On the Use of Blockchain Technology for Education During Pandemics

Cheriguene, A., Kabache, T., Adnane, A., Kerrache, C. A. & Ahmad, F

Original citation & hyperlink:
Cheriguene, A, Kabache, T, Adnane, A, Kerrache, CA & Ahmad, F 2022, 'On the Use of Blockchain Technology for Education During Pandemics', IT Professional, vol. 24, no. 2, pp. 52-61. https://doi.org/10.1109/mitp.2021.3066252

DOI 10.1109/mitp.2021.3066252
ISSN 1520-9202
ESSN 1941-045X

Publisher: Institute of Electrical and Electronics Engineers

On the use of Blockchain Technology for Education during Pandemics

Anissa Cheriguene[1,2], Taieb Kabache[2], Asma Adnane[3], Chaker Abdelaziz Kerrache[4], and Farhan Ahmad[5]
[1]Department of Letters and English Language, University of Ouargla, Ouargla, Algeria
[2]Department of English, ENS of Laghouat, Laghouat, Algeria
[3]Networks and System Research Theme, Department of Computer Science, Loughborough University, UK
[4]Laboratoire d'Informatique et de Mathématiques, Université Amar Telidji de Laghouat, Laghouat, Algeria
[5]Systems Security Group, Institute for Future Transport and Cities, Coventry University, Coventry, UK
cheranissa@gmail.com; taiebkabache@gmail.com; a.adnane@lboro.ac.uk
ch.kerrache@lagh-univ.dz; ad5899@coventry.ac.uk

***Abstract*— In recent pandemic events and lockdown, most of education institutions have moved into online and distance learning. Certain institutions have been more ready than others to shift into full online learning and teaching mode. However, many technical and security challenges and issues related to the Learning Management System (LMS) have been encountered. In this paper, we investigate the technical benefits of Blockchain, and we propose a secured and trusted online-leaning framework based on blockchain. Our proposal takes advantage of Blockchain technology to ensure the expected standard of teaching and fairness of assessment while respecting the schedule of courses and exams. Besides, through Blockchain's reward methods, it also motivates both students and teachers to persist in their efforts, even from home.**

***Keywords*—e-Learning; Distance learning; Blockchain; Coronavirus; pandemic.**

I. Introduction

Although internet has made the information cheap and available everywhere and anywhere, online learning and education platforms have came to provide structured, certified and flexible learning methods which connect learners with experts and tutors/teachers from any side of the globe [1]. e-learning platforms, also called Learning Management System (LMS) provide functionalities which support course management, student enrollment and management, administration, and student performance details (transcripts and achievements) [1].

The aim of the Learning Management System is to provide new skills and knowledge to prepare, educate and inspire employees. Those skills gained should be displayed by qualifications, often in the form of digital certificates (or digital badges) that are awarded to individuals by organizations following completion of their training. These certifications are then checked by the audit staff and "recognized" as valid. The entire ecosystem depends on trust, but a proper verification protocol can be developed with the aid of blockchain[1]

In the recent COVID-19 pandemic events, all education institutions have shifted to online learning and relied heavily on their online platforms for teaching and tutoring students. Many researchers actually started to question the effectiveness of traditional education and learning methods for a possible to shift permanently to online learning, where face to face sessions will be kept for specific purposes such as supervision and practical sessions [2].

However, many security experts have raised concerns regarding data security and privacy in the online learning platforms [3]. Any security breach on those systems could result in compromising valuable information (teaching materials/assets, grades, users personal data...etc) or excluding intended users from access. Indeed, potential users do not all have enough security education and knowledge to be able to use the learning platforms in a secured environments, a security that is often provided when students/staff are within the institution geographical premises and connected from a secured network. Adams and Blanford provided an analysis of security challenges in online learning platforms and how Security is essential to ensure users' trust and acceptance in the online learning environment because any risk can drastically influence students' recognitions of a system's quality and reliability [4].

Besides, many top tier universities have already relied on blockchain technology for various functionalities. For instance, an open standard, Blockcerts, has been developed by MIT Media Lab and Learning Machine for issuing and verifying certificates. The aim of Blockcerts is to prevent a war of standards that could require the use of particular suppliers and their proprietary standards by educational institutions and other organisations. The State University of New York (SUNY) aggregates learning services using technologies focused on Blockchain's peer-to-peer technology from its constituent universities and allied institutions. Finally, San Jose State University is a pioneer in the 'Library 2.0 revolution' and uses blockchain to more effectively handle its libraries. This involves areas such as listing physical and digital books and manuscripts, authenticating library members, and keeping up with members with automatic reminders to return books

[1]https://sparkwork.io/blog/lms/how-blockchain-is-impacting-elearning-industry/

on time [2]

Online platform users (students, teachers and admin) are not IT experts and do not all have an awareness of security requirements and measures. The design and development of online learning and sharing platforms require ' building of a robust, reliable and safe environment as well as the education and training of users. In this research paper we suggest a novel blockchain-based to secure online learning platforms and apply the key benefits of blockchain technology in a blockchain-based certification/credentialing applications including LMSs[3]. We will present the advantages blockchain structures will bring to online learning environments and how it can mitigate current security issues.

