at each major educational step a person goes through. There is also the possibility of collecting data through formal, non-formal, and informal educational paths but, as a starting point, the focus will be on formal education. This means that each time a person graduates from a formal education program, their information will be added as detailed as possible in their profile.
3. Machine Learning suggestions for educational purposes or for the purpose of employment. Based on the data that is gathered throughout a person's educational path, Machine Learning algorithms could be used to analyze the data in regards to learning outcomes, that a person has in order to make suggestions on what job opportunities are available taking into account those mentioned above. The same principle applies to how information is used in order to help the persons involved get a job. This involves the employer also.

These are simplified steps that should be taken into consideration when discussing the possibility of implementing both these technologies in order to achieve the most of what they have to offer.

Other aspects that need to be taken into consideration are the scope of the implementation and the availability of stakeholders to participate. If there is a lack of

commonality between the parties involved in regards to what information must be gathered, then the procedure of data gathering will not be able to function. In order to prevent this, there is a minimum of information regarding qualifications that are required to be compulsory in order for the data gathering part of the model to function. Having a common framework, as in the case of the EQF (European Qualifications Framework) be in place in all the participant countries will enable data gathering.

The other aspect that is important is the availability and cooperation of stakeholders. In the case of such an implementation, there are a lot of parties involved, but the focus will be only on the four most important in our opinion, as follows:

- Educational and training providers – these providers, either private or public, will be involved in the process of data gathering and validation, and will have to agree with the minimum standards imposed by a common framework for skills and competencies, regardless of the training level they offer for their students. The levels that are mentioned are those of the European Qualifications Framework. These educational or training providers will have to use their own personalized credentials to access the nodes for each student and fill in the information in regard to their learning outcomes and in case of data corrections, they will also be the only ones that can correct the information;
- National agencies / awarding bodies – these stakeholders will have to manage the accreditation for each of the educational and training providers in order to enable them to emit certificates, diplomas, and other study documents. These bodies/agencies will also be responsible for verifying, periodically, if the providers meet the standards over a certain period of time. Through their approval and accreditation, the educational and training providers can solicit their certificates which give them access to the platform of choice for data gathering and storage. These bodies are also responsible for informing individuals of the risks and benefits of such an approach to educational outcomes;
- The individual – the person whose data is being collected and managed should agree with the fact that there are entities that manage their information on such a level. They should be informed by all parties involved on how their information is being used and what advantages and disadvantages they have by agreeing to this system. They should not be forced into accepting this system;
- Labor market/employers – the last stakeholder/stakeholders involved should be the employers. These will have to agree to develop hiring procedures that take into account learning outcomes that are clearly defined. This will translate into having to specify exactly what skills and competencies are needed from their future employees in order to have them be communicated to a platform that will match employees with employers based on skills and competencies.

These are the elements that are important in order to be able to use both technologies in a symbiosis.

5. CONCLUSIONS

Society has entered a new digital standpoint where efficiency, security, and predictability have become elements required for it to function. Technologies that enable society to have the elements mentioned above have been gaining momentum in recent years due to free movement restrictions enforced in different parts of the world, that have different levels of freedom. One of the fields that have been affected by such restrictions is education, where individuals of all ages, are required to adapt in order to participate in the educational process. Both students and teachers/trainers have been affected and have been adapting to different technologies and use cases for such technologies. There is room for improvement in the educational process if it is to be efficient, secure, and predictable, no matter the format it will have, online or offline.

As such the use of Machine Learning in combination with BLOCKCHAIN technology can bring a new era of online education, but can also help improve offline teaching techniques and outcomes. Implementing these technologies requires consensus on an international level, but once the groundwork has been set and the first steps put into motion in developing tools that take advantage of what these technologies have to offer, we consider that learning outcomes, employability, and educational transparency can be achieved on a scale never seen before. The model presented in the current document is incomplete and represents a concept that will be detailed in a further article.

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