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Blockchain based Learning Management Platform for Efficient Learning Authority Management

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Abstract

As the demand for distance education increases, interest in the management of learners' rights is increasing. Blockchain technology is a technology that guarantees the integrity of the learner's learning history, and enables learner-led learning control, data security, and sharing of learning resources. In this paper, we proposed a blockchain technology-based learning management system based on Hyperledger Fabric that can be verified through permission between nodes among blockchain platforms. Learning resources can be shared differentially according to the learning progress. Also the percentage of individual learners that can be managed. As a result of the study, the superiority of the platform in terms of convenience compared to the existing platform was demonstrated. As a result of the performance evaluation for the research in this paper, it was confirmed that the convenience was improved by more than 5%, and the performance was 4-5% superior to the existing platform in terms of learner satisfaction.

Keywords: *Learning* Management Platform, Block-chain, Smart Contract

1. INTRODUCTION

With the recent advancement of technology for learning environments and various social issues, the market for remote education in South Korea is growing [1]. Despite environmental factors such as COVID-19, the demand for remote education continues to increase due to the convenience of the learning environment and the preference for non-face-to-face lectures even in the post-COVID era. According to the 2021 e-Learning Industry Report released by the Software Policy Research Institute in 2022, the demand for individual e-learning increased from 1.6682 trillion KRW in 2017 to 1.8133 trillion KRW in 2019. With the increase in non-face-to-face lectures due to COVID-19, it further grew to 2.3658 trillion KRW in 2020. In 2021, it showed a 10.2% increase compared to the previous year, demonstrating a high growth rate. The demand from businesses also increased from the 1.5 trillion KRW range in 2017-2019 to 1.6581 trillion KRW in 2020, showing an approximately 10% increase, and reached 1.8067 trillion KRW in 2021, indicating a 9.0% increase compared to the previous year [1]. Figure 1 shows that the e-learning market size continues to grow steadily from 2019 to 2021.

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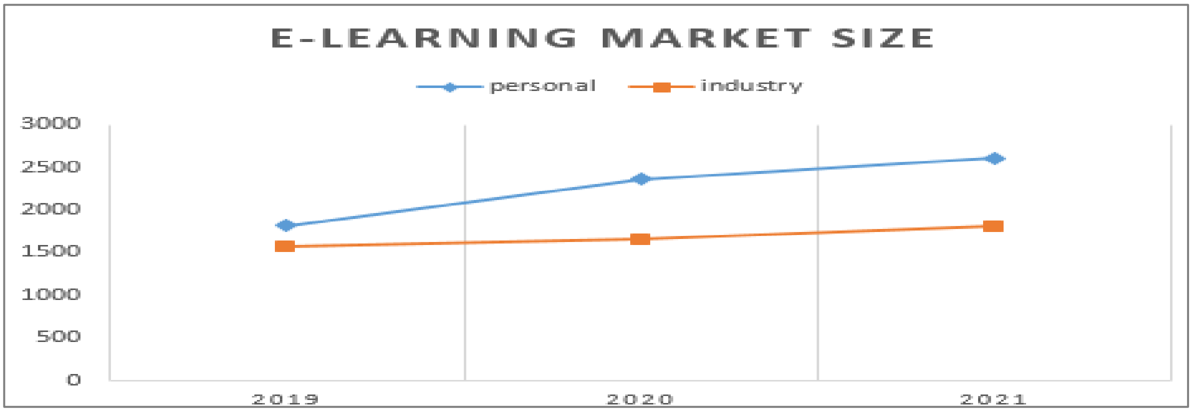

Figure 1. E-Learning market size

Remote education refers to an educational method in which instructors and learners do not directly meet face-to-face but conduct learning through mediums such as printed materials, broadcast materials, audio or video materials, and telecommunication networks [2, 3]. Remote education has the environmental advantage of being less affected by time and location, and it can be developed based on learner's initiative in terms of learning progress and repeatability. While remote education has been operated through cyber universities, credit banking systems, and distance education universities, since February 2022, it has also been approved and implemented in regular universities for online degree programs [3, 4].

Considering the continuous increase in demand for remote education due to social demands, it is necessary to ensure accurate management of various learning data, resource sharing among learners, and transparency in data sharing between learners and institutions. Recently, there has been a growing interest in learning platforms that securely manage individual learning in a distributed storage environment due to issues such as transparent management of learner's learning history, sharing of learning materials, and personal information [4, 5]. Blockchain technology is based on distributed ledger management, which enables multiple institutions within the same network to share data [6]. By applying blockchain technology to a learning platform, transparent and accurate management of the learning process, learning certification processes, and convenient and transparent learning management and records for learners can be achieved [6]. In this paper, we researched a blockchain-based learning platform as a method to enhance the efficiency of learning management, addressing the drawbacks of existing learning platforms such as third-party control of learning, security of learning data, and resource sharing [6,7].

The learning space used for remote education through online platforms is referred to as a learning platform [7-10]. The Learning Management System (LMS) is the learning platform used for remote education. LMS enables support and customization of learning between instructors and learners, and it can be categorized into open-source-based LMS, service-based LMS, and commercialized LMS [7-10].

Open-source-based LMS has the advantage of relatively low development costs and flexible utilization [7-10]. Examples of open-source-based LMS include Moodle, Sakai, and A-Tutor, among which Moodle allows user customization and intuitive interfaces. Service-based LMS has evolved to provide personalized education services [7-10], and it can be used for free, offering integrated learning services. Examples of service-based LMS include Google Classroom and Naver Edwith, which can tailor the learning process according to user demands. Commercialized LMS refers to customized LMS that can be connected through web services via Open API and allows module reconfiguration through Mash Up technology. Examples of commercialized LMS include Canvas and Blackboard Learn [7, 8]. Existing learning platforms each have their own advantages. From the perspective of learners, it can be observed that learner search, online guideline provision, automatic testing, and grading are possible. In most cases, when operating learning platforms, the operating institution stores learning data through servers or the cloud and controls most of the data required for learning. As a result, the learning platforms have a centralized management structure. To ensure the security of the various data stored in this manner, measures such as Single Sign-On (SSO) and Digital Rights Management (DRM) are included. However, since the storage is centrally managed by the operating institution, the top layer of the learning platform's hierarchy model is occupied by administrators, and access to learning resources is also managed through administrators [8, 9].

In this process, the management of shared learning resources and the transparency of learning history are unclear, especially regarding the characteristics of learning management driven by personal information and learner authority. From a data security perspective, it is necessary for learners to actively manage the data generated during learning and securely share the resources required for learning.

Blockchain is a distributed ledger technology in which all nodes connected to the same network share and verify data. It divides data into a series of blocks and connects them in a chain-like data structure through encryption. Through these characteristics, blockchain-based systems operate on trust rather than relying on third-party involvement, enabling the sharing of information [9]. The representative characteristics of blockchain are that it is possible to distribute and manage data without relying on a central server by using a distributed ledger, that it is possible to protect data using hash function and encryption technology, and to secure data transparency and reliability because all records are distributed and stored. It is possible, and through smart contracts, transaction efficiency and reliability can be improved by strengthening automatic verification and automatic execution of transactions [9].

Blockchain can be divided into two type [9]. Public blockchain, where anyone can participate and verify, and private blockchain, consisting of authorized users. Public blockchain, such as the widely known Bitcoin technology for cryptocurrency and the Ethereum platform for smart contracts, allows for automated transactions [9]. Private blockchain, on the other hand, includes prominent examples such as Hyperledger Fabric. Hyperledger Fabric is a private platform led by IBM, which separates membership, authentication, transaction verification, and execution roles within a network composed of authorized institutions [9, 10]. It employs various consensus algorithms to process transactions [11, 12]. Through this, it transparently verifies and guarantees transactions, as well as ensures trust-based protection of diverse data [10-12]. Example of applying blockchain technology to a learning platform is UnBlocked[13], a credit recognition and transfer system in universities within Arizona, USA.

Through UnBlocked, universities within the state exchange grades based on blockchain and simplify the documentation required for credit exchange, allowing certification through the system [13]. Through this platform, learners can search, purchase, and apply for desired courses by receiving tokens as compensation for various activities aligned with their learning plans. Many institutions and universities also provides education programs using a similar approach.

2. EXPERIMENTS

2.1 Modeling & Research Method

Blockchain technology is applied to a learning platform for remote education as follows. In this study, a method is proposed to manage learner metadata as blocks based on the learner's learning progress, distinguishing it from existing similar blockchain learning systems. By computing the learner's learning authorization based on their learning progress, the learner's authority can be strengthened. The blockchain platform applied in this proposed research. Figure 2 is the processing process proposed in this study and implemented through the Hyperledger Fabric platform.

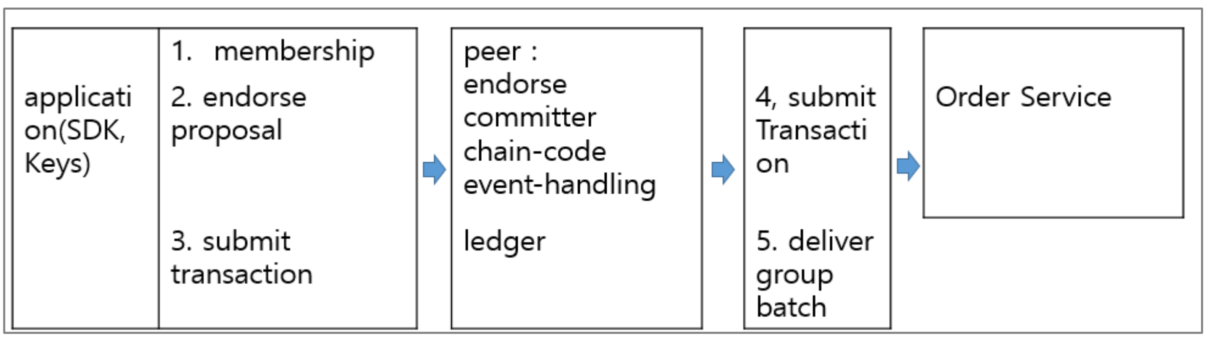

Figure 2. Processing steps

Table 1 shows the processing steps for managing learner authority based on their learning progress:

Table1. Pseudo code for managing learner authority

Creation of learner structure - Student ID, learning progress, weight
Calculation of individual learner's weight
Changing the allowance for self-data management in learner autonomy when the learner's learning progress is 50% or higher
- 50-60%: Assign weight (w) of 50%
- 61-70%: Assign weight of 60%
- 71-80%: Assign weight of 75%
- 81-90%: Assign weight of 85%
- 91% or higher: Assign weight of 100% or higher
Processing grouped learner-specific key data as metadata and passing it as parameters to smart contracts
Automatically grouping 1 to n (user-defined) groups through smart contracts and selectively storing the results in blocks
Managing learner autonomy and ensuring transparent authentication and processing of the learning process for each group.

In the above process, when the default parameter value is set to 1, a weight of 1 is assigned to a learning progress of 50%, and the default parameter value increases as the weight increases. However, in case of disruptions such as learning interruption, the parameter values are reset to their initial values. The authority for learner's learning authentication (A) and sharing their learning data (B) has been addressed, and the authorization for learner authority can be modified in the future. By using computations, individual learner's metadata can be automatically classified through smart contracts, and the classification results are managed in blocks. This allows distinguishing the degree of authority acquired for learning.

Table 2 shows the part of the code of the smart contract for the above processing steps.

Table 2. Pseudo code for smartcontract

```
struct Learner {
string studentId; // Student ID
uint256 progress; // Learning progress
uint256 weight; // Weight
... }
/// Function for managing learning authority of grouped learners
// Set storage for grouped learners and add function
function manageLearningAuthority(uint256 group) public {
uint256 totalWeight = 0; ..
// Calculate and process the total weight of learners in the group
for (uint256 i = 0; i < groupedLearners[group].length; i++) {
uint256 learningAuthority = (groupedLearners[group][i].weight * 100) / totalWeight;
...
// Conditional statements based on learningAuthority
}}
// Process grouped learners' information as metadata in the smart contract
function processGroupedLearnersMetadata(uint256 group, string memory metadata) public {
// Iterate through the list of learners in the group and process the metadata
// Reference the learner struct using Learner storage learner
```

3. RESULTS

To evaluate the proposed approach, we conducted quantitative analysis and surveyed learner satisfaction. The performance of the implemented system was measured using Jmeter to assess throughput. Additionally, to gauge learner satisfaction, we utilized the proposed system with 100 prospective online learners enrolled in programming courses from K institutions, and surveyed their satisfaction regarding learner authority-related aspects. For the experiments, we executed Jmeter with 8GB memory using VMWARE. Regarding Jmeter's thread properties, we set the Number of Threads (users) to 100, Ramp-Up Period (in seconds) to 1, and Loop Count to 20. We designated a sampler to ensure execution within one second for 100 threads, with each request repeating 20 times. For local testing, we specified the following settings: Protocol [http]: http, Server Name or IP: 127.0.0.1, Sampler: 2000, and Method: POST for the HTTP Request. When the evaluation environment was configured as such, the obtained results are depicted in Figure 3 of the summary report.

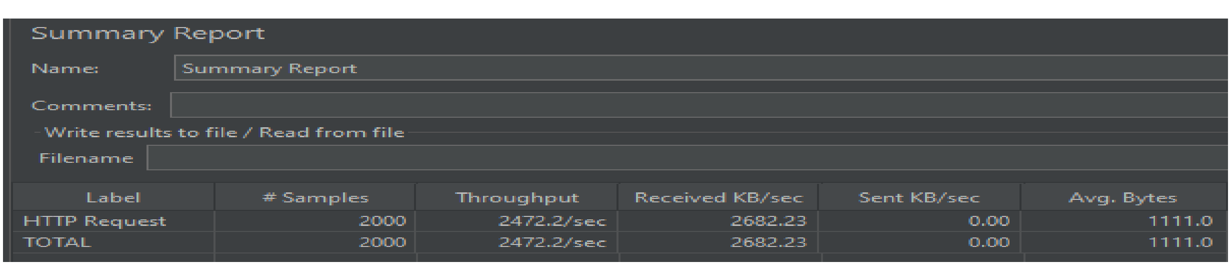

Figure 3. Jmeter screen

Based on the summary report, we calculate the Transactions Per Second (TPS). TPS can be calculated as Number of Threads / Average Response Time (milliseconds).

Given an average response time of 8.679 seconds, the average TPS is approximately 12 TPS, calculated as 100 / 8.679. The execution results for this particular setup are as follows.

Table 3. Performance evaluation result

samples	average(seconds)	Throughput(seconds)	Avg Bytes(bytes)
2000	8679	2472.2/sec	1111

In comparison to the average Transactions Per Second (TPS) of Hyperledger Fabric, the TPS of our research is relatively low. This can be attributed to the virtualized environment (VMWARE) utilized in this study and the complex computational processes involved in handling the dataset. To assess learner satisfaction regarding this research, we employed the proposed system during the learning process for 100 prospective online learners enrolled in programming courses from K institutions. For the satisfaction survey, we divided the participants into two groups based on their progress: a group with progress below 50% (t1-1) and a group with progress at or above 50% (t1-2) on the existing platform (t1). Similarly, on the proposed learning platform (t2), we divided the participants into the same two groups: below 50% progress (t1-1) and at or above 50% progress (t1-2). We then surveyed the participants on convenience (A), processing speed (B), and satisfaction with the learning platform (C) using a 0-10 scale.

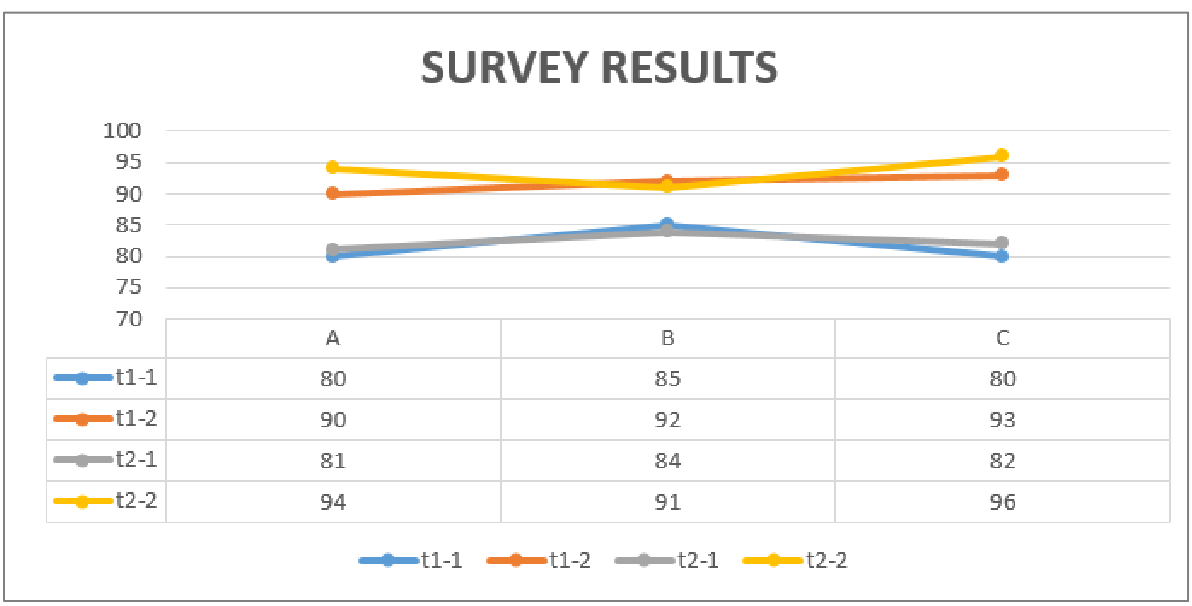

Figure 4. Survey results

4. Discussion

The survey results revealed that learners with low progress had approximately 4% positive responses in terms of convenience and around 2% positive responses in terms of satisfaction. On the other hand, learners with high progress showed approximately 5% positive responses in terms of convenience and around 3.4%

positive responses in terms of satisfaction. However, there were several negative responses regarding processing speed compared to the existing learning platform, indicating a need for improvement in processing speed. Furthermore, there is a requirement for research planning that considers a more diverse range of learning environments.

5. CONCLUSION

In this paper, we conducted research on a blockchain-based learning platform as a solution to address the drawbacks of existing learning platforms, such as third-party-driven learning control, data security, and resource sharing. The blockchain technology used in this study uses distributed ledger sharing technology to enable transparent data management and data security without third party intervention. In this study, a method for transparent data management of learners was presented by applying Hyperledger Fabric and smart contract technology to the learning system. Our research differentiates itself from similar blockchain learning systems by proposing a method to allocate learning authority differentially to learners based on their learning progress, managed through learner metadata stored in blocks. To implement this, we utilized the Hyperledger Fabric platform and applied smart contracts. We performed computations to increase learners' learning authority in cases of high learning progress, thus enhancing their motivation. Additionally, we ensured trust-based handling of learning data and individual learner sharing. For performance evaluation of our research, we conducted a study using Jmeter and assessed learner satisfaction. The results indicated an improvement of over 5% in terms of platform convenience compared to the existing platform, as well as an overall positive evaluation of 4-5% in terms of learner satisfaction. To enhance processing speed, we plan to focus on flexible code design and explore the possibility of applying various parameters in future research.

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