The rest of the paper is organized as follows: In Section II, we provide an overview of the existing Online teaching and assessment solutions, as well as the main principles of Blockchain technology. Section IV discusses our proposed architecture. Section V provides a summary of the advantages of incorporating blockchain technology to the online education. We also discuss the open challenges in Section VI. Finally, Section VII concludes the paper.

II. Background and Related work

A. Existing e-learning approaches

Conventional e-learning solutions are usually classified into three categories: MOOC-based (Massive Open Online Courses), Web2.0-based, and blended learning solutions. Yet, more recent Learning Management System involve also Cloud Computing and Blockchain Technology.

1) MOOC-based solutions: MOOC platforms are considered one of the most recent developments in education, reflect open access and free video-based content through an online platform addressing a high volume of participants who are aiming to take a course or simply obtain an education.

MOOC have an apparent potential to scale, offering access to free online classes to a huge number of users worldwide, outside the boundaries and formalities of conventional education. They have distinctive features that are capable of moving towards a lifelong and on-demand learning partnership for those who work full time or have taken a break from formal education [6].

2) Web2.0-based solutions: In order to transform the direction of teaching and learning processes, Web 2.0 outlets such as online chat, forums , blogs, Flicker, Instagram , Twitter and many more are believed to have played a crucial role. These instruments allow users in a virtual community to connect and collaborate with each other through social media. As it transformed the current educational environment , allowing knowledge sharing and promoting dialogue among online learners, the integration of web 2.0 tools into education became a trend.

Manca and Ranieri [7] proposed a critical analysis of numerous studies along the same line, analyzing how Facebook is used as an instrument in a technology-based learning environment, in order to find out how much their pedagogical ability is actually turned into reality. In addition, the intent of the paper in [8] was to explore the advantages and disadvantages of emerging social networking tools in ESL classrooms (English as a Second Language), particularly in writing lessons, and suggesting ways of designing activities by using social networking services (SNSs) in the field of teaching and learning.

3) Blended learning solutions: Blended learning, also known as "hybrid learning", is the process that refers to both face-to-face teaching and ICT-supported teaching [9]. It is a mix of several conventional classroom features, including face-to-face sessions, live e-learning, and self-paced learning (on-demand), along with an online insertion of relevant material to specific learners.

4) Recent LMS solutions: The work in [10] pointed out that cloud computing provides the learner with a new lacuna to help solve hardware and software problems as a new inspiration for an innovative learning climate. With some tests of some fumes platforms victimization of this technology, it tends to administer transient prohibition to cloud computing and cloud-based LMS. In addition, They tried to outline the key benefits and disadvantages of victimizing this technology in order to serve learners in this period of online learning. Works in [11], [12] presented how blockchain technology can ensure the desired LMS access control and the different security issues that LMS may face. On the other hand and thanks to blockchain, Ocheja et al. [13] have made it possible to logically transfer learning records using a blockchain as a transport medium and connection network for Learning Record Stores (LRSs).

B. e-learning support technologies

Developing an adequate platform to support the different learning approaches requires more than creating a cyber space where all teaching materials are uploaded (power point presentation, lecture videos....etc). Indeed, the platforms should be interactive and stimulative for learners, trusted and secured for all the users, facilitate teacher-student and student-student communications, provide a reliable online assessment tools (e.g. quizzs, online exam grading...etc) and provenance of e-learning credentials (e.g. certificate delivery/verification ...etc).

While first e-learning systems were based on client-server architectures, many limitations have quickly emerged such as the reduced availability, cost, and lack of scalability. Hence, the use of cloud computing in e-Learning has been discussed in many research studies. Indeed, Cloud computing has lot of advantages: scalability and resource management, data availability, cost effective, high performance, and efficiency in managing and updating different software and services [14]. Several Cloud-based architectures have been suggested and developed to provide e-learning solutions [15], where users do not need to have specific high performance equipments, or to install any software on the system. However, no automatic and reliable mechanisms have been suggested to verify and share students grades, qualifications and certificates.

Blockchain has been suggested by different educational institutions as a secure and reliable ledger to record their

[2]https://blog.originlearning.com/the-role-of-blockchain-in-learning/blockchain$_i n_h igher_e ducation$

[3]https://elearningindustry.com/blockchain-and-lms-a-proof-of-concept

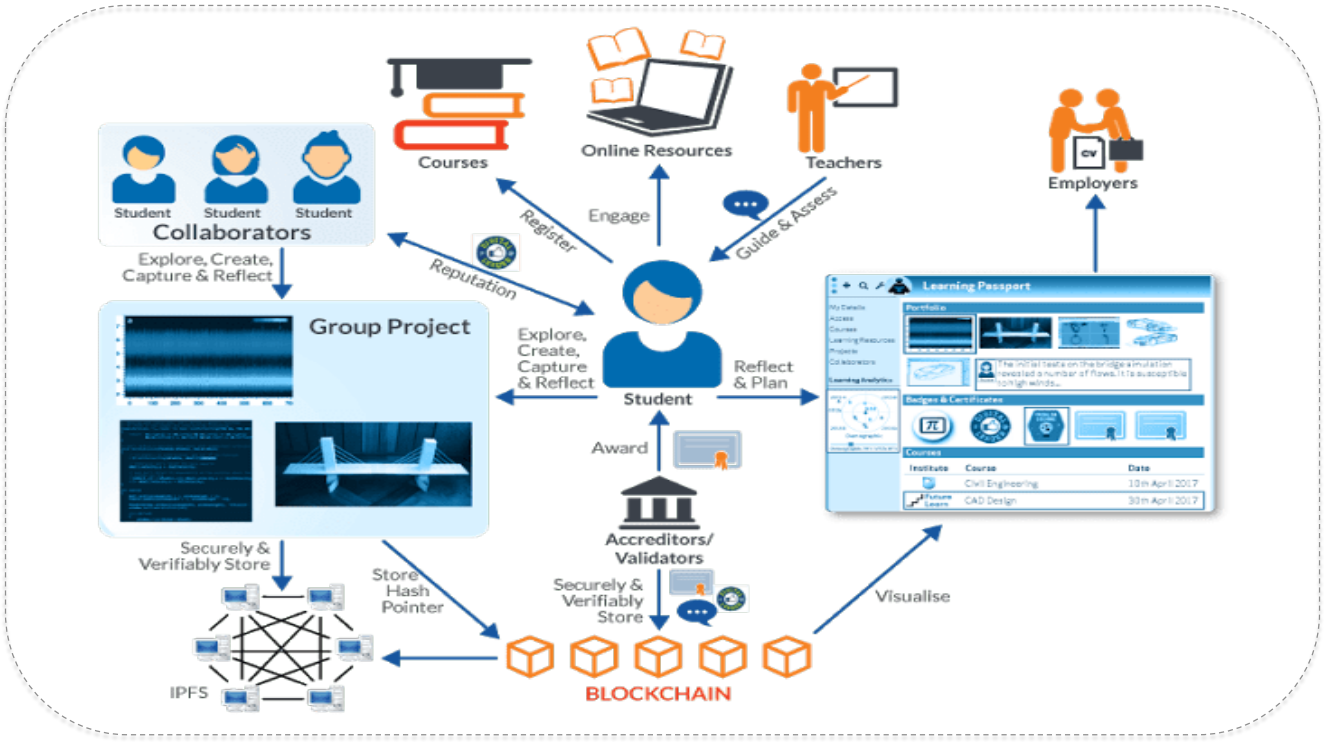


Fig. 1: Blockchain for education [5].

students' academic achievements [16], [17]. The authors concluded that the main benefit of blockchain is the collaborative environment between educational institutions. Blockchain provides a level of transparency, provenance, reliability and trustworthiness in both course delivery and assessments. Moreover, blockchain will accelerate shared acknowledgment of courses and qualifications between instruction suppliers

III. Blockchain technology: an overview

The concept of blockchain was first introduced by Satoshi Nakamoto [18]. Blockchain is a decentralised, trusted and secured data sharing environment, it enables distributed ledger technology which allows users to securely store, process and share data in a peer-to-peer model.

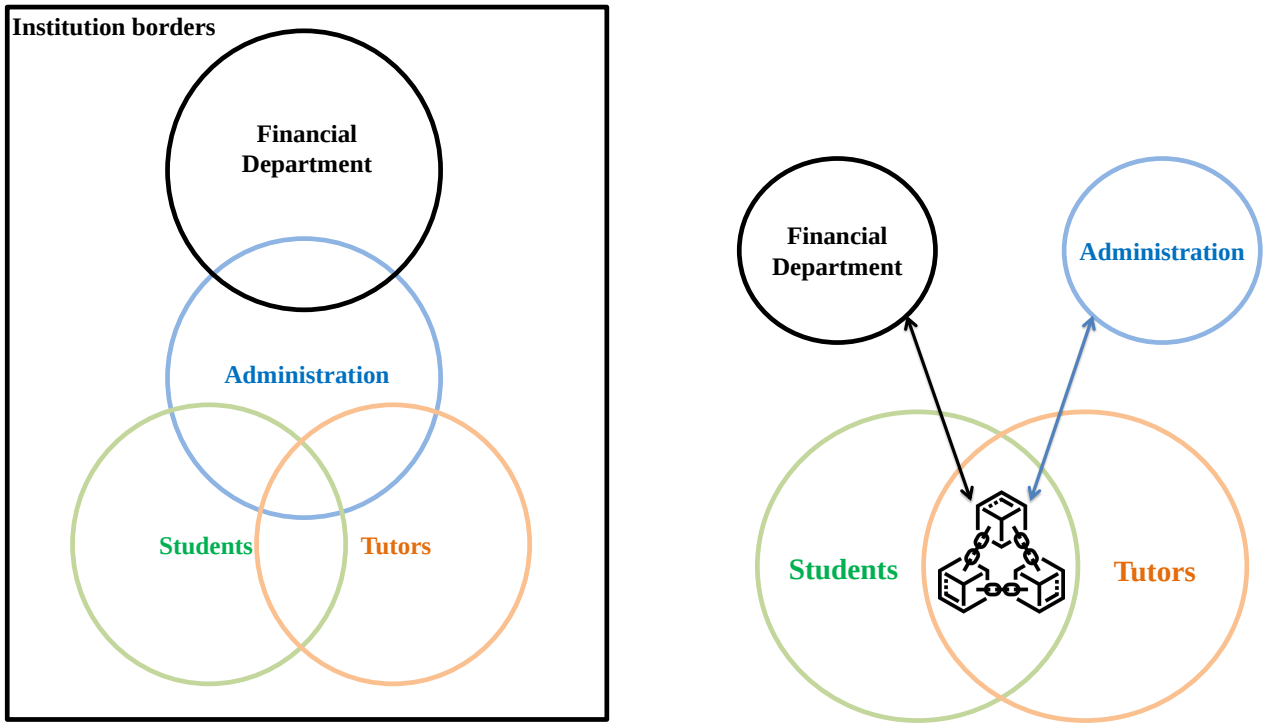
Several scientists and blockchain developers agree that the horizontal breakthrough required to change different industries is blockchain. Three basic principles are involved in blockchain technology: transaction, block and chain. The transaction is a ledger process, such as the data entry, which often leads to a change in the ledger 's status; the block tracks the outcomes of all transaction data over a period; the chain is a chronological string of clocks that represent all the ledger's changes. To ensure full data integrity and availability, blockchain architecture guarantees the following key concepts:

