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Monitoring and Securing Learning in Educational Social Networks

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In the name of Allah, the Most Gracious, the Most Merciful, I humbly dedicate this work, guided by your divine light, which illuminates my path with every word penned and every idea expressed. With profound gratitude and reassurance found in the words of the Quran:

"And whoever fears Allah – He will make for him a way out and will provide for him from where he does not expect." (Quran 65:2-3)

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Abstract

Educational social networks are online platforms designed to foster learning and knowledge exchange. They provide a space where students, teachers, and experts can interact, share educational content, and collaborate on academic projects. These platforms play a crucial role in promoting online learning by creating dynamic virtual educational communities and facilitating access to various educational resources.

A major problem in educational social networks is to work in groups. It can be difficult to ensure effective grouping of students based on their interests, skill levels, or learning needs. This can lead to a less personalized and effective learning experience. Additionally, group management can be complex for teachers who must balance the diverse needs and skills of students within each group. It is essential to develop solutions to facilitate relevant and flexible student grouping in online learning environments. Furthermore, educational environments face significant data security.

To address these problems, we propose an approach that ensures: (1) Effective grouping where the system can develop grouping algorithms based on students' interests, skills, and learning needs using an Artificial Intelligence (AI) algorithm. Students and teachers can also play an active role by monitoring and adjusting groups as needed and (2) we propose solving the security issue using Blockchain technologies.

Keywords : Monitoring, Grouping, Securing, Blockchain, Educational social network.

Résumé

Les réseaux sociaux éducatifs sont des plateformes en ligne conçues pour favoriser l'apprentissage et l'échange de connaissances. Ils offrent un espace où les étudiants, enseignants et experts peuvent interagir, partager du contenu éducatif et collaborer sur des projets académiques. Ces plateformes jouent un rôle essentiel dans la promotion de l'apprentissage en ligne, en créant des communautés éducatives virtuelles dynamiques et en facilitant l'accès à des ressources éducatives variées.

Un problème majeur dans les réseaux sociaux éducatifs est le travail en groupe. Il peut être difficile de garantir un regroupement efficace des étudiants en se basant sur leurs compétences ou leurs besoins d'apprentissage. Cela peut conduire à une expérience d'apprentissage moins personnalisée et moins efficace. De plus, la gestion des groupes peut être complexe pour les enseignants qui doivent équilibrer les besoins et compétences divers des étudiants au sein de chaque groupe. Il est essentiel de développer des solutions pour faciliter la formation de groupes pertinents et flexibles dans les environnements d'apprentissage en ligne. Aussi, les environnements éducatifs sont confrontés à des problèmes significatifs de sécurité des données.

Pour résoudre ces problèmes, nous proposons une approche qui assure : (1) Un regroupement efficace basé sur les compétences et les besoins d'apprentissage des étudiants en utilisant un algorithme d'Intelligence Artificielle (IA). Les étudiants et les enseignants peuvent également jouer un rôle actif en surveillant et en ajustant les groupes selon les besoins, et (2) nous proposons de résoudre le problème de sécurité en utilisant les technologies Blockchain.

Mots-clés : Suivi, Regroupement, Sécurisation, Blockchain, Réseau social éducatif.

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General Introduction

Social networking activities have seen a significant increase, with more internet users joining these platforms. While social networking itself isn't new, its popularity is growing due to greater engagement in virtual communities and digital environments. In the realm of education, there's a rising acceptance of social networks to support classroom activities and learning tools across various settings. Educators see substantial value in incorporating social networks into learning environments, where ideas are shared, and important discussions take place. In the internet era, social media platforms such as blogs, Social Networking Sites (SNS), and forums have become popular hubs for fostering a new form of social capital known as virtual social capital. Consequently, SNSs have become a key focus in the study of computer-mediated communication and online social media research [12].

Educational social networks (ESN) face significant challenges, particularly in real-time student monitoring and data security. Monitoring involves tracking student engagement, analyzing behavior. On the data security part, safeguarding personal information, ensuring data integrity, securing communications, and managing access control are critical. These challenges necessitate the use of sophisticated technology, stringent policies, and ongoing oversight to ensure a safe and effective learning environment.

To address these problems, we propose developing a new platform with advanced functionalities to monitor learners by tracking their activities and analyzing their behavior. Additionally, to solve data security problem, we have introduced blockchain technology to ensure the secure storage and transmission of data. This innovative approach aims to provide a robust data security within educational social networks.

This thesis is organized as follows:

— **Chapter 1 - State-of-the-Art :** This chapter provides a comprehensive review of the current literature and existing technologies related to educational social networks (ESNs), real-time student monitoring, and data security. It highlights the key challenges and limitations in these areas.

— **Chapter 2 - System Design :** In this chapter, we outline our proposed approach to solving the identified problems. It includes a detailed description of the new platform's functionalities for tracking and analyzing learner behavior, as well as

the integration of blockchain technology to enhance data security.

— **Chapter 3 - System Implementation Presentation :** In this chapter, we showcase the developed system of the new platform. This chapter includes the platform's features, demonstrating how it monitors learners in real-time and secures data using blockchain technology. Screenshots and user interface descriptions are provided to illustrate the system functionality.

— **Appendix - Project Guide :** This appendix presents the different axes of the developed system: (1) Project presentation, (2) Innovative aspects, (3) Strategic Market Analysis, (4) Production and Organisation Plan and (5) Financial plan.

Finally, the thesis concludes with a summary and a discussion of future work.

Chapter 1

State of the art

1.1 Introduction

Educational social networks are platforms that facilitate learning and collaboration among students, teachers, and experts. These networks offer various tools for communication, content sharing, and group projects, fostering an engaging and interactive learning environment. However, they also face significant challenges, particularly in monitoring users and ensuring the security and privacy of user data.
Blockchain is a ground-breaking technology that offers creative and disruptive solutions in a number of industries in this dynamic environment. Among these industries, e-learning in particular has a lot to gain from the application of blockchain. Blockchain technology has gained significant attention across various industries for its potential to revolutionize traditional processes. In the realm of education, particularly in the domain of e-learning, blockchain offers promising opportunities to enhance security, transparency, and efficiency.
This chapter the use of the group formation in order to monitor learners and also the integration of Blockchain technologies in educational social networks to address security challenges. It is divided into two main parts: an overview of educational social networks and the second part for the state of the art about group formation and Blockchain technologies.

1.2 Educational social networks

In this section, we present the educational social networks starting with their different definitions.

1.2.1 Social Networks Definition

There are several definitions of social networks, where each definition differ from another one based on the system objectives.

A social network is "*an online platforms for creating, disseminating, and interacting with user-generated content within virtual communities*" [36]. In 2024, social media was defined as follows "*It describes a digital technology that facilitates the exchange of ideas, information and thoughts through virtual networks and communities*" [15]. Also, social networks can be considered as "*Internet-based channels that allow users to opportunistically interact and selectively self-present, either in real-time or asynchronously, with both broad and narrow audiences who derive value from user-generated content and the perception of interaction with others*" [15].

1.2.2 Educational Social Networks Definition

Educational social networks has been defined as "*Learning that based on the use of Information and Communication Technologies (ICT) to improve the quality of teaching and learning. EdTech is experiencing great development at different educational levels worldwide*" [34]. Also, Firat defined EducSN As "*An software platform used to deliver and manage online learning content and experiences. are used by educational institutions, businesses, and other organizations to provide online learning opportunities to students and employees*" [9]. In another defintion, ESN refers to "*The use of electronic technologies to facilitate education at higher education institutions, adopted as an alternative to traditional face-to-face education. ESN systems rely on digital platforms to deliver educational content and support interaction between students and instructors*" [4].

1.2.3 Some Educational Social Networks

Educational social networks are platforms designed to facilitate collaboration, communication, and resource sharing among students, educators, and institutions. Here are some different platforms that serve these purposes:

- Edmodo : A social learning platform for teachers, students, and parents. It offers classroom communication, assignment distribution, and grading, with a social media-like interface [W1].

- Google Classroom : Part of Google's G Suite for Education, it integrates with other Google services to help manage coursework, create assignments, provide feedback, and foster communication [W2].

- Schoology : A learning management system (LMS) that offers tools for managing and sharing academic content. It includes features like gradebooks, attendance tracking, and analytics [W3].

- Moodle : An open-source LMS that supports customizable management of courses, content, and communication. It's widely used in educational institutions for its flexibility and extensive plugins [W4].

- ClassDojo : A communication platform for teachers, students, and parents, focusing on building classroom communities. It includes features like student portfolios, behavior tracking, and messaging [W4].

- Microsoft Teams for Education : Part of Microsoft's Office 365 suite, it provides tools for collaboration, communication, assignments, and integration with other Office apps [W5].

1.2.4 Educational Social Networks Advantages

- Enhanced Learning: Social media platforms make it easier for students to exchange information, collaborate on projects, and engage in discussions. By connecting with peers and educators, students can enhance their learning experiences [31].

- Information Sharing: Students can quickly share not only personal opinions but also valuable study materials and resources through social media. This facilitates knowledge exchange and supports collaborative learning [W6].

- Supporting Research: Social networks provide a platform for students to explore research topics, discover relevant articles, and connect with experts in their field. This can enhance their understanding and contribute to academic growth [W7].

- Blogs from Educators: Many educators use social media platforms to share insights, teaching strategies, and educational resources through blogs. These blogs can serve as valuable learning tools for students [W6].

- Professional Collaborations: Social media encourages networking and collaboration among educators, researchers, and professionals. It promotes cross-cultural teamwork, project management skills, and global connectivity. [W7]

1.2.5 Educational Social Networks Challenges

Educational social networks has several challenges, we cite:

1. **Difficulty of Work in Groups** The students have a problem to Organize groups which pose a major problem between members where they exist ones may contribute less, causing an imbalance in group work and affecting overall group performance. Furthermore, the lack of effective communication tools can hinder collaboration.
2. **Problem of Data Security** Protecting sensitive personal and educational data from unauthorized access and breaches. Also, other risks from cyber attacks, such as hacking, phishing, and malware.

3. **No Information Available About Learners' Engagement and Performance** This absence of information makes it challenging to assess student participation, progress, and areas needing improvement.
4. **No Display of Updating News and Educational Resources** The limitation can hinder the timely dissemination of important information and learning materials to students, impacting their learning experience and access to resources.

1.3 Used techniques

In this section, we present the used techniques in this work including solution of the problem of monitoring learners and also the problem of the security of data.

1.3.1 Group Formation for monitoring students engagement

In both online and face-to-face teaching environments, the formation of student groups is a crucial factor influencing the success of collaborative learning. It is important to consider both the number of participants and their diversity. Effective groups should consist of at least three members, with four or five members being ideal for optimal results [21].

several works are made in the field of group formation to achieve different objectives such as: prediction of student performance, Monitoring students engagement, assessment online learning in order to improve student learning. we present in this section the recent related works of group formation.

In 2021, the authors [21] focus on enhancing collaborative learning outcomes in online courses by developing an intelligent Moodle plugin. Traditional e-learning platforms often use random group formation, which may not optimize learning due to varying student capabilities. The project introduces a novel plugin using machine learning to create heterogeneous student groups. It employs clustering algorithms on Moodle data to identify similar behavior patterns among students, forming homogeneous groups. These groups are then combined to create heterogeneous groups, aiming to improve collaborative performance. The plugin enables teachers to easily create these groups, potentially enhancing student success in online group activities across various disciplines. Also, The authors [29] introduces the Learner Performance based Behavior (LPB) algorithm, inspired by the process of transitioning high school graduates to university and optimizing their study behaviors. LPB integrates phases of exploitation and exploration akin to metaheuristic algorithms, improving learner study levels by mimicking educational transitions and enhancing study skills. In another work, the authors [32] propose an approach to assess the impact of the Covid-19 pandemic on online learning outcomes in statistics and probability courses compared

to traditional offline methods. It employs k-means and fuzzy C-means clustering algorithms to categorize students based on their performance across attendance, assignments, midterm exams (UTS), and final exams (UAS), aiming to identify patterns and differences in learning effectiveness between online and offline educational settings. Ramos and his colleagues [30] studied the Forming effective student groups in distance education is challenging ited in-person interaction. This study proposes an automated approach to assist teachers in recommending student groups for LMS using learning paths (LPs) and the k-means algorithm with Euclidean, Manhattan, and cosine distance metrics. The developed framework, validated through the M-Cluster tool, facilitates group formation by characterizing learners based on LPs. The authors [11] proposes a novel methodology for dynamic group formation in Computer-Supported Collaborative Learning (CSCL) environments, focusing on students' learning styles and knowledge levels. The methodology features an activity-based dynamic group formation technique where students are swapped into clusters based on their knowledge levels after each activity. The formed heterogeneous groups are integrated with the Intelligent Tutor Collaborative Learning (ITSCL) platform, providing a real-time collaborative learning environment. An experiment was conducted to evaluate the methodology's effectiveness. The results demonstrate that balanced groups yield better outcomes than random or individual learning approaches. The authors [17] introduces an intelligent system designed to assist teachers in efficiently organizing group work in educational environments. Featuring a parameter setting module and a visualization panel for group member results, the system applies algorithms to learning log data to simplify and expedite group formation. A pilot study conducted in a primary school mathematics class demonstrated positive outcomes, indicating improved student engagement and interaction facilitated by system-generated groups. This empirical evidence supports the effectiveness of Computer-Supported Collaborative Learning (CSCL) systems in enhancing educational practices. The system's novel approach integrates multiple algorithms and synchronized data sources, offering a versatile solution for diverse educational contexts and contributing to advancements in CSCL research and practice.

In 2022, Pillai [27] presents an automated method using Natural Language Processing (NLP) to group students based on shared interests extracted from their personal narratives. Each student composed several stories, and the Rapid Automatic Keyword Extraction (RAKE) algorithm, an unsupervised and language-agnostic technique, was employed to identify key phrases. These phrases were used to cluster students, aligning groupings with their interests to enhance collaborative learning. The study demonstrates the feasibility of RAKE in educational settings, potentially increasing engagement and streamlining the group formation process by reducing subjective bias. The method's effectiveness depends on the quality of the narratives and cultural nuances, and future work will address scalability and dynamic interest changes.

In 2023, the authors [8] introduce FairFed, a novel algorithm for fairness-aware aggregation in federated learning, aiming to enhance group fairness across demographic groups while preserving data privacy. They demonstrate FairFed's effectiveness compared to standard fair ML and federated learning approaches, particularly under diverse data distributions across clients.

Table 1.1 presents the summary of the related works on group formation in different environments.

Authors	**Objective**	**Algorithms Used**
[21]	Develop a Moodle plugin to automatically form heterogeneous student groups using machine learning, aiming to optimize collaborative learning outcomes in online courses.	- K-means - Mean-Shift Clustering - Agglomerative Clustering - DBSCAN - Gaussian Mixture Models Clustering - SOM
[29]	Develop a novel metaheuristic algorithm inspired by the process of transitioning graduated learners from high school to university and improving their studying behaviors.	Metaheuristic optimization techniques , LPB algorithm
[32]	Analyzing Covid-19's impact on online learning outcomes in statistics and probability courses using clustering algorithms for student performance.	K-Means, Fuzzy C-Means
[30]	Develop and validate an automated approach for recommending student groups in learning management systems.	k-means
[11]	Propose a novel methodology for dynamic group formation in Computer-Supported Collaborative Learning (CSCL) based on students' learning styles and knowledge levels.	Intelligent Tutor Collaborative Learning (ITSCL)
[17]	This research aims to develop and implement an intelligent system for optimizing group formation in educational settings.	Homogeneous and heterogeneous algorithms

[27]	Develop an automated method using the RAKE algorithm to group students based on shared interests extracted from their personal narratives, enhancing engagement in collaborative learning.	RAKE algorithm
[8]	Develop FairFed to improve group fairness in federated learning by addressing bias across demographic groups while ensuring data privacy.	FairFed

Table 1.1 – Summary of related works on Group Formation

From the table 1.1, we observe that:

— The use a variety of methodologies and algorithms aimed at optimizing collaborative learning outcomes and improving educational practices.
— The use of different group formation techniques to solve the different problems of educational environments.

1.3.2 Blockchain for securing Educational environments

This section presents the blockchain technology where blockchain definitions, components, types, characteristics and application area are given.

Blockchain Definition

In 2017, Nofer and his colleagues [23] defined Blockchain as " a chain of digital blocks that contain data. The data chain is formed so that each block is inextricably linked to the previous block, through cryptographic methods. Thus, if someone attempts to make a change to a block, all the following blocks must be changed in order for the chain to remain valid, otherwise all blocks after what has changed will be invalid."

In 2019, a blockchain is defined as “having the potential to transform the global economy due to its ability to increase transparency and trust. A blockchain is a distributed digital ledger of transactions, the contents of which are verified and agreed upon by a network of independent actors. Transactions are recorded in a series of blocks that gives a clear timeline of who did what and when. Blocks of information (time stamping of life events) are secured by complex algorithms that are hard to hack and cannot be manipulated."[25].

In 2020, the authors [35] defined Blockchain as "a term in the field of information technology. In essence, it is a Shared database of data or information that is “not falsifiable,” “traces,” “open and transparent,” and “collective maintenance”. Based on these characteristics, blockchain technology has laid a solid foundation of “trust,” created a reliable “cooperation” mechanism, and has a broad application prospect.". Also, the authors [2] considered Blockchain as "a distributed digital record of transactions. The terminology comes from its setup structure where blocks are connected to each other chronologically. These blocks are linked together with each other, and in accordance with the implemented consensus protocol, in a single list which is called a chain. The current implementation of blockchains is now seeing in recording cryptocurrencies transactions. The notion of decentralization is a core component; hence, any involved transactions cannot be altered without the alteration of all concurrent blocks. The key characteristics of the blockchain include decentralization, persistence, anonymity, and audibility."

In 2021, the authors [33] defined Blockchain as "a Peer-to-Peer, decentralized, distributed ledger that records transactions efficiently, and in a verifiable and robust fashion. Blockchain is a transaction where we store the database records that is distributed, validated and maintained around the world by a network of computers. Blockchain Technology is a new generation and innovative internet that is absolute, transparent, dispersed, auditable, determined, and secured. Multiple parties share using this technology in the distributed database, and it is trustable. Each party shares a personal copy of the database in the networ transactions. This technology is tamper-proof and has automatic trust with transparent and resilient features.

Blockchain Components

Blockchain technology can seem complex. However, it can be simplified by examining each component individually. The main components of blockchain are cryptographic hash functions, transactions, asymmetric-key cryptography, addresses, ledgers and blocks [25].

• **Cryptographic Hash Functions -** An important component of blockchain technology is the use of cryptographic hash functions for many operations. This component calculates a relatively unique output for an input of nearly any size (e.g., a file, text, or image). It allows individuals to independently take input data, hash that data, and derive the same result proving that there was no change in the data.

• **Transactions -** A transaction represents a transfer of the cryptocurrency between blockchain network users. Each block in a blockchain can contain zero or more transactions. A blockchain network user sends information to the blockchain network. The information sent may include the sender’s address, sender’s public key, a digital signature, transaction inputs and transaction outputs.

• **Asymmetric-Key Cryptography -** It uses a pair of keys: a public key and a private

key. Asymmetric-key cryptography enables a trust relationship between users who do not know to each other, by providing a mechanism to verify the integrity and authenticity of transactions while at the same time allowing transactions to remain public. In contrast, symmetric-key cryptography in which a single secret key is used to both encrypts and decrypt. The data is encrypted with symmetric key cryptography and then the symmetric-key is encrypted using asymmetric-key cryptography.

• **Addresses and Address Derivation -** Blockchain networks make use of an address along with some additional data (e.g., version number and checksums). The blockchain implementations make use of addresses in a transaction. To generate an address, it creates a public key, applying a cryptographic hash function to it, and converting the hash to text. Addresses may act as the public-facing identifier and oftentimes an address will be converted into a QR code for easier use with mobile devices.

• **Ledgers -** A ledger is a collection of transactions. In modern times, ledgers have been stored digitally, often in large databases owned and operated by a centralized trusted third party (i.e., the owner of the ledger) on behalf of a community of users. These ledgers can be implemented in a centralized or distributed fashion. There is growing interest in exploring having distributed ownership of the ledger. The growing interest in distributed ownership of ledgers is due to possible trust, security, and reliability concerns related to ledgers with centralized ownership.

• **Blocks -** Blockchain network users submit candidate transactions to the blockchain network via software. The software sends these transactions to nodes (non-publishing full nodes as well as publishing nodes) within the blockchain network. The submitted transactions are then propagated to the other nodes in the network. Transactions are added to the blockchain when a publishing node publishes a block. A block contains a block header and block data. The block header contains metadata for this block. The block data contains a list of validated and authentic transactions, which have been submitted to the blockchain network. The other full nodes will check the validity and authenticity of all transactions in a published block.

• **Chaining Blocks -** Blocks are chained together through each block containing the hash digest of the previous block's header. If a previously published block were changed, it would have a different hash. This, in turn, would cause all subsequent blocks to also have different hashes since they include the hash of the previous block. This makes it possible to easily detect and reject altered blocks.

Blockchain Types

Blockchain Technology is classified into mainly three categories (as Public blockchain, Private blockchain and Federated blockchain) as it is mentioned in Table 1.2.

• **Public blockchain:** is the standard blockchain Network that is open to all and there is no centralized management. Here anyone can access the network and participate in reading, writing and audit the blockchain. It is a fully decentralized permission

Blockchain	Public	Private	Federated/Consortium
Access	Anyone	Single Organization	Multiple Selected Organizations
Participants	Permissionless and Anonymous	Permissioned and Known Identities	Permissioned and Known Identities
Security	Consensus Proof-of-Work Proof-of-Stake	Pre-approved Participants Voting-Bases Consensus	Pre-approved Participants Voting-Bases Consensus
Transaction Speed	Slow	Lighter and Faster	Lighter and Faster

Table 1.2 – Types of Blockchain

less and open source system means anyone create, validate and view transactions at a given point of time. To validate transactions decision making happen by consensus algorithms like Proof-of-Work or Proof-of-Stake. Bitcoin and Ethereum are the well-known examples of a Public blockchain.

- **Private blockchain :** is a type of blockchain where an incharge of the network can read, write and audit the blockchain. The central incharge can also provide permissioned access to selected nodes to make validate and view transactions at specified point of time only. As it is an essential Private consensus is a achieved at the discretion of the central incharge go through a voting and multi party consensus algorithm. Hyperledger Fabric is the well-known example of a Private blockchain.
- **Consortium or Federated blockchain:** is a group owned system and Permissioned blockchain where an autonomy is removed. In this type of blockchain, there is more than one central incharge who will provide access to pre-selected nodes to read, write and audit the blockchain. Consensus is achieved by members of the consortium through a voting and multi party consensus algorithm based on the agreement of the participants. R3's and Corda blockchain are the well-known examples of a Consortium or Federated blockchain [6].

Smart Contract Concept

It is a computer program on the blockchain, which contains the terms of the agreements between two or more peers, and can be executed in an automatically and safe way [5]. The smart contracts receive as input a series of conditions that remain constantly monitored and when they are met, the contract executes itself. The whole process is automated and can be totally virtual or mixed, as a complement to paper-based contracts. Hence, the smart contract strengthens and facilitates the negotiation and

performance of a contract. They are divided in three steps [20]:

Step 1. Codification Initially, the contract is coded in a programming language. In the code, instructions that the contract must execute are carefully defined and must be in accordance with the interest of the parties.

Step 2. Submission to the blockchain After encoding, the code is encrypted and sent to other computers via blockchain. This occurs in a similar way to cryptocurrencies transactions.

Step 3. Execution The blockchain receives the code and processes it on one of its nodes. The network then updates the registries so that all nodes contain the results of the contract processing. The contract is then monitored by the network.

Principle of Blockchain working

A blockchain is a tamper-proof, shared digital ledger, which records transactions in either a public or a private network. As it is distributed to all participants in the network, the ledger makes a permanent record as blocks. Each computer on the network is known as a "node". Instead of relying on a third party, such as a financial institution, to mediate transactions, participants in a blockchain network use a consensus protocol to agree on ledger content, and cryptographic hashes and digital signatures to ensure the integrity of transactions [25]. Figure 1.1 shows the principles of blockchain working.

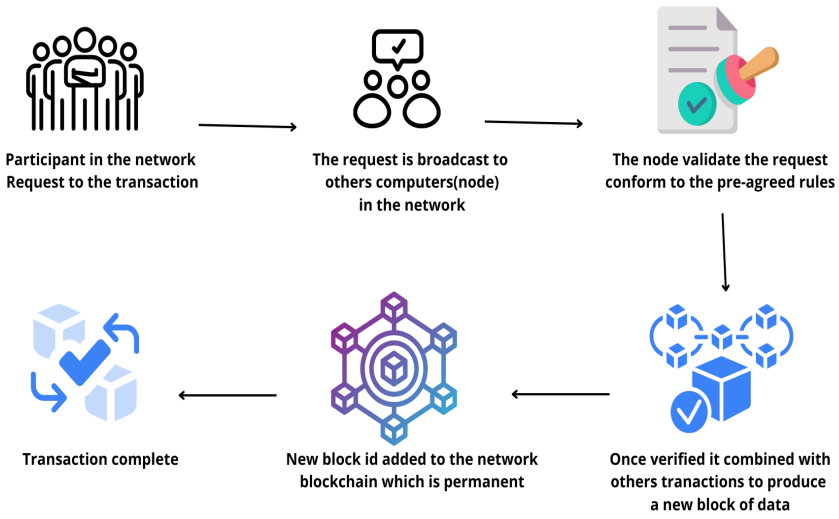


Figure 1.1 – Principles working of blockchain technology.

The peer-to-peer blockchain network prevents any single participant or group of participants from controlling the underlying infrastructure or system. Participants in the network are all equal, adhering to the same protocols. At its core, the system records the chronological order of transactions with all agreeing to the validity

of transactions using the chosen consensus model. The result is transactions that are irreversible and agreed by all participants in the network.

Blockchain Characteristics

The blockchain technology can provide a secure chain of custody for both digital and physical assets through its functional characteristics that facilitate transactions through trust, consensus, security, and smart contracts. The blockchain technology generally has key characteristics of decentralization, persistency, anonymity and auditability.

•**Decentralization:** In conventional centralized transaction systems, each transaction needs to be validated through the central trusted agency (e.g., the central bank), inevitably resulting in the cost and the performance bottlenecks at the central servers. Contrast to the centralized mode, the third party is no longer needed in the blockchain.

• **Persistency:** Transactions can be validated quickly and honest miners would not admit invalid transactions. It is nearly impossible to delete or rollback transactions once they are included in the blockchain. Blocks that contain invalid transactions could be discovered immediately.

•**Anonymity:** Each user can interact with the blockchain with a generated address, which does not reveal the real identity of the user.

• **Auditability:** Bitcoin blockchain stores data about user balances based on the unspent transaction output (UTXO) model. Once the current transaction is recorded into the blockchain, the state of those referred unspent transactions switches from unspent to spend. Therefore, transactions could be easily verified and tracked. With the above traits, blockchain can greatly save cost and improve efficiency.

Blockchain Application Area

Blockchain nowadays describes solutions and approaches that make blockchain technology usable to business demands. The benefits to business can be many, such as improving transaction's security, managing digital relationships, eliminating intermediaries, and tracking and tracing products with supply chain and ERP integration. Industries ranging from financial services, healthcare to retail are some to mention that are benefiting from these aspects [6]:

•**Financial:** services lead the initiatives on blockchain application as expected. But, for other areas, its applicability maybe not easily understood [14].

•**Healthcare:** Patient's data such as age, gender, and basic medical history data like immunization or data signs are all eligible for blockchain recording. None of this information could help identify any particular patient, so it could be shared and accessed by numerous individuals without violating any privacy concerns. These data, collected by medical devices, could be stored on a healthcare blockchain and append

it to personal medical records. A key issue currently facing connected medical devices is the isolation of the data generated, but the blockchain could be solution for this.

•**Supply Chain Management:** Blockchain provides a new dynamic means of organizing tracking data and putting it to use. Its immutable ledger makes it perfect to perform tasks such as real-time tracking of goods as they move from depart to destination. Therefore, no unauthorized person can change, manipulate, or erase the data.

•**Media:** Eliminate fraud, reduce costs, and protect Intellectual Property rights of content are some of the usability of blockchain in this sector. By eliminating intermediaries, the exchange of the content among developers, publishers, and end-users at a reasonable cost can be streamlined.

•**Gaming:** Gamers can collaborate and make secure transactions using blockchain. They can start generating revenue by reselling their in-game amenities to other players. The gaming market in 2021 reached 175.8 dl Bn in revenue [14], and this in-game services/components are gaining attention more than ever.

•**Energy:** Energy supply transactions, providing the bases for metering, billing, and clearing processes, are all usable ways for blockchain in the energy sector according to PwC [6]. Other potential applications include documenting ownership, asset management, emission allowances, and renewable energy certificates

Related Works: Blockchain in E-learning systems

In this study, the authors [16] focus on validating digital certificates issued to participants of the Turkish stage of the International Informatics and Computational Thinking event through an Ethereum blockchain-based smart contract. The event assignments were delivered to students in Turkey using the Moodle learning management system. The research involved the development of a smart contract to securely store certificate information on the Ethereum blockchain, facilitating verification when required. In addition, an existing certificate module in the Moodle Learning Management System was updated to comply with the Ethereum blockchain smart contract.

The authors [24] explores the application of blockchain technology to improve the quality of e-learning materials and platforms, drawing attention to the benefits of security, faster transactions, reduced costs, anonymity and data integrity associated with blockchain. The research develops a model based on the funnel e-learning model, leveraging blockchain's capabilities, and explores how it can improve the quality of education. The research identifies challenges in existing e-learning systems and refines the model through structured equation modelling. The resulting model provides valuable insights for learning institutions looking to implement or enhance e-learning, and shows where blockchain can be used to improve education.

The authors [25] proposes a blockchain-based architecture for higher education learning solutions, called the Proof of Educational Transcript System (PETS). PETS is a decentralised system that stores student transcripts on a global network of comput-

ers. This makes it tamper-proof and accessible to students and employers anywhere in the world. PETS offers a number of advantages over traditional higher education data management systems, including security, transparency, efficiency and portability. PETS is still in the early stages of development, but it has the potential to transform the way student transcripts are issued and managed, and to lead to new and innovative ways of delivering and recording educational achievement.

The authors [22] have proposed the use of blockchain and Merkle tree structure to improve user profile-based authentication in e-learning systems. Their proposed MB-PBA framework aims to provide a secure method for storing user profiles and an efficient authentication process, ultimately improving the existing PBA framework. This framework not only enhances data security and integrity for user profiles, but also mitigates identity misuse, a significant challenge in e-learning systems. Preliminary experiments and evaluations indicate the feasibility of the MB-PBA.

The authors [18] built a blockchain-dependent mechanism for assessing the overall condition of students. The smart contracts, the interplanetary file system (IPFS), and the web service are used to guarantee that information movement is effective, secure, and consistent in this system, which combines "on-chain and off-chain" data. They presented a network infrastructure centered on an education consortium blockchain, in which they developed a blockchain data structure and preservation framework to make learners' quality evaluation data more accessible. Furthermore, a data flow framework is being developed for the secure transfer and authentication of student data, combining the benefits of the RBFT-based hyper chain consortium blockchain with classical data permanence. The system is then built using the microservices fram.

The authors [13] proposes to combine E-Learning with AI and Blockchain technologies to improve security and efficiency. The authors discuss the potential and challenges of applying these technologies to E-Learning in Vietnam. They also propose to combine independent testing models integrated with AI and Blockchain into the same smart E-Learning system.the authors argue that E-Learning is an inevitable trend in the future. They believe that AI and Blockchain technologies can help to improve the efficiency and explicitness of training. However, they also acknowledge that there are challenges to integrating these technologies with E-Learning.

Cheriguene and his colleagues [1] introduced a novel online teaching and assessment (NOTA) technique, which uses blockchain technologies to ensure the desired quality of education and assessment integrity while adhering to the course and examination schedules. Furthermore, NOTA use blockchain's incentive systems to encourage both teachers and students to persevere in their objectives, even if they work remotely. The preliminary findings from the Coronavirus era revealed a much higher satisfaction rate of more than 90 . This made them quite hopeful about the proposal's possibilities when implemented on a bigger scale.

In this research, the authors [3] developed a trust-based blockchain system for

evaluating students in e-learning. Their system uses smart contracts to manage assessments and courses, increasing transparency and trust in the process. They also discussed adaptive access control on an authorised blockchain in the context of e-learning. To increase trust, they introduced an encryption method called Improved Elliptic Curve Cryptography Algorithm (IECCA). Their system provides increased security compared to existing methods, and increased trust through their algorithm. Overall, their approach results in highly secure data transmission, faster execution and reduced energy consumption.

The authors [19] propose a digital brick platform that uses blockchain and open badge technology to provide a secure, transparent and open certification system for students. The platform also includes a novel machine learning-based recommendation system that helps students find the right learning materials and learning pathways. they argue that their platform is the first to use the Ethereum blockchain and reinforcement learning to improve the competency certification process in education. They also report that their platform achieved better transaction latency and throughput than the Ethereum single node blockchain, and better prediction accuracy when measuring MAE and RMSE indices.

Dias [7] addresses challenges in remote assessment within higher education institutions (HEIs), specifically focusing on mitigating plagiarism and fraud. In the context of the Covid-19 pandemic, which has prompted a shift to alternative teaching methods using Information and Communication Technologies (ICT), the research highlights the crucial role of remote assessment due to health security concerns. The identified challenges include fraud and plagiarism in remote assessments, and the proposed solution involves a technological framework incorporating plagiarism detection tools, digital signature principles, and blockchain. The objective is to enhance information security and reliability in distance learning assessments within HEIs. The thesis emphasizes the importance of authenticity and reliability in remote assessment systems, underlining the need to address potential fraud risks. The integration of blockchain is highlighted for promoting the integrity and immutability of academic documents, contributing to ongoing efforts to improve assessment processes in distance learning.

Panagiotis [26] explores the applications of blockchain technology in education, with a specific emphasis on language learning. It highlights the need for secure data flow in the context of technological developments like 5G networks and IoT, identifying blockchain as a crucial solution. The paper discusses diverse applications of blockchain in education, covering areas such as certificate issuance, academic degree management, intellectual property protection, and more. While recognizing the benefits of transparency and security, it also acknowledges challenges like scalability and regulatory concerns.

Zhao and his colleagues [37] explores the intersection of blockchain and online learning, focusing on sustainability. the study identifies thematic clusters, highlighting

the importance of standardized practices in online learning facilitated by blockchain. Key findings include the potential to understand learner behavior patterns, validate achievements through blockchain-based digital badges, and the overall empowerment of education by ensuring authenticity, security, and trust through blockchain integration. The research significantly contributes to ongoing discussions on leveraging blockchain for sustainable and effective online education.

The research goal [28] is to create a configurable voice recognition system with automatic login authentication, improving efficiency among organizations by bringing more utility and customs. The user's voice must be considered while choosing the job to be processed. The project's fundamental duties can be divided into three modules: creating a voice assistant-friendly environment with necessary packages and APIs; creating functionality for the package and APIs using Python; and building new features using automation tools.

Table 1.3 presents the summary of the related works of the use of Blockchain technologies in educational systems.

Ref	**Field(s)**	**Research Object**	**Actor**	**Technologies Used**
[16]	Security	Verify digital certificates during the Turkish stage of the International Informatics and Computational	Students	Ethereum Blockchain, Smart Contract
[22]	Security	Enhance user profile-based authentication in E-Learning systems	Student	Blockchain, Merkle tree structure
[24]	Security	Development of a blockchain-based e-learning model to enhance the quality of educational materials	Students	Blockchain technology, Structured equation modeling
[25]	Security	Blockchain-based architecture for higher education learning solutions	Students, Employers	Blockchain
[18]	Evaluation Security	Use blockchain technology for secure assessment of student performance	Student	Blockchain, Smart Contract, Interplanetary File System (IPFS), Web Service
[3]	Evaluation	Enhance trust and security in student performance assessment in e-learning	Student	Improved elliptic curve cryptography algorithm, Blockchain technology
[13]	Security	Potential and challenges of applying AI and Blockchain technologies to develop E-Learning applications in Vietnam	Students, Teachers, Administrators	AI, Blockchain

[1]	Evaluation	Develop a novel online teaching and assessment scheme using blockchain technology to ensure the quality of education and assessment integrity	Students, Teachers	Blockchain
[19]	Security	Improve student experience in online education and certification with the Digital Brick platform	Students	Blockchain technology, Open badge systems, Machine Learning, Ethereum Blockchain
[26]	Security	Discuss the applications of blockchain technology in the field of education	Students	Blockchain technology, Open badge systems, Machine Learning, Ethereum Blockchain
[7]	Security	Address the challenges of remote assessment in higher education institutions (HEIs), particularly	Students	Block Chain, Degital signature, Plagiarism Detection Tools
[37]	Security	Explore the intersection of blockchain technology and online learning within the context of sustainability.	Students	Blockchain technology, Open badge systems, Machine Learning, Ethereum Blockchain
[28]	Security	Revolutionize education through the automation of manual processes using electronic tools and computer programming.	Students, teachers	: Voice Assistant, API, AES, Cryptography, Learning 4.0

Table 1.3 – Summary of research on blockchain in e-learning

From the table 1.3, we conclude that:

— The related works have used blockchain technologies to enhance security and to evaluate students.

— Various technologies like Ethereum Blockchain, Smart Contracts, and advanced cryptographic methods are utilized to achieve these goals.

1.4 Conclusion

The educational social network are environments where learners can interact and communicate with each other, share resources, etc. In this chapter, we have presented state of the art into two parts : (1) Educational Social Networks and (2) the used techniques. In the first part, ESN definition, platforms, advantages and challenges are given. While, in the second part we

present an overview about group formation and Blockchain technologies.

Chapter 2

System design

2.1 Introduction

After exploring the state of the art and current technologies in the field, it is time to move on to the design of our system. This chapter is dedicated to defining and developing the various components of our solution. We will describe the the various objectives of the system. Then, we present the Global and functional architecture of the system where a detailed presentation of the system's overall structure and the specific functionalities of each component is given. Also, we present the database structure where the organization and schema of the data that will be managed by the system is presented.

2.2 System objectives

To solve the problems of monitoring, assessing ans securing education social networks, we have designed Safe Learn system. The latter has various objectives:

— Grouping of students in order to react to and solve given problems

— Taking exams

— Securing student data, including exam grades and projects.

— Profile updates

— Sharing of courses, statuses, and tests

— Reaction to shared statuses (like, comment, share)

— User, page, and group search

— Creation and joining of groups and pages

— Organization and participation in events

— Tracking learners

— Visualizing learners traces

2.3 System Architecture

The Safe Learn system has two architectures: one presenting the main interfaces ('the global architecture') and the other presenting the functionalities ('the functional architecture'):

2.3.1 Global System Architecture

Figure 2.1 presents the global architecture of the Safe Learn system.

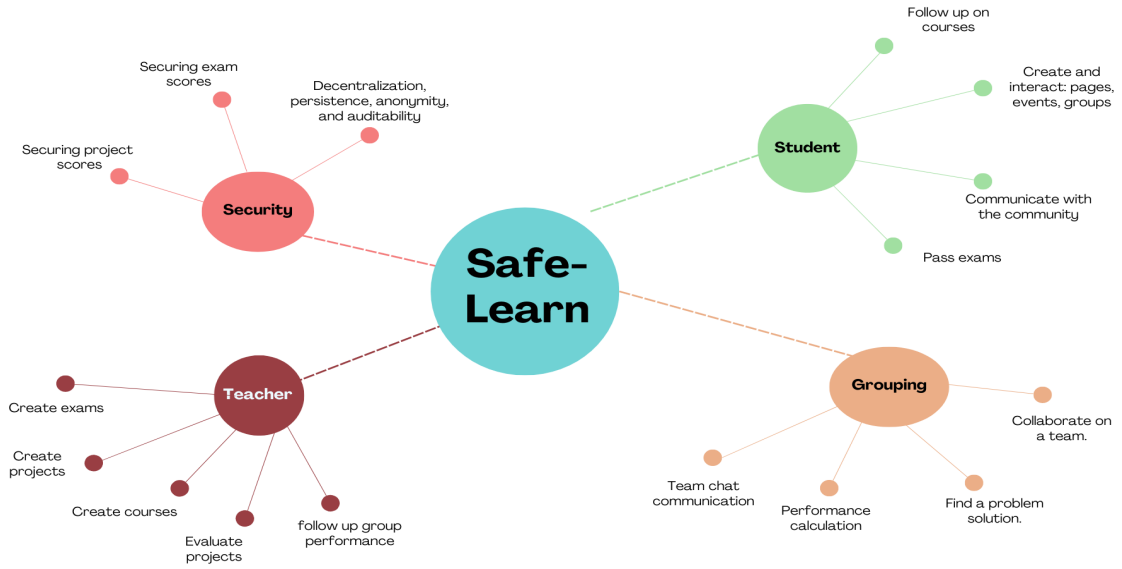


Figure 2.1 – Safe Learn Global Architecture.

2.3.2 Functional Architecture of the System

The Figure 2.2 presents the functional architecture of the SafeLearn system. The architecture illustrates the operation and activities performed within the system, as well as the various interactions between the system's actors.

Our system consists of several subsystems, including:

A. Learning sub system

After logging into the system, teachers can share educational resources and tests in their dedicated space. The system then automatically displays these shared resources to students at the appropriate level and in the appropriate specialty. Students make the tests created by their teachers, which are designed to assess their knowledge. Subsequently, teachers can review the students' responses and their scores.

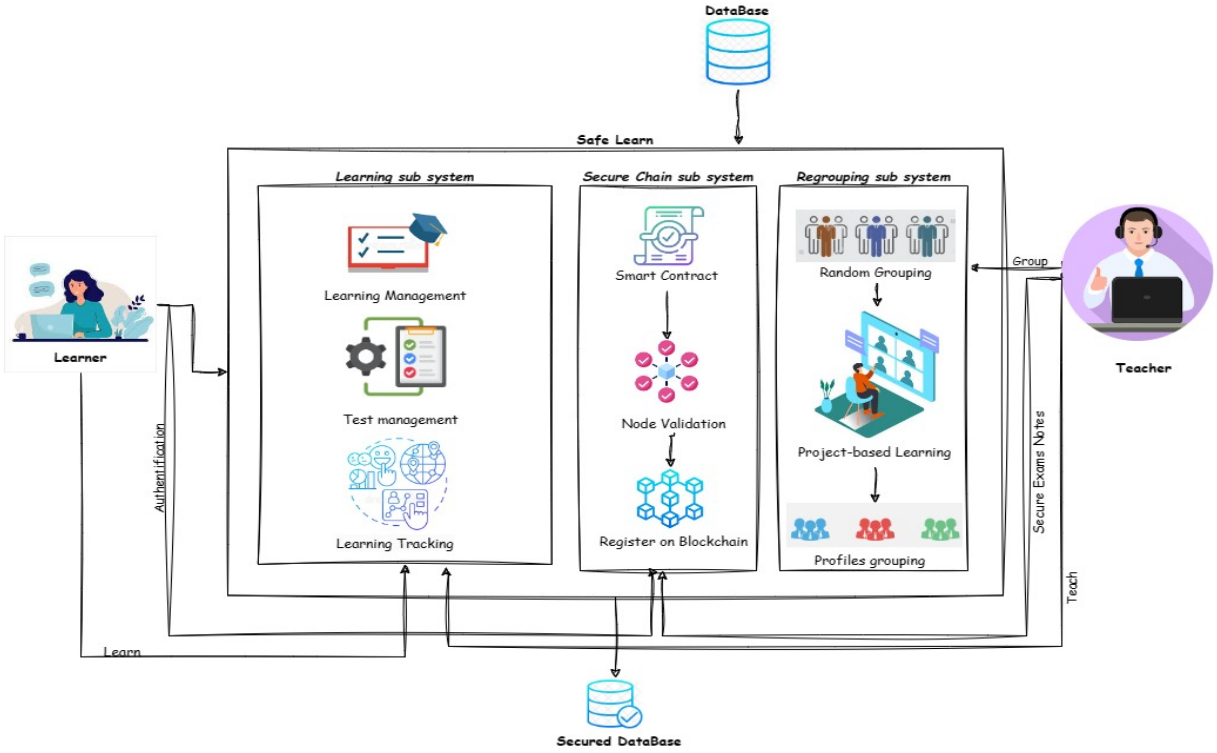


Figure 2.2 – Safe Learn Functional Architecture.

B. Regrouping Sub system

1. **The PeSOA Algorithm** Penguins search optimisation algorithm (PeSOA) is a bio-inspired meta-heuristics based on collaborative hunting strategy of penguins. Penguins swarms have several collaborative characteristics, they collaborate their efforts and synchronise their dives to save the global expenditure of energy in food searching process. In the hunting process, penguin population is divided into groups and each group is composed of a variable number of penguins depending on food availability in a specific location. In each group, each penguin searches separately for food according to their oxygen reserve (updated according to the objective function). After each food-foraging iteration, penguins return back on the surface (ice) to share with affiliates, the location of food (this rule ensures intra-group communication). If the number of fishes (calculated according to the objective function) in a specific location is not enough (or none) for a given group, part of the group (or the whole group) migrates to another hole (this rule ensures inter-group communication).[10]

2. **Dynamic Grouping based on PeSOA**
   Algorithm 1 describes the pseudo code of the Dynamic Grouping based on PeSOA.

Algorithm 1 Dynamic Grouping based on PeSOA

Generate randomly initial groups of students based on their specialty and level
for each group i **do**
    Students collaborate to construct the global solution of the given project
end for
Calculate the performance scores for each group
Redistribute Groups if: Group size $\leq$ 2 or Group performance $\leq$ a threshold
if The length of the group ≤ 2 **then**
    Dispatch Group
    for each learner $L(i)$ **do**
        Calculate Learner Performance (Lpr)
        if Lpr ≤ 40 **then**
            Re-affect $L(i)$ to another group where PerfGroup ≥ 60
        else
            Re-affect $L(i)$ to another group where PerfGroup ≤ 60
        end if
    end for
end if
for each group $g(i)$ **do**
    if Performance Group $L(PerfGroup) \leq$ Threshold **then**
        Dispatch Group
        for each learner $L(i)$ in $g(i)$ **do**
            if Lpr of $L(i) \leq 40$ **then**
                Re-affect $L(i)$ to another group where PerfGroup ≥ 60
                Replace $L(i)$ by learner (Lpr$\geq$ 60) from group his $PerfGroup \geq 60$
            else
                Re-affect $L(i)$ to another group where PerfGroup ≤ 60
                Replace $L(i)$ by learner (Lpr$\leq$ 40) from group his $PerfGroup \leq 40$
            end if
        end for
    end if
end for

3. **How to calculate the performance of groups?**

   (a) **Calculating Average Project Scores:**
   Summing up all project scores obtained by a group and dividing by the total number of projects gives the average project score. This metric provides an

overview of the group's performance across all projects.

$$\text{Average Project Scores} = \frac{\text{Total Project Scores}}{\text{Number of Projects}}$$

(b) **Calculating Traces Found:**

The number of traces found during communication activities is divided by a fixed value (4) to represent a certain weight in the overall performance assessment. Traces indicate the level of group interaction and collaboration.

The general trace model used is as follows: (type of trace, date, time). The traces used are:

- The collaboration or communication traces: This type of trace contains all actions performed by team members regarding communication and collaboration among learners within the same team to resolve the given projects.

$$\text{Traces Found} = \frac{\text{Number of Traces Found}}{4}$$

(c) **Calculating Completed Tasks Ratio:**

Dividing the number of tasks completed by the group by the total number of tasks available provides a ratio indicating the proportion of tasks accomplished. This metric assesses the group's ability to meet project requirements and deadlines.

$$\text{Completed Tasks Ratio} = \frac{\text{Completed Tasks}}{\text{Total Tasks}}$$

(d) **Calculating Performance:**

- Each criterion is assigned a weight representing its importance in the overall performance assessment.
- The performance score is calculated by multiplying each criterion's value by its weight and summing up the contributions. This yields an overall performance score reflecting the group's performance across multiple dimensions.

$$\begin{aligned}\text{Performance} = &(\text{Weight of Project Notes} \times \text{Average Project Scores}) \\ &+ (\text{Weight of Traces} \times \text{Traces Found}) \\ &+ (\text{Weight of Completed Tasks} \times \text{Completed Tasks})\end{aligned}$$

(e) **Classifying Groups:**

Based on the overall performance score calculated, groups are classified into different categories:

•**Excellent Performance (Performance Score $\geq$ 80):** If the performance score is equal to or greater than 80, the group is classified as having an excellent performance. The group has performed exceptionally well across all evaluated

criteria, demonstrating high levels of effectiveness and efficiency in project execution.

• **Good Performance (Performance Score $\geq$ 60 and $<$ 80):** If the performance score falls between 60 and 79, the group is classified as having a good performance. While not reaching the highest level of performance, the group still demonstrates competence and achieves satisfactory results across most evaluated criteria.

• **Average Performance (Performance Score $\geq$ 40 and $<$ 60):** If the performance score falls between 40 and 59, the group is classified as having an average performance. The group's performance is moderate, with room for improvement in certain areas. It suggests that the group meets basic requirements but may lack consistency or excellence in execution.

• **Weak Performance (Performance Score $<$ 40):** If the performance score is less than 40, the group is classified as needing improvement, and arrangements will be made to disband the group and place the members in another group.

4. **How to calculate the performance of Students?**

   (a) **Calculation of Behavioral Profile:**
   The system computes the behavioral profile based on student action traces. These traces encompass various user actions such as searching, group activities (creation and joining), page interactions (creation and liking), event actions (creation, interest, and participation), status updates (adding, liking, commenting, sharing), invitations, file downloads, and information modifications.

   (b) **Calculation of Cognitive Profile:**
   The system calculates the cognitive profile of students based on their performance in past tests.

   (c) **Calculation of Performance Profile:**

   After calculating the Cognitive and Behavioral Profiles, we can now determine the performance of the students. The performance (*perf*) is calculated as the average of the two profiles:

$$\text{perf} = \frac{\text{Cognitive Profile} + \text{Behavioral Profile}}{2}$$

C. Secure Chain sub system

Figure 2.3 presents the Secure Chain sub system architecture.
The main steps of the Secure Chain sub system are :

1. **Secure Recording in Blockchain:**
   After students complete their exams, their scores are automatically calculated based

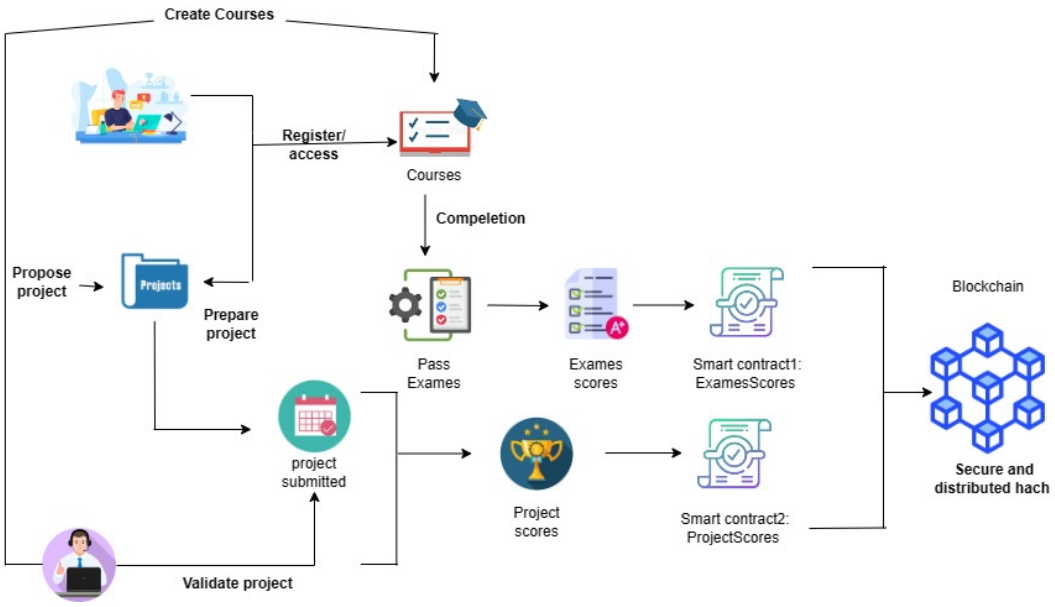


Figure 2.3 – Secure Chain sub system architecture.

on their answer. Once project teams have validated their projects and teachers have confirmed their approval, crucial data points such as exam scores and project validations are securely recorded on a blockchain using blockchain technology. This process ensures that all recorded information remains secure, maintaining its integrity and immutability. The blockchain provides a transparent and tamper-proof record of students' performance, enhancing trust and reliability in the assessment and validation processes.

2. **Smart Contracts and Web3.js Integration:**
   Smart contracts play a pivotal role in our system by facilitating the seamless recording of exam and the project scores into the blockchain. These contracts are equipped with predefined logic that governs the storage and retrieval of grade-related data. Through the use of Web3.js, our platform establishes a secure and efficient communication channel with the blockchain. Web3.js acts as the bridge, enabling interactions between our application and the blockchain network. This integration ensures that exam-related data, including project scores , are securely transferred and recorded on the blockchain

2.4 Database Structure

In this section, we present the structure of the used database:

2.4.1 Data Dictionary

Table 2.1 presents the Data Dictionary.

No.	Designation	Code	Type
1	Test ID	id_test	Integer
2	Test Name	$Test_name$	Characters (60)
3	Test Specialty	$Test_specialty$	Characters (60)
4	Number of Questions	Nb_qst	Integer
5	Module ID	id_mod	Integer
6	Module Name	$Module_name$	Characters (60)
7	Module Field	$Module_field$	Characters (60)
8	Module Description	$Module_Desc$	Long characters (150)
9	Module Image	$Module_pic$	Long variable characters (150)
10	Course ID	id_cr	Integer
11	Course Name	$Cours_name$	Characters (80)
12	Course File	$File_c$	Long variable characters (60)
13	Course File Name	$Name_fcr$	Long variable characters (60)
14	Course File Type	$Type_fcr$	Long variable characters (60)
15	Teacher ID	id_tec	Integer
16	Teacher Faculty	$Faculty_tec$	Characters (40)
17	Teacher Department	$Department_tec$	Characters (40)
18	Grade	Grade	Characters (40)
19	Teacher Field	$Field_tec$	Characters (40)
20	User ID	id_user	Integer
21	First Name	Name	Characters (30)
22	Last Name	$Family_name$	Characters (30)
23	Birth Date	$Birth_date$	Date
24	Email	Email	Long variable characters (50)
25	Password	Password	Variable characters (40)
26	Gender	Sex	Characters (15)
27	Category	Category	Characters (15)
28	Picture	Picture	Long variable characters (150)
29	Student ID	id_st	Integer
30	Faculty	Faculty	Characters (80)

31	Department	Department	Characters (80)
32	Specialty	Specialty	Variable characters (80)
33	Level	Level	Integer
34	Registration Number	Numinscrp	Integer
35	Question ID	$\text{id}_q st$	Integer
36	Question Text	$\text{Text}_Q st$	Long characters (200)
37	Number of Choices	$\text{Num}_c hoices$	Integer
38	Answer ID	$\text{id}_a ns$	Integer
39	Answer	Answer	Long characters (200)
40	Answer Status	$\text{Answer}_s tatus$	Integer
41	Collaboration Trace ID	$\text{id}_c lb$	Integer
42	Collaboration Type	$\text{Type}_c lb$	Characters (40)
43	Collaboration Date	$\text{Date}_c lb$	Date
44	Collaboration Time	$\text{Time}_c lb$	Time
45	Page ID	$\text{id}_p age$	Integer
46	Page Name	$\text{Name}_p g$	Characters (60)
47	Page Domain	$\text{Domain}_p g$	Characters (80)
48	Page Date	$\text{Date}_p g$	Date
49	Page Picture	$\text{Pic}_p g$	Long variable characters (150)
50	Group ID	$\text{id}_g roup$	Integer
51	Group Name	$\text{Name}_g rp$	Characters (60)
52	Group Domain	$\text{Domain}_g rp$	Characters (80)
53	Group Date	$\text{Date}_g rp$	Date
54	Group Picture	$\text{Pic}_g rp$	Long variable characters (150)
55	Event ID	$\text{id}_e v$	Integer
56	Event Name	$\text{Name}_e v$	Variable characters (60)
57	Event Location	$\text{Place}_e v$	Variable characters (80)
58	Event Description	$\text{Desc}_e v$	Long characters (250)
59	Event Date	$\text{Date}_e v$	Date
60	Event Picture	$\text{Pic}_e v$	Long variable characters (150)
61	Publication ID	$\text{id}_p ub$	Integer
62	Publication Content	$\text{Content}_p ub$	Long variable characters
63	Publication Date	$\text{Date}_p ub$	Date

64	Publication Picture	Pic$_{p}ub$	Long variable characters
65	Publication File	File$_{p}ub$	Variable characters (60)
66	Publication File Name	NameF$_{p}ub$	Variable characters (60)
67	Publication File Type	TypeF$_{p}ub$	Variable characters (60)
68	Invitation ID	id$_{i}nvt$	Integer
69	Recipient ID of Invitation	id$_{r}es_{i}nvt$	Integer
70	Invitation Date	Date$_{i}nvt$	Date
71	Invitation Status	State$_{i}nvt$	Integer
72	Team Chat ID	id$_{t}eam$	Integer
73	Team Number	Num$_{t}eam$	Integer
74	Team Creation Date	Creation$_{d}ate$	Date
75	Chat Content	Chat$_{c}ontent$	Long variable characters (200)
76	Identifier 0	Id0	Integer
77	Identifier 1	Id1	Integer
78	Identifier 2	Id2	Integer
79	Identifier 3	Id3	Integer
80	Message Time	Time$_{m}esg$	Time
81	Team File	File$_{t}$	Long variable characters (80)
82	Team File Name	Name$_{f}t$	Long variable characters (80)
83	Team File Type	Type$_{f}t$	Long variable characters (80)
84	Consultation Trace ID	id$_{c}ons$	Integer
85	Consultation Type	Type$_{c}ons$	Characters (40)
86	Consultation Date	Date$_{c}ons$	Date
87	Consultation Time	Time$_{c}ons$	Time
88	Project ID	id$_{p}r$	Integer
89	Project Name	Project$_{n}ame$	Variable characters (40)
90	Project Creation Date	Creation$_{D}atepr$	Date
91	Project Deadline	Deadline	Date
92	Project Scores	Scores	Float
93	Project File	File$_{p}r$	Long variable characters

94	Project File Name	$Name_pr$	Long variable characters
95	Project File Type	$Type_fr$	Long variable characters
96	Action Trace ID	id_ac	Integer
97	Action Type	$Type_ac$	Characters (40)
98	Action Date	$Date_ac$	Date
99	Action Time	$Time_ac$	Time

Table 2.1 – Data Dictionary

2.4.2 Conceptual Data Model

Figure 2.4 shows the Conceptual Data Model.

2.4.3 List of entities

Table 2.2 presents the list of entities.

No.	Table	Attributes	Identifier
1	Test	- id_test - Test_name - Test_specialty - Nb_qst	id_test
2	Module	- id_mod - Module_name - Module_field - Module_Desc - Module_pic	id_mod
3	Course	- id_cr - Course_name - File_c - Name_f_cr - Type_f_cr	id_cr
4	Teacher	- id_tec - Faculty_tec - Department_tec - Grade - Field_tec	id_tec

5	User	- id_user - Name - Family_name - Birth_date - Email - Password - Sex - Category - Picture	id_user
6	Student	- id_st - Faculty - Department - Specialty - Level - Numinscrp	id_st
7	Question	- id_qst - Text_Qst - Num_choices	id_qst
8	Answer	- id_ans - Answer - Answer_status	id_ans
9	Collaboration Trace	- id_clb - Type_clb - Date_clb - Time_clb	id_clb
10	Page	- id_page - Name_pg - Domain_pg - Date_pg - Pic_pg	id_page
11	Group	- id_group - Name_grp - Domain_grp - Date_grp - Pic_grp	id_group

12	Event	- id_ev - Name_ev - Place_ev - Desc_ev - Date_ev - Pic_ev	id_ev
13	Publication	- id_pub - Content_pub - Date_pub - Pic_pub - File_pub - NameF_pub - TypeF_pub	id_pub
14	Invitation	- id_invt - id_res_invt - Date_invt - State_invt	id_invt
15	Team Chat	- id_team - Num_team - Creation_date - Chat_content - Id0 - Id1 - Id2 - Id3 - Time_mesg - File_t - Name_ft - Type_ft	id_team
16	Consultation Trace	- id_cons - Type_cons -Date_cons - Time_cons	id_cons

17	Project	- id_pr - Project_name - Creation_Datepr - Deadline - Scores - File_pr - Name_pr - Type_fr	id_pr
18	Action Trace	- id_ac - Type_ac - Date_ac - Time_ac	id_ac
19	Chat	- id_chat - id_res_msg - Content_msg - Time_msg - File_msg - NameF_msg - TypeF_msg - State_msg	id_chat

Table 2.2 – List of entities

2.4.4 List of relations

Table 2.3 presents the list of relations.

No.	Relation	Dimensions	Collection	Cardinality
1	Have_pg	2	Publication, Page	(0-n, 0-n)
2	Have_grp	2	Publication, Group	(0-n, 0-n)
3	Contact	2	User, Chat	(0-n, 1-1)
4	Send	2	User, Invitation	(0-n, 1-1)
5	Liking_page	2	User, Page	(0-n, 0-n)
6	Create_page	2	User, Page	(0-n, 1-1)
7	Joined_group	2	User, Group	(0-n, 0-n)
8	Create_group	2	User, Group	(0-n, 1-1)
9	Participate_events	2	User, Events	(0-n, 0-n)
10	Create_events	2	User, Events	(0-n, 1-1)
11	Have_cr	2	Module, Course	(0-n, 1-1)

12	Create_Mod	2	Teacher, Module	(0-n, 1-1)
13	Have_test	2	Module, Test	(0-n, 1-1)
14	Have_qst	2	Test, Question	(1-n, 1-1)
15	Have_ans	2	Question, Answer	(2-4, 1-1)
16	Add_pub	2	User, Publication	(0-n, 1-1)
17	Liking_pub	2	User, Publication	(0-n, 0-n)
18	Comment_pub	2	User, Publication	(0-n, 0-n)
19	Possesses$_T$*races*	2	Student, Consultation Traces	(0-n, 1-1)
20	Submit	2	Team$_c$*hat*, *Project*	(0-n, 1-1)
21	Create_pr	2	Teacher, Project	(0-n, 1-1)
22	Create_gr	2	User, Group	(1-n, 1-1)
23	Have	2	Students, Team Chat	(1-4, 1-1)
24	Possesses$_T$*races*	2	Students, Action Traces	(0-n, 1-1)
25	Possesses	2	Team$_c$*hat*, *CollaborationTraces*	(0-n, 1-1)
26	interrested	2	User, events	(0-n, 0-n)

Table 2.3 – List of relations

2.4.5 Logical data model

— **Test** (*id_test*, Test_name, Test_specialty, Nb_qst, #id_mod)

— **Module** (*id_mod*, Module_name, Module_field, Module_Desc, Module_pic, #id_tec)

— **Course** (*id_cr*, Cours_name, File_c, Name_f_cr, Type_f_cr, id_mod)

— **Teacher** (*id_tec*, Faculty_tec, Department_tec, Grade, Field_tec)

— **User** (*id_user*, Name, Family_name, Birth_date, Email, Password, Sex, Category, Picture)

— **Student** (*id_st*, Faculty, Department, Specialty, Level, Numinscrp)

— **Question** (*id_qst*, Text_Qst, Num_choices, id_test)

— **Answer** (*id_ans*, Answer, Answer_status, id_qst)

— **Answer1** (id_test, id_qst, id_st, answer)

— **Collaboration Trace** (*id_clb*, Type_clb, Date_clb, Time_clb, id_team)

— **Page** (*id_page*, Name_pg, Domain_pg, Date_pg, Pic_pg, #id_user)

— **Comment_pub** (id_user, id_pub)

— **Liking_pub** (id_user, id_pub)

— **Participate_events** (id_user, id_ev)

— **Interested** (id_user, id_ev)

— **Joined_group** (id_user, id_group)

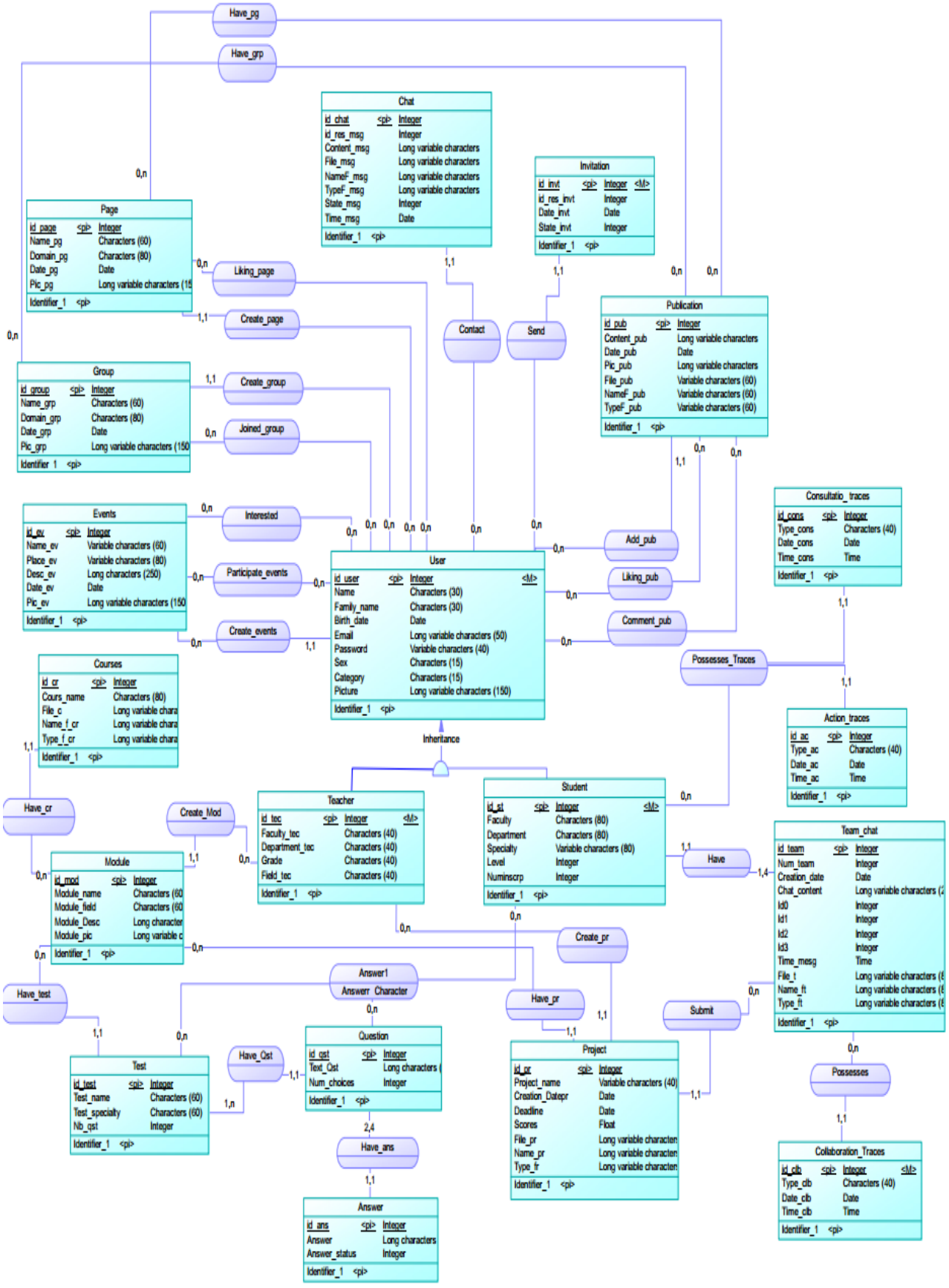


Figure 2.4 – Conceptual Data Model.

— **Liking_page** (id_user, id_page)

— **Have_grp** (id_pub, id_group)

— **Have_pg** (id_pub, id_page)

— **Group** (*id_group*, Name_grp, Domain_grp, Date_grp, Pic_grp, #id_user)

— **Event** (*id_ev*, Name_ev, Place_ev, Desc_ev, Date_ev, Pic_ev, #id_user)

— **Publication** (*id_pub*, Content_pub, Date_pub, Pic_pub, File_pub, NameF_pub, TypeF_pub, #id_user)

— **Invitation** (*id_invt*, id_res_invt, Date_invt, State_invt, #id_user)

— **Team Chat** (*id_team*, Num_team, Creation_date, Chat_content, Id0, Id1, Id2, Id3, Time_mesg, File_t, Name_ft, Type_ft)

— **Consultation Trace** (*id_cons*, Type_cons, Date_cons, Time_cons, #id_user)

— **Project** (*id_pr*, Project_name, Creation_Datepr, Deadline, Scores, File_pr, Name_pr, Type_fr, #id_team, #id_mod)

— **Action Trace** (*id_ac*, Type_ac, Date_ac, Time_ac, #id_user)

— **Chat** (*id_chat*, id_res_msg, Content_msg, Time_msg, File_msg, NameF_msg, TypeF_msg, State_msg, #id_user)

2.5 Conclusion

In conclusion, this chapter presented the design process of our system, addressing its main components from defining the system's objectives to presenting its global and functional architecture and database structure.

Chapter 3

System Implementation

3.1 Introduction

The implementation phase focuses on the practical and technical aspects of our project, with the goal of delivering a finalized product ready for user utilization. In this chapter, we will describe the working environment, detailing the physical setting and necessary tools for the project's realization. Additionally, we will discuss the programming languages used for both frontend and backend development. Finally, we will showcase the interfaces of our application, including illustrations of the project's interface design.

3.2 The tools and languages used

3.2.1 Solidity

Solidity is a powerful programming language designed specifically for writing smart contracts on blockchain. Solidity, developers can define the rules and behavior of decentralized applications (DApps). It is influenced by C++, Python, and JavaScript [W8].

3.2.2 Ganache

Ganache is a high-end development tool that is part of the Truffle Suite ecosystem, which includes Truffle and Drizzle.It used to run a local blockchain for developing, deploying, and testing projects and smart contracts in a safe and deterministic environment [W9].

3.2.3 Node.js

Node.js is an open-source, cross-platform JavaScript runtime environment that executes JavaScript code outside of a web browser. It is a powerful tool used for various types of projects, enabling server-side scripting and the development of scalable network applications.

In the context of the Truffle Suite ecosystem, Node.js is used to manage the interaction between Ganache and the development platform, ensuring smooth communication and operation within the local blockchain environment [W10].

3.2.4 PHP

PHP, short for Hypertext Preprocessor, refers to a computer language, or scripting language, primarily used for designing dynamic websites. It is an open-source programming language that can be used by anyone free of charge. Created in the early 1990s by Canadian and Greenlandic programmer Rasmus Lerdorf, PHP is often associated with the MySQL database server and the Apache server. Together with the Linux operating system, it forms an integral part of the LAMP software suite. Technically, PHP is mostly used server-side. It generates HTML, CSS, or XHTML code, as well as data in formats like PNG, JPG, etc., or even PDF files. It has undergone specific development over many years and enjoys a strong reputation for reliability and performance today [W11].

3.2.5 Mysql

MySQL is an open-source relational database management system (RDBMS) with a client-server model based on the Structured Query Language (SQL). MySQL is the world's most popular relational database management system. It is used by Facebook, Google, Adobe, Alcatel Lucent, Zappos, and numerous other websites and online applications. It is developed, distributed, and supported by Oracle Corporation. MySQL is a powerful, flexible, and scalable cross-platform relational database based on the standardized SQL (Structured Query Language) used to create and manipulate relational databases. Like most database management systems, MySQL has a client-server architecture and can be used in a networked environment [W12].

3.3 System Overview

In this section, we will present the different interfaces of our system with their functionality

3.3.1 The Main Interface

This page provides access to the registration and connection interfaces. The figure 3.1 3.2 shows the main interface of the system.

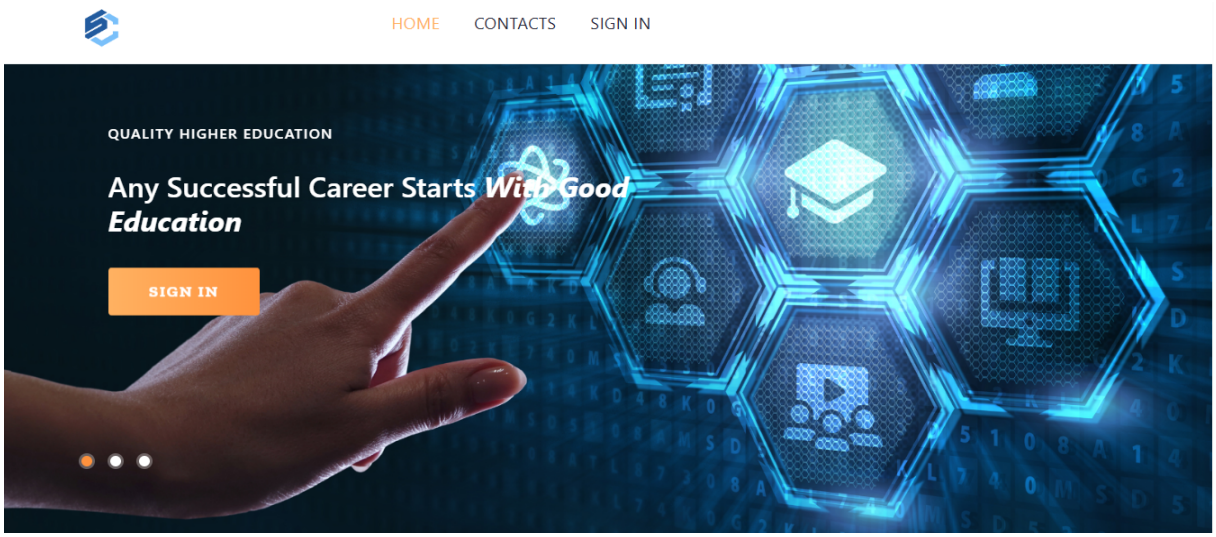


Figure 3.1 – The main interface of the system.

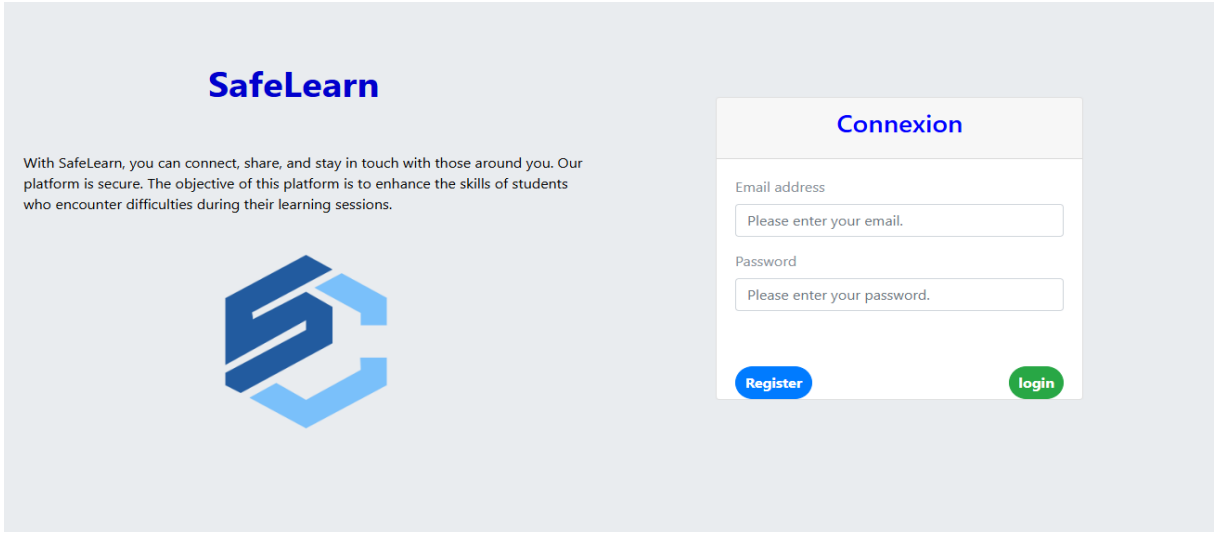


Figure 3.2 – The main interface of the system.

3.3.2 Home Page

The figure 3.3 below shows the home page of our system where each user can add statuses/images and files

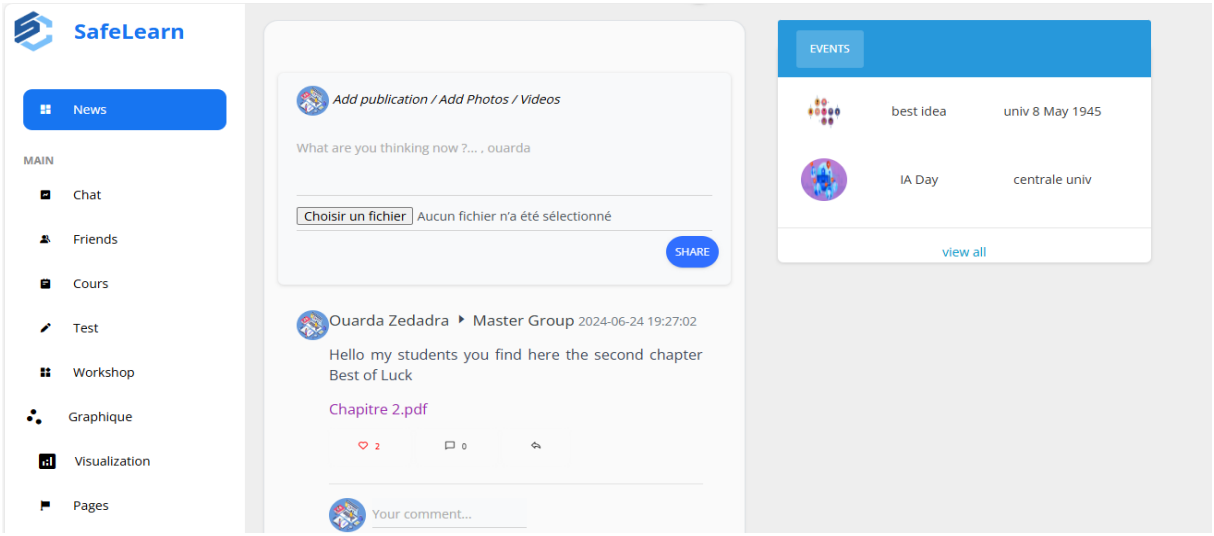


Figure 3.3 – Home Page.

3.3.3 Messaging Interface

Figure 3.4 shows the messaging interface.

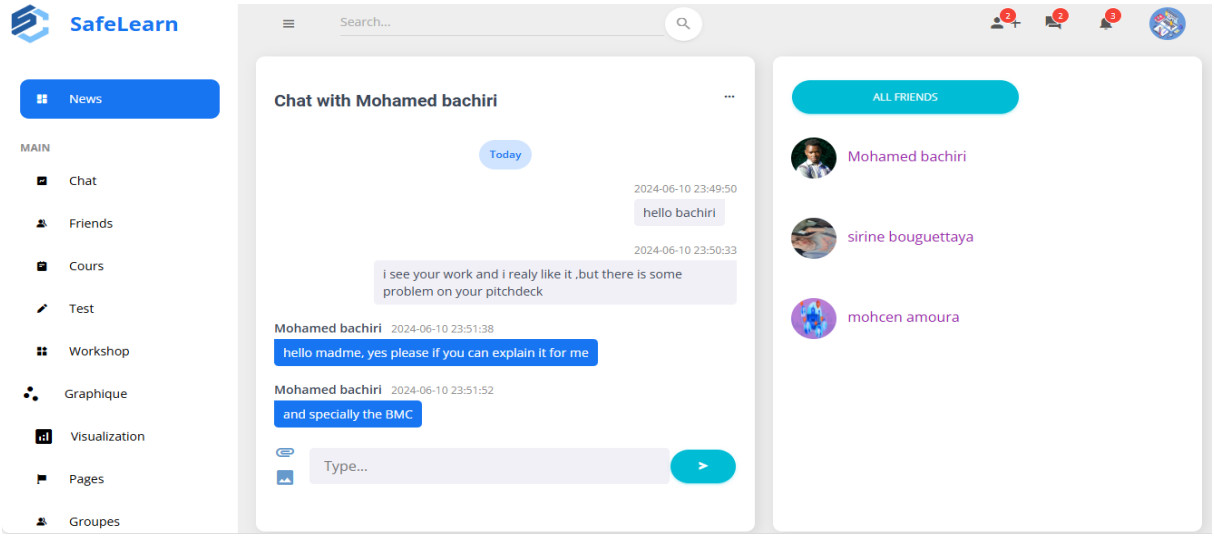


Figure 3.4 – The messaging interface

3.3.4 Course

Each student can follow courses online, and each teacher creates their own module and the courses for each module.Figure 3.5 shows the courses from the learner's side, and Figure

3.6shows the courses from the teacher's side.

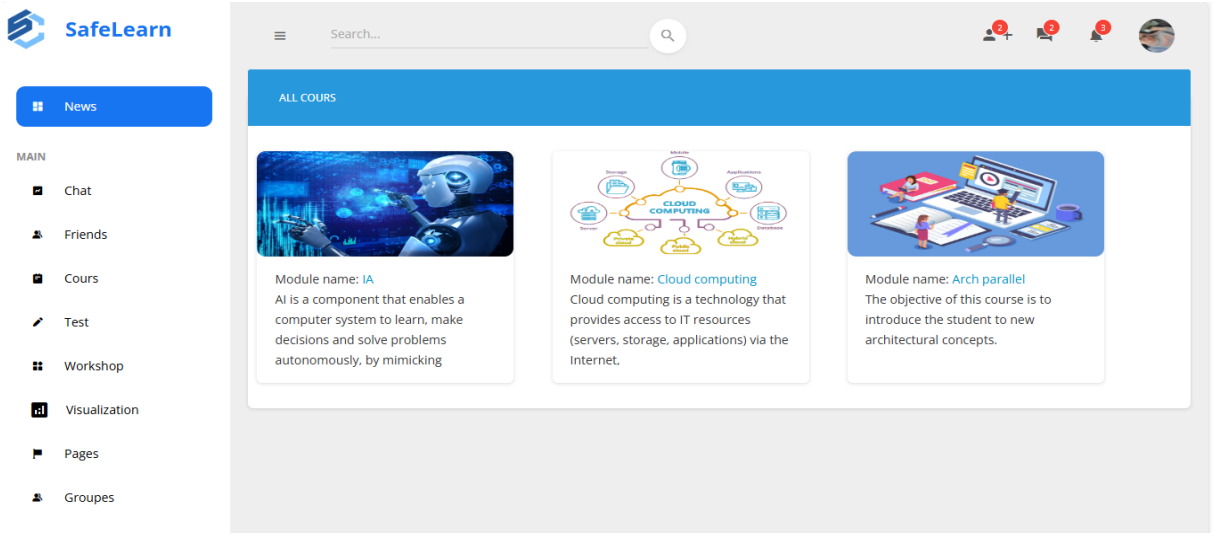


Figure 3.5 – The Courses from the learner's side

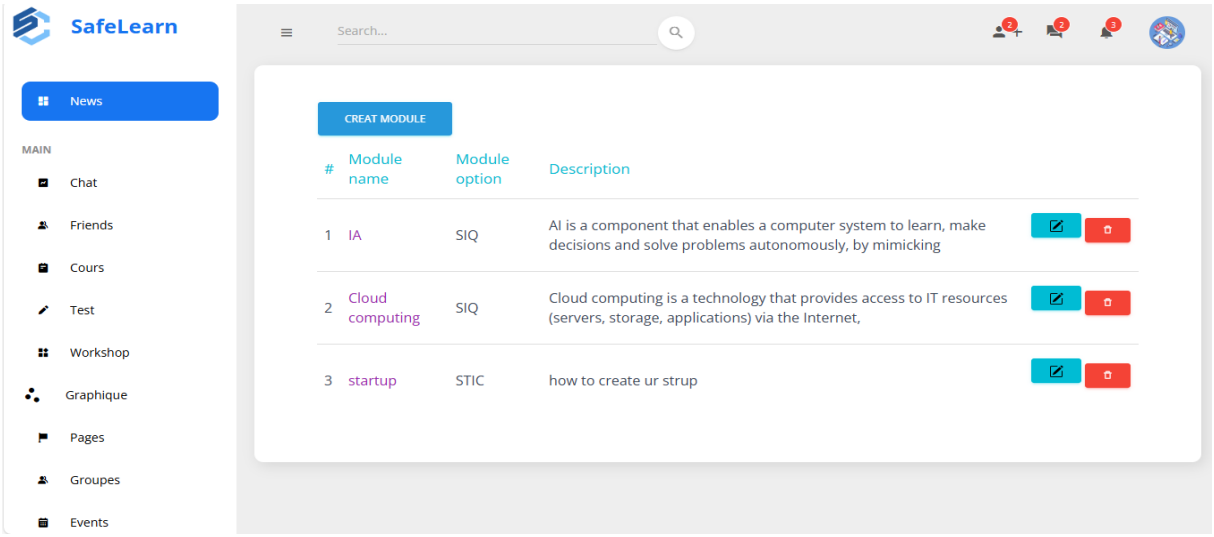


Figure 3.6 – The Courses from the teacher's side

3.3.5 Project

Each student can collaborate with a group of students to solve a problem created by the teacher 3.7.

Figure 3.8 presents the interface where the teacher validates each student group's projects.

Each project's scores are automatically recorded in a blockchain 3.9

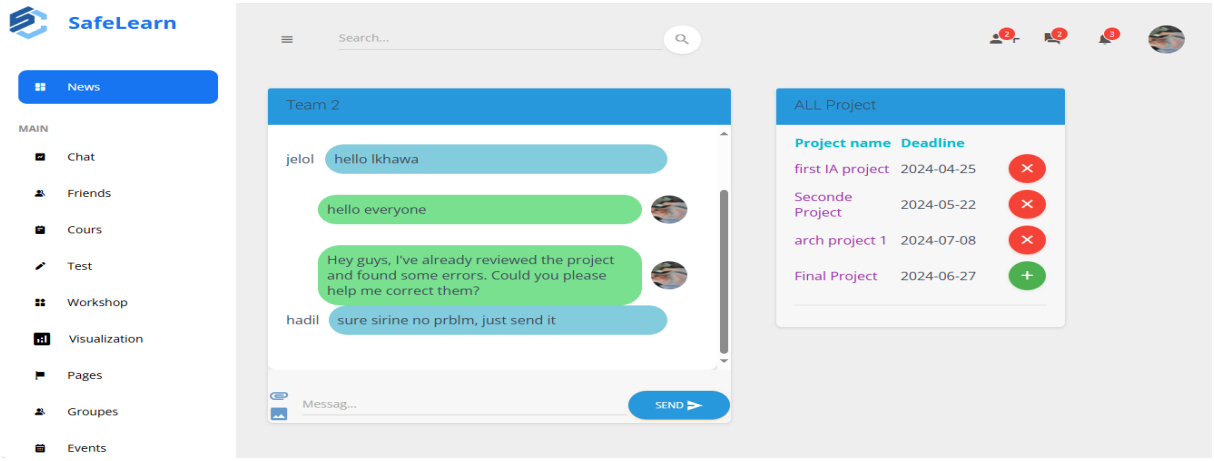


Figure 3.7 – Students group collaborate

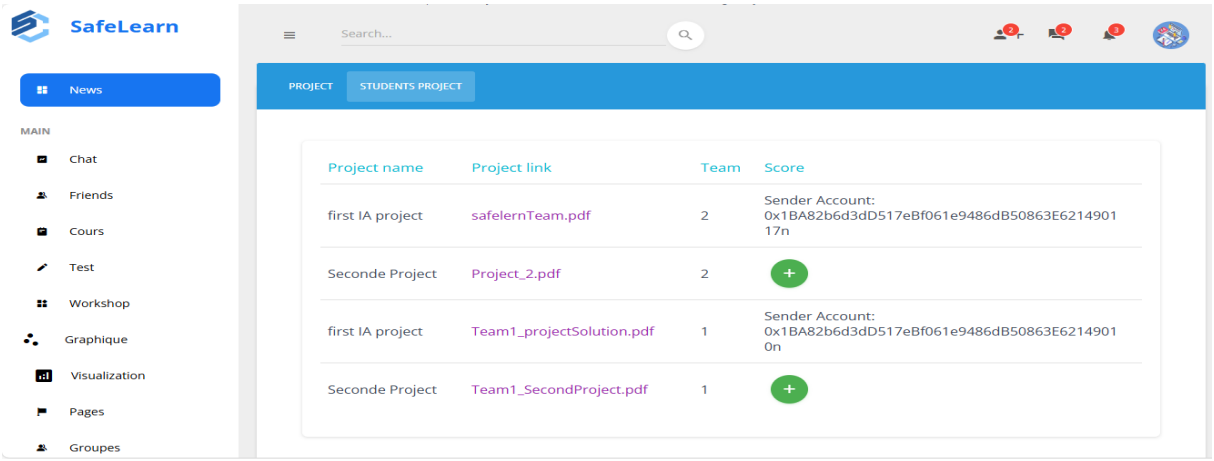


Figure 3.8 – Teacher Validation Project

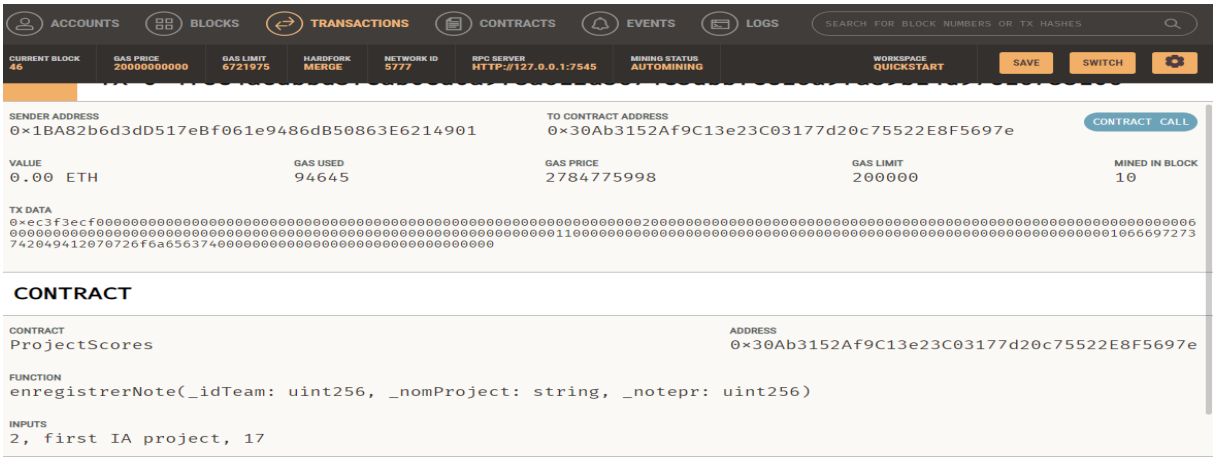


Figure 3.9 – Blockchain-Recorded Project Scores

3.3.6 Test

Each learner takes the test proposed by their teacher. Figure 3.10 shows the test from the learner's side.

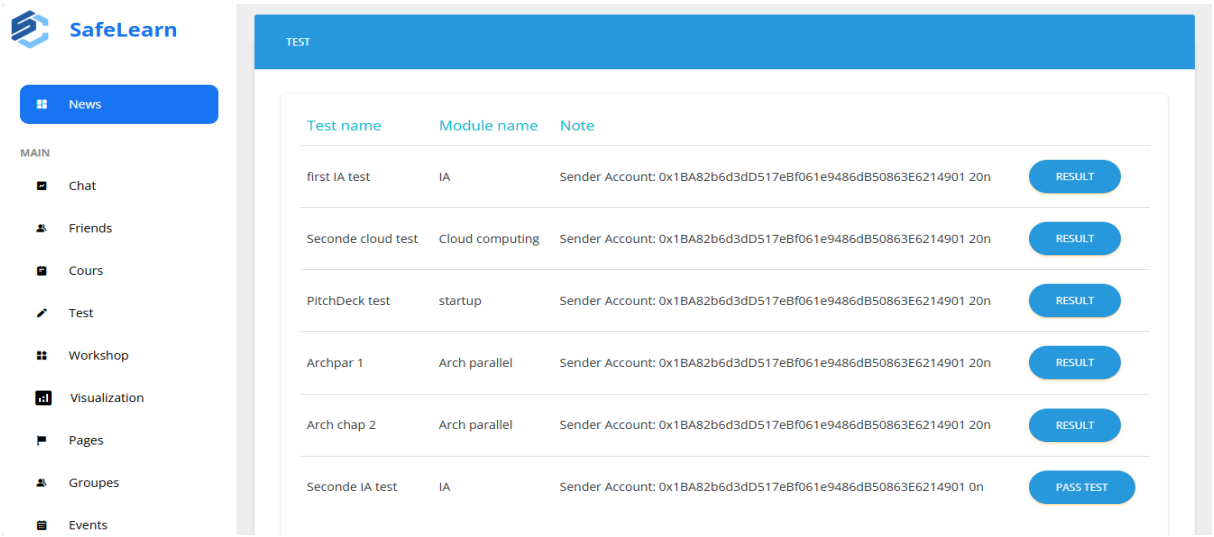


Figure 3.10 – Test from the learner's side.

Figure 3.11 presents the interface where the teacher can create test, see the students' scores and their answers.

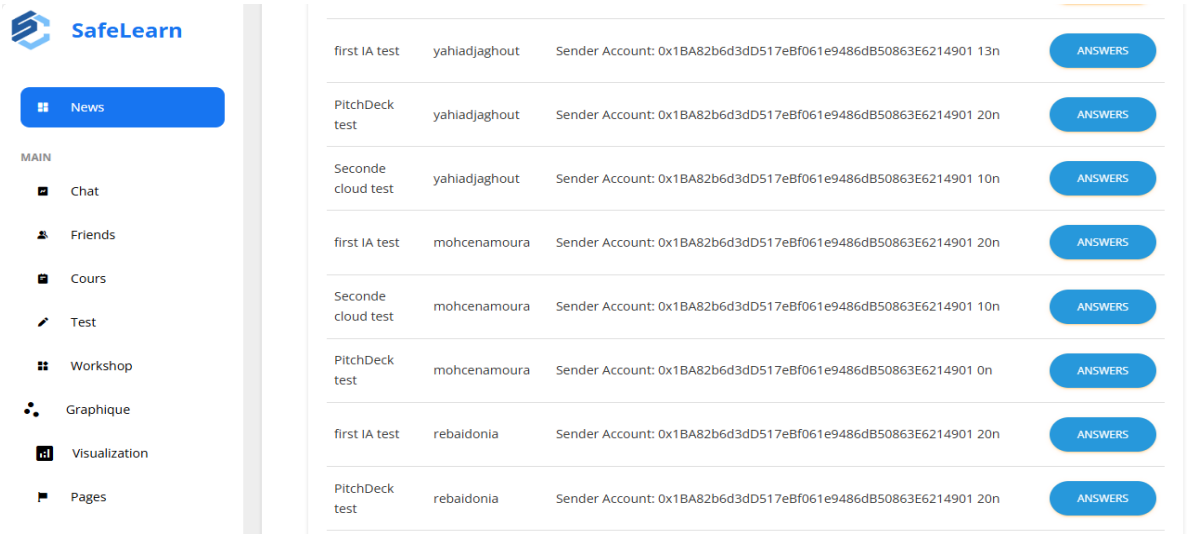


Figure 3.11 – Test from the Teacher's side.

Each test's scores are automatically recorded in a blockchain (figure 3.12).

3.3.7 Group Tracking

Teachers can monitor and track the performance of each student on each group (figure 3.13)

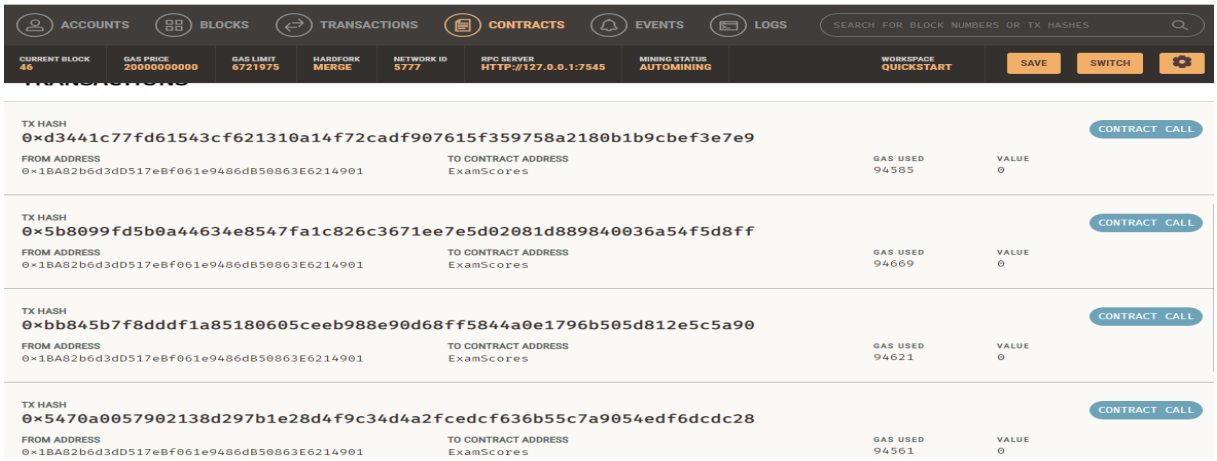


Figure 3.12 – Blockchain-Recorded Test Scores

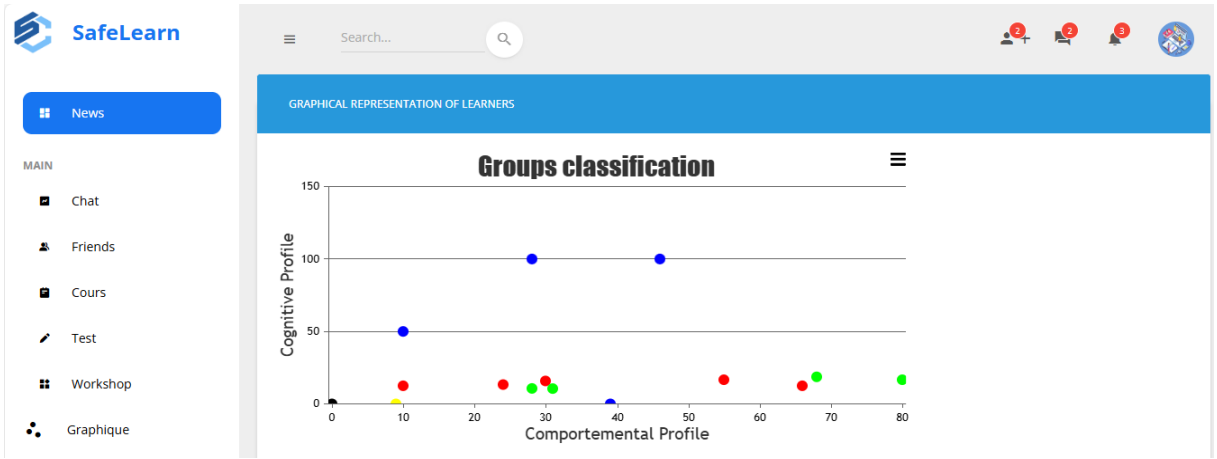


Figure 3.13 – Group Tracking

3.3.8 Trace visualization

Teachers can monitor and track the performance of each student (figure 3.14), and students can also track their own performance(figure 3.15).

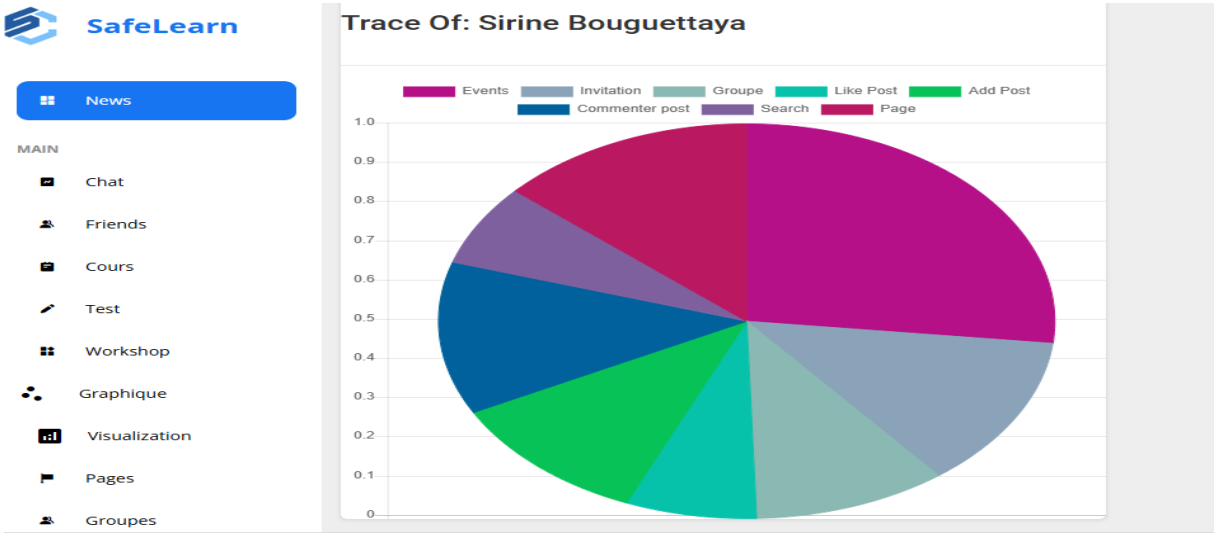


Figure 3.14 – Students Tracking

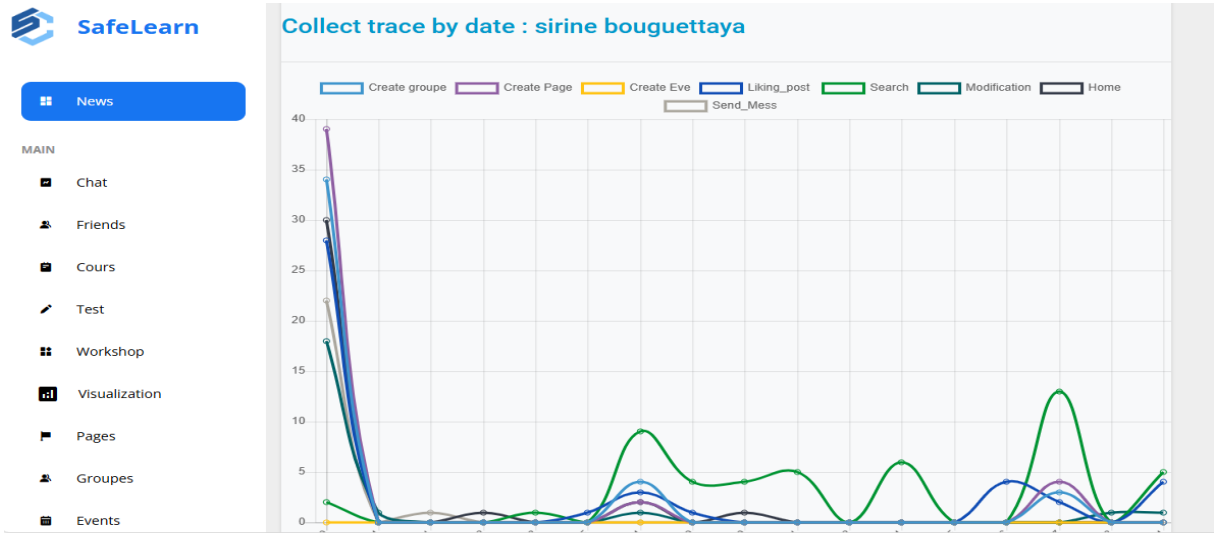


Figure 3.15 – Teacher Tracking

3.4 Conclusion

In this last chapter, we talked about all the technology and programming languages used in this application, and we also presented screenshots of the application.

Chapter 4

Appendix: Project Guide

Information Card

About the Supervisory Team of the Working Group

1. **Supervisory Team:**

Supervisory Team	
Principal Supervisor 01:	**Specialization:**
ZEDADRA Amina	Computer Science

2. **Project Team:**

Project Team	**Faculty**	**Specialization**
BOUGUETTAYA Sirine	MISM	Computer Science

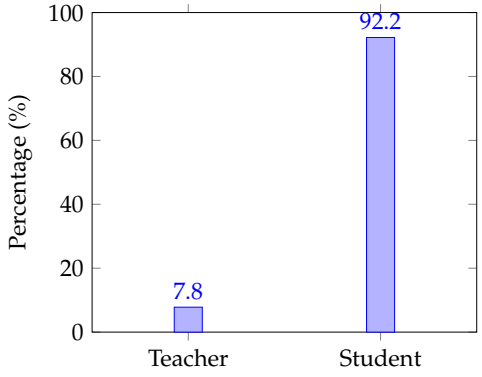
4.1 Axe 01 : Project presentation

4.1.1 Project idea

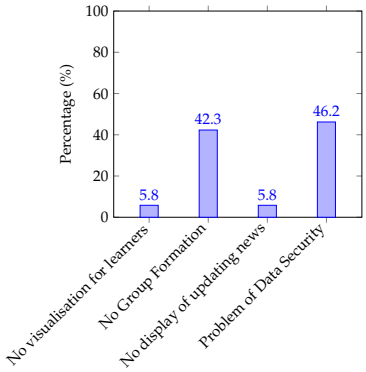
we have created an online questionnaire on Google Form. The latter is made to study the customer needs. The results of the customer responses are shown in figure 4.1. The questionnaire is composed of six questions: Question 1 (Figure 4.1a), Question 2 (Figure 4.1b), Question 3 (Figure 4.1c), Question 4 (Figure 4.1d), Question 5 (Figure 4.1e) and Question 6 (Figure 4.1f).

From the questionnaire presented above, we observe that the Educational Social Networks encounter significant challenges, such as:

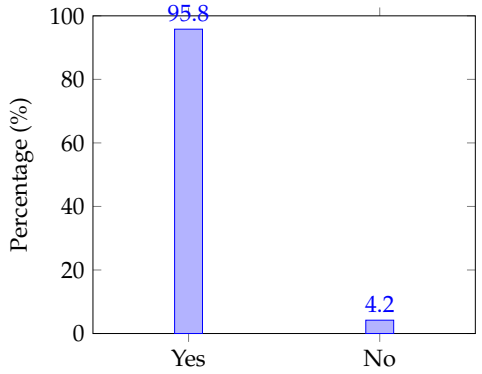
1. **Difficulty of Work in Groups** The students have a problem to Organize groups which pose a major problem between members where they exist ones may contribute less, caus-



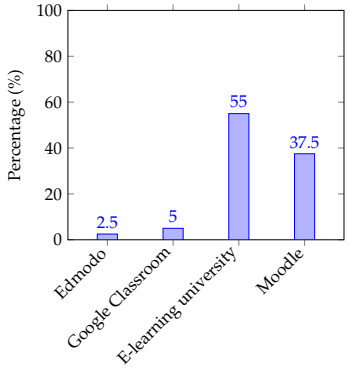
(a) Question 1: Are you?



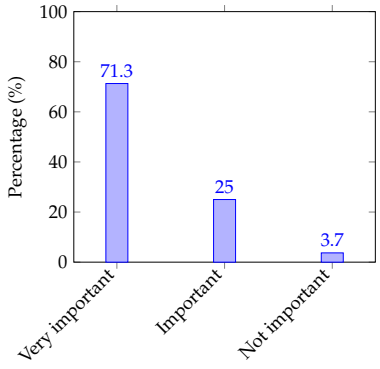
(b) Question 2: What are the biggest challenges with ESN?



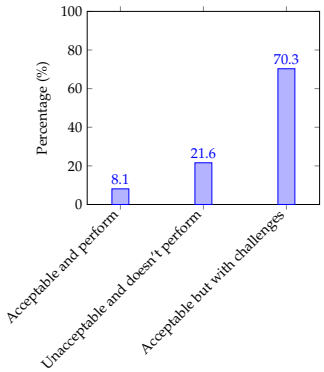
(c) Question 3: Have you recently used an educational social network?



(d) Question 4: Which educational system have you used?



(e) Question 5: How do you perceive the importance of monitoring and security on educational social networks?



(f) Question 6: How do you perceive existing educational social networks?

Figure 4.1 – Customers Needs.

ing an imbalance in group work and affecting overall group performance. Furthermore, the lack of effective communication tools can hinder collaboration.

2. **Problem of Data Security** Protecting sensitive personal and educational data from unauthorized access and breaches. Also, other risks from cyber attacks, such as hacking, phishing, and malware.
3. **No Information Available About Learners' Engagement and Performance** This absence of information makes it challenging to assess student participation, progress, and areas needing improvement.
4. **No Display of Updating News and Educational Resources** The limitation can hinder the timely dissemination of important information and learning materials to students, impacting their learning experience and access to resources.

4.1.2 Suggested Values

To develop an educational social network platform called "SafeLearn," we will implement several key solutions to address the challenges faced by traditional ESNs. The following propositions solve the problems cited above:

Monitoring Students:

1. **Regrouping learners:** Implement a dynamic regrouping subsystem where students can connect and interact based on their interests and learning needs, facilitating effective group formation and collaboration.
2. **Dashboard for Tracking Visualization:** Provide insights into student engagement and performance. Implementation: Develop a comprehensive dashboard that offers real-time analytics on student performance, group dynamics, and engagement levels. Visualize individual and group progress to identify areas for improvement. Generate customizable reports for teachers to monitor student activities effectively.
3. **Updating News: Publication, Page, