

# Papers

**Dr. Hsu Mon Kyi**

**Outcome-based Education System using Blockchain Technology**

# Outcome-based Education System using Blockchain Technology

Hsu Mon Kyi<sup>1</sup>, Swe Swe Aung<sup>2</sup>, Yuzana<sup>3</sup>, Thinn Thu Naing<sup>4</sup>

Faculty of Computer Science

University of Computer Studies (Taunggyi), Shan State, Myanmar

hsumonkyi@ucstgi.edu.mm, swesweaung@ucstgi.edu.mm, yuzana@ucstgi.edu.mm,

thinnthunaing@ucstgi.edu.mm

*Abstract: Outcome-Based Education (OBE) is a student-centric teaching and learning methodology in which the course delivery, assessments are planned to achieve stated objectives and outcomes. Outcome-based education focuses on: (i) Student assessments are designed to measure the learners' achievement of the learning outcomes (ii) Backward design of curriculum where courses and learning experiences are designed to help learners to achieve the learning outcomes (iii) Constructive alignment of learning outcomes, curriculum, teaching and learning methods, and student assessments. In OBE system, the student evaluation result is decided by educational stakeholders. Thus, the important problem of traditional OBE system can be absent to evaluate the student learning, abilities and states by educational stakeholders. As a next problem, society is unable to effectively evaluate the teachers and students as well as student evaluation results. Moreover, traditional document records can be destroyed in the case of natural disasters or wars.*

*To fulfill those requirements, this paper designs a system, entitled "Outcome-based Education System using Blockchain Technology". The important concept of Blockchain technology is a combination of secured distributed ledger, cryptocurrency and smart contract system. Blockchain is a reliable mechanism, and the development of blockchain brings significant benefits to education including providing a secure data processing platform, cost-saving, immutable and enhancing trust and transparency. Therefore, blockchain technology is applied to the traditional OBE system for higher education. In this case, this research focuses on the university curriculum and student credit system specialized in computer science and technology as a case study. The intended outcomes of this system would be (i) ensure the secure, reliable and robustness services for credit transfer and industry relationship (ii) support unique standardization for student data between all institutions and universities linkage.*

**Keywords:** OBE, blockchain, cryptocurrency, smart contract

## Introduction

The blockchain is an emerging technology that provides significant opportunities to disrupt traditional products and services due to the distributed and decentralized in nature. The features such as the permanence of the blockchain record and the ability to run smart contract blockchain technology based products or services significantly different from previous internet-

[1]

based commercial developments and of particular interest to the education sector [12]. As part of the fourth industrial revolution since the invention of steam engine, electricity, and information technology, blockchain technology has been applied in many areas such as finance, judiciary, and commerce [1]. Nowadays, some universities and institutes have applied blockchain technology into education, and most of them use it to support academic degree management and summative evaluation for learning outcomes [1].

In recent years, with the development of network, digitalization and globalization of the learning environment, traditional educational institutions tend to lack the necessary means, resources and ability to verify learners' knowledge, skills and achievements in management, certification learners learning activities, processes and results, etc [2]. Traditional evaluation is also a problematic issue in the education system. Formative assessment has been advocated for a long time, and yet it is still not ripe because it is not easy to track every detail of teaching and learning. Applying blockchain can solve this challenge [1].

OBE based students' achievement system has two types of learning contexts. In the formal learning context, this includes learning contents and outcomes as well as students' achievements and academic certificates. Subsequently, in the informal learning context, information about research experience, skills, online learning experience as well as individual interests are included. These data can be safely stored and accessed on a blockchain network in appropriate ways [1].

Blockchain is a reliable mechanism, and the development of blockchain is applied in various societies because of decentralization and non-tampering. Overall, blockchain can be used to construct a balance to measure the learning process and outcomes. Theoretically, blockchain can solve the problems of information asymmetry and trust among strangers because of its decentralized distributed database which protects secure information. Each block contains the hash value of the previous block and ensures the traceability of data on the chain. Therefore, blockchain is the strong technical support for the ability of the student evaluation system. The main contributions of this paper are as follows: (i) Outcome-based Education (OBE) system is designed for degree achievement. (ii) Develop the design scheme for OBE system with blockchain technology.