- **Data immutability**: Once data is stored it can not be deleted or modified.
- **Shared ledger**: a network where all member has an immutable copy of all transactions.
- **Consensus**: mechanism used to achieve agreement on a piece of data between all members of the network.
- **Permissions**: Blockchain can either be permissioned or permissionless, meaning that members of a blockchain either have restricted access on a blockchain or do not.

Several higher educations institutions have adopted the blockchain technology to design different learning solutions. [16], [17]. Few researches proposed to develop a framework for a blockchain-based storage and verification of education records and academic achievements [19] [4] [5]. MIT for example developed a digital learning certificate system using blockchain technology [20].On the other hand, Sony Global

[4]University College London using Bitcoin Verification to overcome cv fraud, [Link]

[5]L. Coleman, Engineering School Simplifies Verifying Certificates Using the Blockchain—CryptoCoinsNews: [Link]



(a) (b)

Fig. 2: Conventional education system (b) Blockchain-based education system

education uses Blockchain and AI to redefine the future education, the platform stores and manages transcripts and high security data in education. By using blockchain, the authenticity of the transcripts will be secured and the examiner will be able to manage their data and share it with others safely[6]. Finally, Mozilla's Open Badges project provides a solution to get recognition for skills and achievements that happen outside of school and encourages life long learning[7]. Figure 1 illustrates the different blockchain functionalities when involved for educational purposes.

To illustrate the difference between the conventional education system and the blockchain-enabled education system, Figure 2 shows that the conventional education system highly relies on the administration within a restricted geographical area, which results in the traditional issues of the centralized system. Hence, Blockchain-enabled education system can solve the issue as every information is stored on the Blockchain, which ensures privacy and reliability and data immutability. Indeed, using a permissioned Blockchain platform like MultiChain would ensure that only the university authority has the permissions to add and manage student records. However the access to read and check the records would be open to everyone.

In the next section, we provide details of our proposed architecture using blockchain technology.

[6]https://blockchain.sonyged.com/
[7]https://openbadges.org/

IV. Proposed Architecture

A. Architecture different domains

Our proposed architecture based on Blockchain is depicted in Figure 3. It is a three-tier architecture, which consists of three distinct levels, including blockchain, interaction middleware and teaching domain.

1) Teaching Domain: The two key actors of the educational system, learners and teachers, make up this domain. It also include the additional means of learning that learners outside the online course can use, such as books, handouts, and documents on the internet, to name a few. In addition , learners will share and discuss their courses through various communication technologies and social networks, as in the traditional case.

2) Interactions Middleware: This interaction middleware domain is responsible for communicating the message with the back-end infrastructure of both learners and teachers through a dedicated interface accessible via previously provided credentials to ensure position separation (i.e. a different interface for learners and teachers). In addition, department servers in this domain will act as cluster heads (CH) to transfer the data to the back-end network to record data into the Blockchain.

3) Blockchain-enabled Infrastructure domain: This domain is the back-end domain of the Blockchain-equipped architecture. Miners are first selected in this area on the basis of their ability to solve the complex puzzle of Proof-of-Work (PoW), which will later also be the subject of a reward. The permissioned blockchain servers are deployed within the

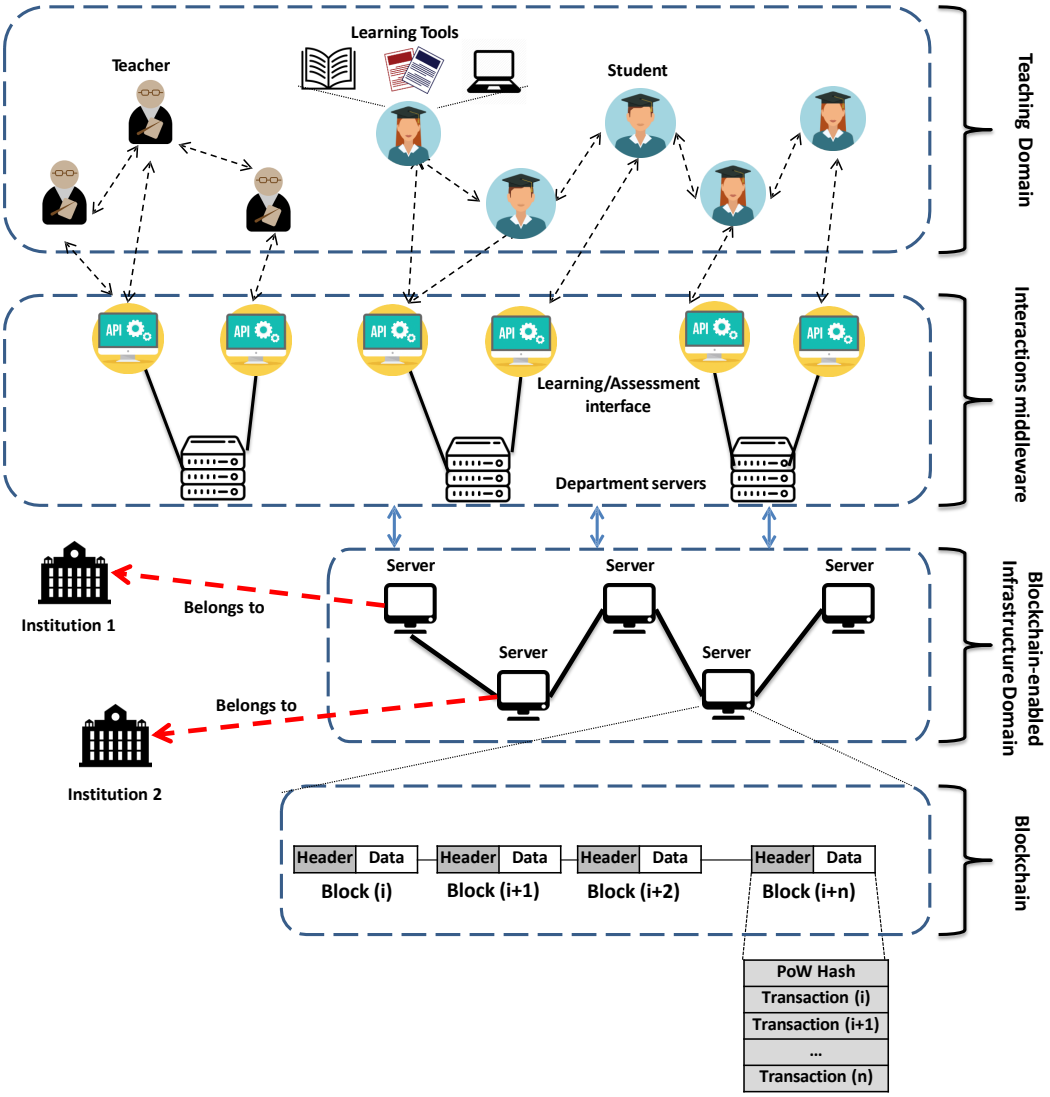


Fig. 3: Proposed architecture

institutions because they are the main cores having education-dedicated servers.

B. Architecture functionalities

Our architecture uses permissioned blockchain to provide a safe and timely link between students, teachers, and their respective departments. It operates in two key phases:

- First, system actors (students and teachers) login into the system and record the various authorized acts through dedicated interfaces (APIs). This details can include confidential data, such as names, scores, and contacts of students/teachers.
- Second, after solving the PoW algorithm, the miners in the Blockchain-enabled Infrastructure domain will incorporate the information into the Blockchain. The only nodes responsible for the addition of the data into the Blockchain are miners. The data is not, however, applied to the Blockchain if the PoW consensus algorithm can not be solved by a miner. Unlike the conventional case (applied for the Blockchains of the courses and student responses), in the assessment Blockchain, which reflects three separate evaluations of a given student answer, we allow three miners to add data into the same block. This is a configurable parameter that can be used in various situations where, for example, with few enrolled students, we want to achieve a fair assessment in particular exams. We need to get a fair classification of the success of students in this situation.

The student is also the most significant player in any education system. Students can move through an authentication process prior to accessing the course materials, much like their instructors. They then pick the goal course from the Blockchain, which will be accessible to them. They can also access the exam after completing the course, which will activate a timer for the specified exam period.

After the student returns the responses or the time response elapses, the responses will be added to the Blockchain after the department server conducts a mining method. A receipt confirmation note is then sent back to the student, as shown

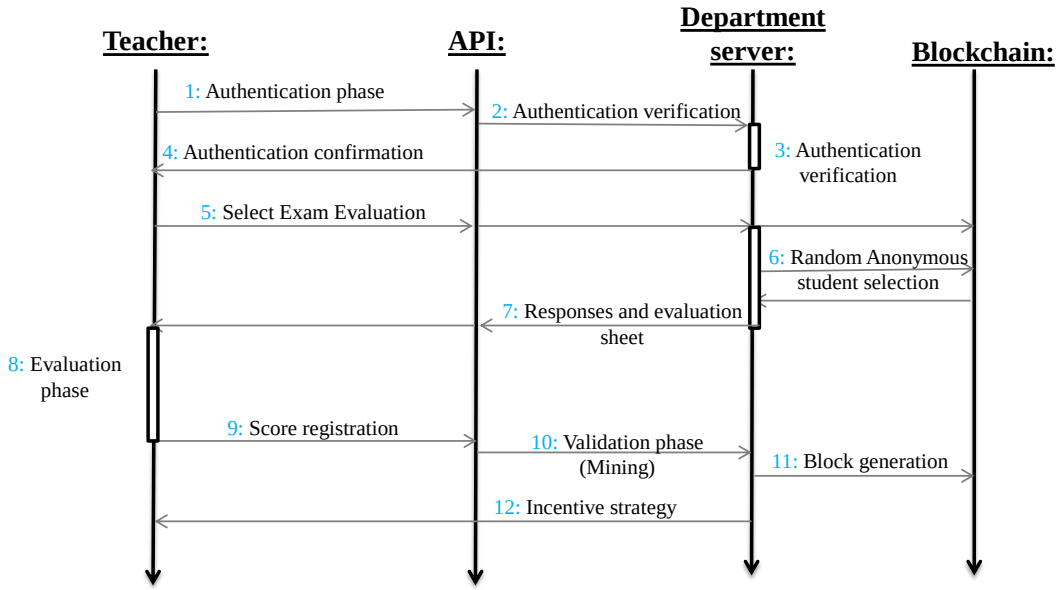


Fig. 4: Tutors/teachers interactions with the system

in Figure 5.

C. Blockchain additional overhead

Using the MultiChain platform, we implemented blockchain-related behavior (i.e., blockchain development, validation and insertion process) in Java. We evaluated the average consumed energy per hour for the three main servers in the Department of Computer Science at the University of Laghouat, Algeria, to determine the effect of using Blockchain on the resources of the department's servers.

A comparison of the average energy consumed by these servers with and without Blockchain is shown in figure 6. It shows that for a number of 2000 students' data, the servers consumed 15 percent more energy than the traditional situation by using Blockchain. Yet, compared to the benefit of such a fully distributed education system, this extra overhead is still minimized. In addition, the cost will be greatly reduced when implementing the full scheme on a regional or national scale, since all computations will run on the edge of the network.

V. Advantages of incorporating Blockchain technology to the online education process

Several new applications emerged along with Blockchain, including educational applications, with the following advantages:

- Online resources are available in a reliable, secured and trusted environment for all users at anytime and from anywhere.
- Reliable, verifiable and trusted support for students' achievements, grades and transcripts. Blockchain-based framework insures the data remains unchanged.
- The reward system would enable teachers to be more active and to work more.
- Robust and trusted verification of students' achievements and grades which are stored and available in the Blockchain platform. This will ease and speed up recruitment or registrations to other degrees.
- Blockchain platforms are decentralised and provide a quicker recovery in case of an IT disaster (technological or natural causes)
- Strong authentication: Blockchain solves most of the authentication issues. Within a blockchain-based authentication environment, there would be no way to fake an ID, passport, credit card number, grades, etc. Even if a hacker was able to access the data/credentials via the data owner, he wouldn't be able to copy it, change or remove it. It would be impossible to add a new data to the chain without the majority of nodes verifying its validity.
- The blockchain reliable and secure environment will promote the public acceptance of online distance learning.

VI. Open challenges

Even though, Blockchain-based architecture has solved many issues related to e-learning, there are still few open challenges. First, it is important to understand the limitations and boundaries of the security measures offered in Blockchain-based solutions. For example, the it cannot stop the learners from sharing their logins with other malicious user, or from uploading a malware. Indeed, in traditional education, students will have access via the trusted institution network (e.g. for enrollement, exams ...etc) which follows the IT security policy. However, using an e-learning solution implies that the institution needs to implement and enforce a remote access policy to secure the learners and the institution.

Second, online assessment and marking are still a big challenge in the design of e-learning platforms, especially in the case of big classes. Artificial intelligent could be used for

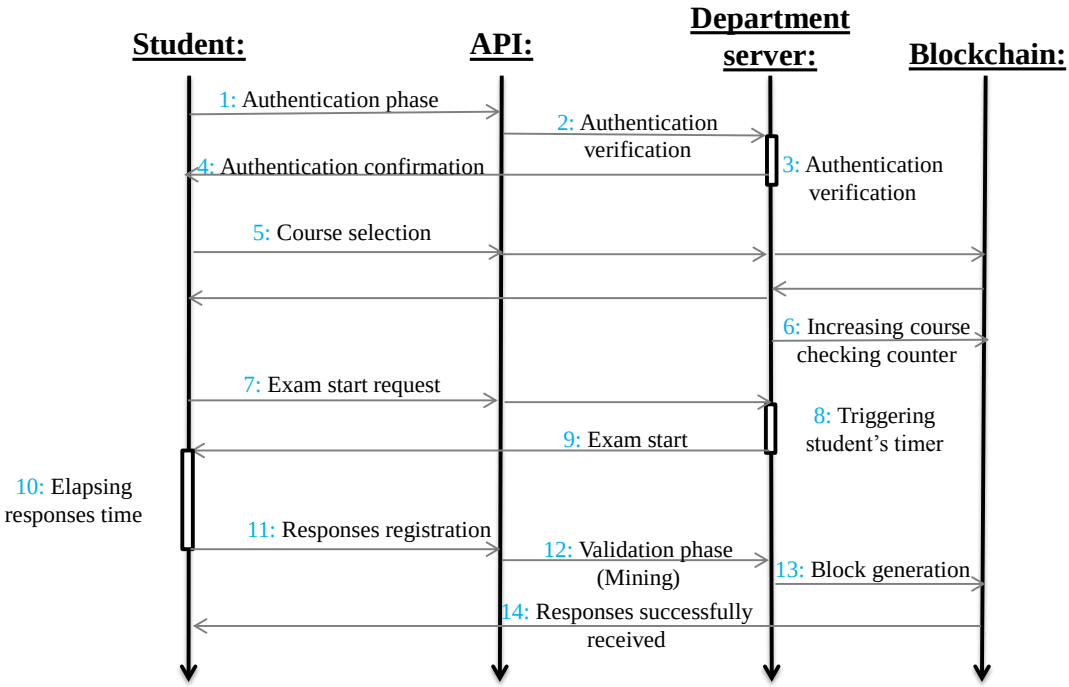


Fig. 5: Students interactions with the system

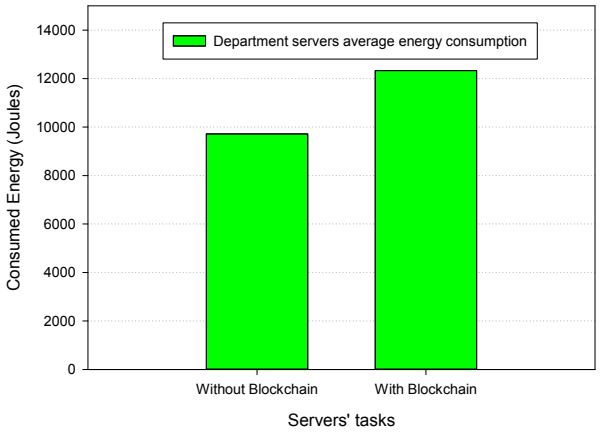


Fig. 6: Department servers energy consumption with and without Blockchain.

online camera monitoring of learners, and assisting tutors in marking.

Finally, blockchain scalability and privacy issues need to be taken into account. For scalability, few researches suggested combining Blockchain with cloud-computing and AI solutions to increase the efficiency of the service delivery. Privacy is another issue because data is shared between all Blockchain participants.It is also likely that in some areas centralised web options will remain even as the decentralised web develops

VII. Conclusions

The availability of the Internet has improved the combination of several existing multimedia resources as tools to create a Virtual Learning Environment (VLE) that reinforces the management of content, strengthens the teaching environment and restores the learner's active role. In this paper, Blockchain technology is used to offer a novel distance-learning approach for emergency situations where learners and teachers are forced to stay at home. It uses the functionality of the safe open ledger of Blockchain to provide both students and teachers worldwide with remote access to courses and exams. Our plan further promotes the efforts of educators to prepare materials for courses and to engage in the assessment process. Motivating them to continue operating while in quarantine.

We plan to add more functionalities to this architecture as future work, including distance supervision and tutoring, defense of dissertations, and laboratory sessions. We also intend to construct an intuitive interface for the API that facilitates the various tasks.

References

[1] D. Dagger, A. O'Connor, S. Lawless, E. Walsh, and V. P. Wade, "Service-oriented e-learning platforms: From monolithic systems to flexible services," *IEEE Internet Computing*, vol. 11, no. 3, pp. 28–35, 2007.

[2] P. Jandrić, D. Hayes, I. Truelove, P. Levinson, P. Mayo, T. Ryberg, L. D. Monzó, Q. Allen, P. A. Stewart, P. R. Carr *et al.*, "Teaching in the age of covid-19," *Postdigital Science and Education*, vol. 2, no. 3, pp. 1069–1230, 2020.

[3] W. Chen, Yong ; He, "Security risks and protection in online learning: A survey," *International Review of Research in Open and Distributed Learning*, vol. 14, no. 5, pp. 108–127, 2013.

[4] A. Adams and A. Blandford, "Security and online learning: to protect or prohibit," in *Usability Evaluation of Online Learning Programs*, C. Ghaoui, Ed. UK: IDEA Publishing, March 2003, pp. 331–359.

[5] *Open Blockchain*, (accessed October 15, 2020), https://blockchain.open.ac.uk/.

[6] L. Haumin and M. Madhusudhan, "An indian based mooc: An overview," 2019.

[7] S. Manca and M. Ranieri, "Is facebook still a suitable technology-enhanced learning environment? an updated critical review of the literature from 2012 to 2015," *Journal of Computer Assisted Learning*, vol. 32, no. 6, pp. 503–528, 2016.

[8] S. A. Shariffuddin, W. R. W. Shaaidi, and S. M. Hashim, "Social networks as instructional tools beyond a classroom," *International Journal of Advanced and Applied Sciences*, vol. 4, no. 12, pp. 185–192, 2017.

[9] C. N. Stevenson, *Enhancing Education Through Open Degree Programs and Prior Learning Assessment*. IGI Global, 2018.

[10] H. F. Aldheleai, M. U. Bokhari, and A. Alammari, "Overview of cloud-based learning management system," *International Journal of Computer Applications*, vol. 162, no. 11, 2017.

[11] J. Y. Chun and G. Noh, "Blockchain-based access control audit system for next generation learning management," *KIPS Transactions on Software and Data Engineering*, vol. 9, no. 11, pp. 351–356, 2020.

[12] M. K. T. N. K. Mahmood, "Using blockchain to resolve database distribution and security issues in the learning management systems (lms)," *IJCSNS*, vol. 19, no. 11, p. 139, 2019.

[13] P. Ocheja, B. Flanagan, H. Ueda, and H. Ogata, "Managing lifelong learning records through blockchain," *Research and Practice in Technology Enhanced Learning*, vol. 14, no. 1, pp. 1–19, 2019.

[14] Q. Naveed and N. Ahmad, "Critical success factors (csfs) for cloud-based e-learning," *International Journal of Emerging Technologies in Learning (iJET)*, vol. 14, no. 01, pp. 140–149, 2019. [Online]. Available: https://onlinejour.journals.publicknowledgeproject.org/index.php/i-jet/article/view/9170

[15] N. Selviandro and Z. A. Hasibuan, "Cloud-based e-learning: A proposed model and benefits by using e-learning based on cloud computing for educational institution," in *Information and Communication Technology*, K. Mustofa, E. J. Neuhold, A. M. Tjoa, E. Weippl, and I. You, Eds. Berlin, Heidelberg: Springer Berlin Heidelberg, 2013, pp. 192–201.

[16] B. Awaji, E. Solaiman, and A. Albshri, "Blockchain-based applications in higher education: A systematic mapping study," in *Proceedings of the 5th International Conference on Information and Education Innovations*, 2020, pp. 96–104.

[17] T. Y. Lam and B. Dongol, "A blockchain-enabled e-learning platform," *Interactive Learning Environments*, pp. 1–23, 2020.

[18] S. Nakamoto, "Bitcoin: A peer-to-peer electronic cash system," 2008, [online] Available: https://bitcoin.org/bitcoin.pdf [Accessed July 2020].

[19] M. Jirgensons and J. Kapenieks, "Blockchain and the future of digital learning credential assessment and management," *Journal of Teacher Education for Sustainability*, vol. 20, no. 1, pp. 145 – 156, 01 Jun. 2018. [Online]. Available: https://content.sciendo.com/view/journals/jtes/20/1/article-p145.xml

[20] E. Durant and A. Trachy, "Digital diploma debuts at mit," 2017. [Online]. Available: https://news.mit.edu/2017/mit-debuts-secure-digital-diploma-using-bitcoin-blockchain-technology-1017

Anissa Cheriguene (cheranissa@gmail.com) is a lecturer and a PhD student currently at the Department of English Language and Literature, University of Ouargla, Ouargla, Algeria and the Department of English, ENS of Laghouat, Laghouat, Algeria. Her research interests are mainly related to English as a Second Language writing for journal publications, flipped classrooms, end educational technology.

Taieb Kabache (taiebkabache@gmail.com) is with the Department of English, ENS of Laghouat, Laghouat, Algeria. He received the Ph.D. degrees from the University of Sidi Bel abbes in 2018; His research interests are mainly related to English as a Second Language, and English literature.

Asma Adnane is a lecturer in the Computer Science department of Loughborough University. Before joining Loughborough, Asma was a senior lecturer in the University of Derby (2013-2018) and a KTP associate at the university of Leicester and Crowdlab – Leicester (2011-2013).Her main research focus is on networks and security. She had been involved in research related to the multipath routing performance in ad hoc networks, and in different applications of trust management for secured routing in ad hoc networks and Vehicular networks.

Chaker Abdelaziz Kerrache (ch.kerrache@lagh-univ.dz) is an Associate Professor at the department of Computer Science, University of Laghouat, Algeria. He received his MSc. degree in Computer Science at the University of Laghouat, Algeria, in 2012, and his Ph.D. degree in Computer Science at the University of Laghouat, Algeria, in 2017. His research activity is related to Trust and Risk Management, Secure Multi-hop Communications, Vehicular Networks, Named Data Networking (NDN), and UAVs.

Farhan Ahmad (ad5899@coventry.ac.uk) is working as an Assistant Professor with Systems Security Group at the Institute for Future Transport and Cities, Coventry University, United Kingdom. Dr. Ahmad received his Ph.D. in Computer Science from the University of Derby, the United Kingdom in 2019; M.Sc. in Communication and Information Technology from the University of Bremen, Germany, and B.Sc. in Electronics Engineering from COMSATS University Islamabad, Pakistan. His research is focused on the vehicular networks security and Industrial Internet-of-Things security from a trust management perspective.