[2]

## Literature Review

In this section, we will review the blockchain technology is applied to education in many innovative ways for various purposes. Therefore, some of these few studies of the field are briefly summarized below.

One of the studies recommends based on the learning outcomes, a study in which educational-purpose blockchain technology is addressed used this technology and an automatic assessment software as a learning tool based on the university's graduation condition index and professional certification. In the evaluation of the students' achievement, the transformation towards the post-employment qualification evaluations is completed and the curriculum is continuously developed by sending a curriculum to evaluate the difficulties facing student success [2].

According to Nespor (2018), blockchain could undercut the educational institutions' central role as certification agents and provide students with more learning opportunities. Due to the high efficiency of blockchain, several applications could measure and evaluate the students' performance based on qualitative and quantitative parameters [5]. Moreover, Farah et al. (2018) built a system to trace the performance of students for their multi-learning activities [6]. Authors in Reference [9] introduced the Ubiquitous learning (U-learning) system, which uses the blockchain technology to provide students with anytime/anywhere collaborative learning environment with a high level of security. Thus, U-learning has an interactive multimedia system to encourage an efficient communication system among teachers and students.

Liu et al. (2018), which applied the blockchain technology to a link between educational institutions and employment enterprises for sharing all necessary information regarding recruitment and industry requirements [8]. Similarly, another example was illustrated by Zhao et al. (2019), where an application program was developed using blockchain to evaluate students' professional skills based on their academic achievements and performances, which then could be provided to any interested industry. This evaluation system has been designed to assess and analyze students' abilities based on the clustering algorithm within the blockchain [10].

To the best of our knowledge, the proposed design scheme for OBE system with blockchain is an appropriate technology for the measurement of the student capability evaluation effectively and efficiently.

## Outcome-based Education (OBE) System using Blockchain Technology

### Outcome-based Education

Outcome-based education (OBE) as “defining, organizing, focusing, and directing all aspects of a curriculum on the things we want all learners to demonstrate successfully when they complete the programme”. The objective of OBE teaching and learning is to shift the paradigm from a teacher-centered approach to a student-centered approach. That means, learning outcome statements are to reflect and express what students are expected to be able to do at the end of the learning period. Learning outcomes are commonly divided into different categories of outcomes such as discipline-specific outcomes that relate to the subject discipline and the knowledge and/or skills related to it; and generic (sometimes called transferable skills or lifelong learning skills) outcomes that none discipline-specific e.g. written, oral, problem- solving, information technology, and team working skills, etc. In this study, this paper focus on the university curriculum and student credit system specialized in computer science and technology. OBE is realized by the 9 requirements for computer science degree program reference on ACM/IEEE-CS 2013 Curricular Guidelines (ACM and IEEE-CS, 2013). Degree program requirements will be measured by several key point indicators (KPI). In this computer science degree program case study, the course “Operating System Concept” as one of the requirements courses for the graduation ability index. The detail requirements are shown in Figure 1.

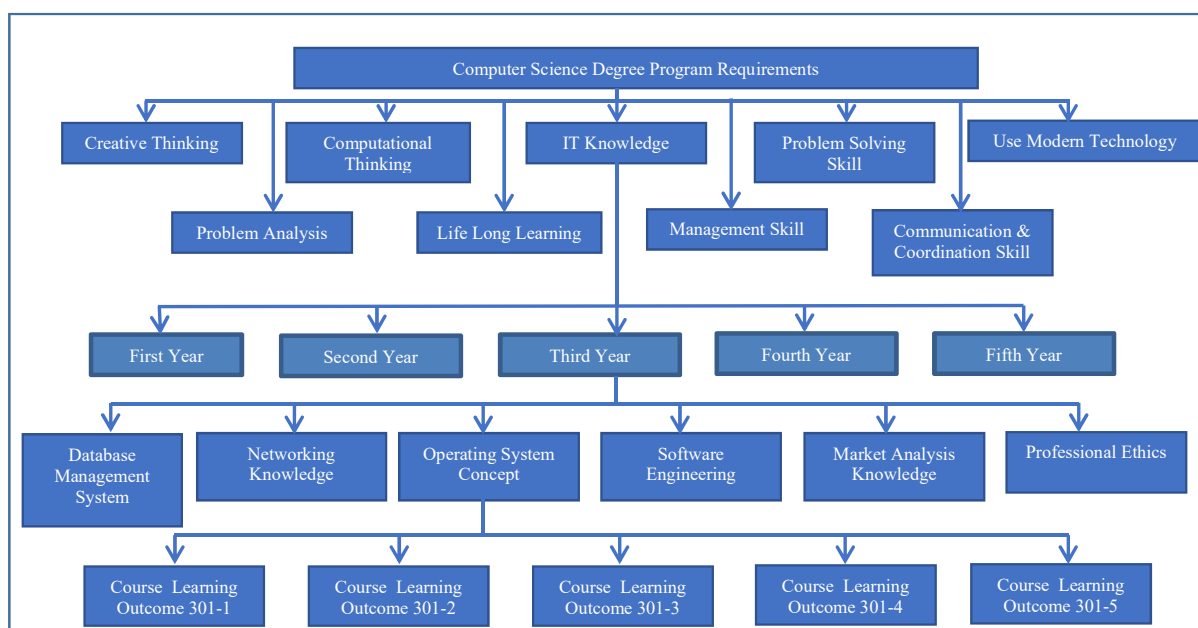


Figure 1. Computer Science Degree Program Requirements

Outcome-based education (OBE) is measured by Academic credit units (ACUS) for the graduate degree program requirement. In this case study, 128 credit units are required for an undergraduate computer science degree program. Each course has the 3 credit units for measurement of fulfilling the Course Learning Outcomes (CLOs) and assessment of the informal learning (knowledge/skill). To achieve the CLOs objective, 2 credit units are used for each course lectures and 1 credit unit for other assessments (i.e., classroom participation, Assignments/Tutorials, Practical and Projects/Team works). To fulfill the Course Learning Outcomes (CLOs) for each course, they are divided into corresponding credit point value according to their course requirements. The following table 1 is shown the evaluation type and credit point value for the “Operating System Concept Course” course code is 301 as an example. The table 2 is another assessment value for the “Operating System Concept Course”.

<b>Table 1</b>		
Credit Point Value for Operating System Concept Course		
<b>Course Learning Outcomes (CLOs)</b>	<b>Credit Point Value (2- ACUs)</b>	<b>Evaluation Type</b>
301-1 Examine major objectives, functions, features, and concepts of modern operating systems.	0.30	Exam test
		Discussion question
301-2 Analyze and design the applications to run in parallel either using process or thread models of different OS	0.50	Practical operation
		Exam test
		Analyzing the understanding of lecture from the interview question
301-3 Analyze the various device and resource management techniques for timesharing and distributed systems	0.40	Exam test
		Assignment test
		Discussion question
301-4 Investigate the need for concurrency within an operating system	0.55	Practical Operation
		Exam test
		Report the experimental result by applying the theory
301-5 Analyze the concept of virtualization concerning hardware and software.	0.25	Investigate the concept
		Implementation

**Table 1 Credit Point Value for Operating System Concept Course**

These formal student learning outcome achievement and other informal assessment data can be collected at the end of the academic year. Then, the achievement value together with the student ID, course code, year code, the credit point of the course and other information will be shaped like a record. And then, this data will be stored into a blockchain network. This data is

how to efficiently store the blockchain node and detail technique of blockchain are explained in the following section.

<b>Table 2</b> Other Assessment value for Operating System Concept Course	
<b>Assessment Type</b>	<b>Credit Point Value (1- ACUs)</b>
Classroom Participation	0.10
Presentations/ Project(Team work)	0.45
Assignments	0.20
Tutorials	0.25

**Table 2 Other Assessment value for Operating System Concept Course**

## **Blockchain Technology**

There are several questions about education system services and blockchain technology:

- Why should Blockchain technology use in the development of student evaluation?
- How to implement blockchain technology into the student evaluation system?

To answers the above questions, Blockchain technology should be introduced first. Blockchain technology is one of the megatrends for recent years. It is potentially a revolutionary means of secure and transparent data sharing and processing in a wide variety of sectors. The blockchain is an effective and efficient technology for the implementation of OBE with the help of its features like transparency, immutability and distributed way of storing the student evaluation records. The following sections will explain the blockchain, distributed ledger and a consensus mechanism in detail.

### **A. Blockchain**

Some researchers said that blockchain is an unhackable technology because of the concepts of distributed ledger, smart contract system, and cryptocurrency. Blockchain technology would appropriate to apply for trusted data processing between various types of users and stakeholders. Blockchain construct as a linked chain of blocks in which a group of validated transactions has hashed. First, those transactions have converted into a block by calculating with hash functions. Then it produces a unique hash code of that block. The block will link to the existing blockchain of the system.

A transaction of a block has calculated a unique hash code. A block in the blockchain has the read-only privilege. Nobody can modify any block of the blockchain. If someone tries to modify the block, the hash code will be changed. This block will be discarded automatically

from the blockchain link. Standard cryptographic algorithms are applying as hash functions in blockchain technology.

### **B. Distributed Secured Ledger System**

The blockchain distributes to the nodes of a dedicated network that is either a distributed network or a peer-to-peer network. The users can access the blocks from the blockchain for additional processes. They can create a new block of the transaction then it links to the blockchain. That is called the distributed and secured ledger system.

In the blockchain network, some users have the authority to validate and confirm whether transactions in the block are corrected or not. Then they proved it as an auditing process. A new block creates after auditing of the previous block. A new block links into existing blockchain and then distributes it to others. As a consequence, the person who proved the blocks of blockchain can reward for their proof work like consultant fees. Therefore, blockchain technology should apply for proof of work and proof of authority. For that reason, blockchain technology appropriate to apply for education services such as proof of student evaluation records, student certificate, and transcripts need to prove whether it is confirmed.

### **C. Consensus Mechanism**

The consensus mechanism is the core of the blockchain, which is related to the normal operation of the blockchain. The so-called consensus mechanism is the algorithm that all nodes reach consensus on transactions in a period of time [11]. The most commonly used consensus mechanisms are Proof of Work-PoW, POS Proof of Stake, Practical Byzantine Fault Tolerance [10].

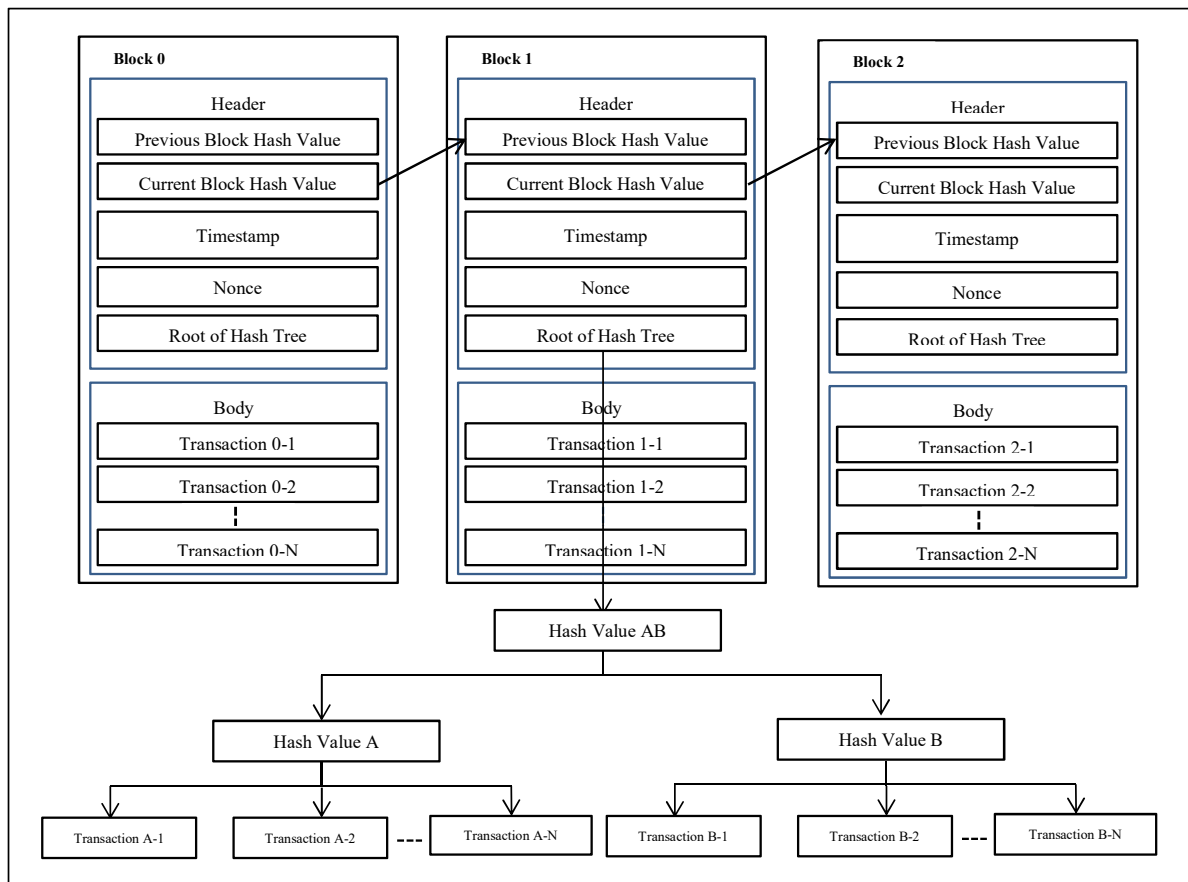
## **Design Scheme of Outcome-based Education System based on Blockchain**

The proposed system uses a decentralized and distributed peer to peer (P2P) network where the student data is stored in the form of transaction blocks. These blocks are connected to one another forming a chain of transactions. The “transaction” is the record of the students’ score and evaluate the students’ ability in the blockchain structure will be distributed to every node in the network to ensure the operation process of the student ability evaluation result is open and transparent and cannot be modified with. The student ability evaluation record is stored to the blockchain as a "transaction" to enable stakeholders such as students, teachers, and schools.

[7]



Therefore, the students' information is queried at any time and in any place. Since all the nodes on the blockchain are interconnected, the data stored can be traced. At that time, the hash value in the block will change because of the existence of the hash pointer, each subsequent block hash will change, and it is easy to see whether block data is tampered with by creating blocks. Therefore, the assessment record of students to achieve value is stored in the blockchain, which can form a social consensus.



**Figure 2. Blockchain Structure**

In this section, the design of the proposed open framework describes. There are four layers in the framework:

#### **A. Development Platform Layers for Education Applications Services**

This layer supports application developers for the standard developing platform of front end and back end applications. This layer provides front-end services such as UI template,

[8]

application template and data template for end users. The users can directly interact at this layer and necessary information related to student evaluation results is accessed from the application interface. Moreover, the ability of student records is submitted to the node as a “transaction” and then transmitted to the blockchain.

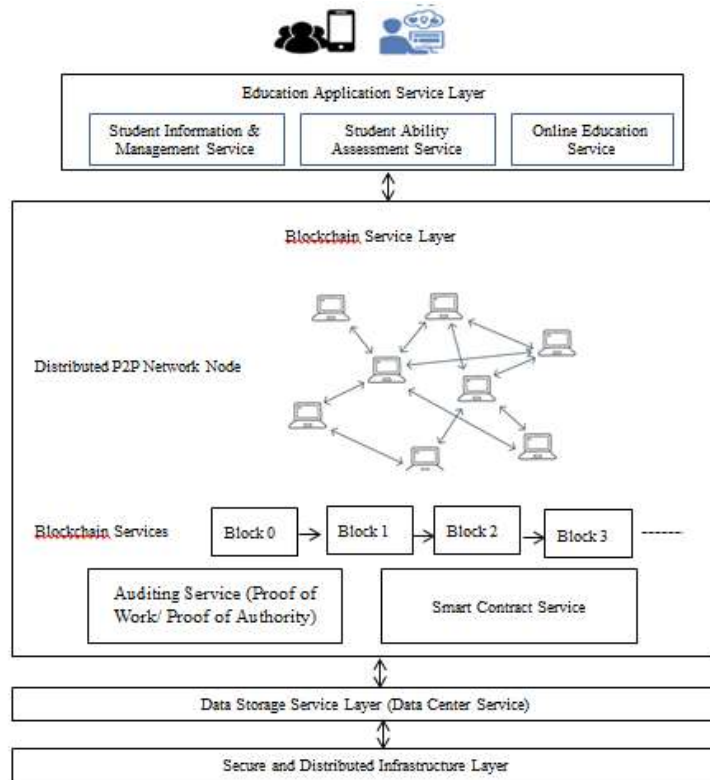


Figure 3. Proposed System Framework for OBE using Blockchain Technology

## B. Blockchain Technology Services Layer

This layer is the most important layer of the proposed framework. Layer 2 is a supporting layer for blockchain technology and related services such as Blocker Service, Distributed Ledger Service, Smart Contract Service, and Auditing Service, (Proof of Authority) as following:

### Blocker Service

The blocker service generates the transaction using secured cryptographic algorithms and returns hash code for that transaction.

```

Algorithm Blocker (Blockchain, Block, Transaction)
{ hash-code= Encrypt(Transaction);
  Add(Block, hash-code, Blockchain);
}
Algorithm Encrypt(Transaction)
{ hash-code= Cryptographic_fun(Transaction);
  return hash-code;
}

```

### **Distributed Ledger Service**

The blockchain will be distributed to the appropriate node of a dedicated network is a peer-to-peer network. P2P network nodes are used for receiving encapsulated "transactions" from the application layer, and verifying the "transactions" for “proof of work” and “proof of authority”. Then, a new block has been created and links it into blockchain again. Blockchain is used to store all "transactions", that is student capability evaluation results. Data in the blockchain is distributed across a P2P network. To enhance the reliability of the student evaluation system, the node of the system includes relevant education departments. All of their relevant departments can check the information released by the system at any time, and enhance the reliability and high trust of the student evaluation system.

```
Algorithm
Distributed_Ledger(blockchain,transaction)
{
    new-block= Proof_of_Work(transaction);
    Blocker(blockchain,new-block,transaction);
    return blockchain;
}
```

**Distributed Ledger Algorithm**

### **Auditing Services (Proof of Work/Proof of Authority)**

The main tasks of these services are auditing and confirming for a given transaction. In order to do these services, Educational assessment rules play a vital role in transaction confirmation.

### **Smart Contract Service**

The most important service of blockchain technology is the Smart Contract service. Universities can use this technology to hand over certificates, transcripts, and degrees once the student successfully clears the exams on the parameter set by the universities and industry linkage.

### **C. Data Storage Service Layer (Data Center Service)**

This layer is also a physical layer to support data center service. In this layer, all data systems are storing into the data storage layer as virtual storage or cache storage. Some data are physically stored as well.

[10]

#### **D. Secure and Distributed Infrastructure Layer**

This layer is the underlying layer of secure communication for the blockchain network. The special-purpose protocols are supporting to communication channel and blockchain network.

The intended outcomes of this system would be (i) ensure the secure, reliable and robustness services for credit transfer and industry relationship (ii) support unique standardization for student data between all institutions and universities linkage.

#### **Conclusion**

In this paper, a system is designed, entitled “Outcome-based Education System using Blockchain Technology”. The university curriculum and student credit system specialized in computer science and technology as a case study to evaluate the ability of the student. The paper proposed a design scheme of the Outcome-based Education System applying blockchain technology including open framework design, network node construction and the related process of student evaluation record data is stored in form of blocks applying blockchain technology. This paper is beneficial research on blockchain technology in education services. However, blockchain technology still needs further research and implement in the field of education and other e-government services.

#### **References**

- [1] Chen, G.; Xu, B.; Lu, M.; Chen, N.-S. (2018). Exploring blockchain technology and its potential applications for education. *Article No.1 Smart Learning Environment*.
- [2] Duan, B.; Zhong, Y.; Liu, D. (2017). Education application of blockchain technology: Learning outcome and meta-diploma. *In Proceedings of the 2017 IEEE 23rd International Conference on Parallel and Distributed Systems (ICPADS)*, Shenzhen, China, 15–17 December 2017, pp. 814–817.
- [3] Li, T., Duan, B., Liu, D., Fu, Z. (2018). Design of Outcome-based Education Blockchain. *International Journal of Performability Engineering*, Vol. 14, No. 10, October 2018, 2403-2413.
- [4] Thinn Thu, N. (2019). Initiation of Blockchain Technology based Open Framework for e-Government Development in Myanmar. *Myanmar University Research Conference*, June 2019, Yangon.
- [5] Nespov, J. (2018) Cyber schooling and the accumulation of school time. *Pedag. Cult. Soc.* 2018, 1–17.

[11]

- [6] Farah, J.C.; Vozniuk, A.; Rodríguez-Triana, M.J.; Gillet, D. (2018) A Blueprint for a Blockchain-Based Architecture to Power a Distributed Network of Tamper-Evident Learning Trace Repositories. *In Proceedings of the 2018 IEEE 18th International Conference on Advanced Learning Technologies (ICALT)*, Mumbai, India, 9–13 July 2018; pp. 218–222.
- [7] Alammary, A., Alhazmi, S., Almasri, M., Gillani, S., Blockchain-Based Applications in Education: A Systematic Review. *Appl. Sci.* 2019, 9, 2400.
- [8] Liu, Q.; Guan, Q.; Yang, X.; Zhu, H.; Green, G.; Yin, S. (2018). Education-Industry Cooperative System Based on Blockchain. *In Proceedings of the 2018 1st IEEE International Conference on Hot Information-Centric Networking (HotICN)*, Shenzhen, China, 15–17 August 2018; pp. 207–211.
- [9] Bdiwi, R.; De Runz, C.; Faiz, S.; Cherif, A.A. (2018) A Blockchain Based Decentralized Platform for Ubiquitous Learning Environment. *In Proceedings of the 2018 IEEE 18th International Conference on Advanced Learning Technologies (ICALT)*, Mumbai, India, 9–13 July 2018; pp. 90–92.
- [10] Zhao, W.; Liu, K.; Ma, K. (2019) Design of Student Capability Evaluation System Merging Blockchain Technology. *Proc. J. Phys. Conf. Ser.* 2019, 1168, 032123.
- [11] Eyal I. Blockchain Technology: Transforming Libertarian Cryptocurrency Dreams to Finance and Banking Realities[J]. *Computer*, 2017, 50(9):38-49.
- [12] Palanivel, K. (2019) Blockchain Architecture to Higher Education Systems. *International Journal of Latest Technology in Engineering, Management & Applied Science (IJLTEMAS)*, Volume VIII, Issue II; pp. 124–138.

[12]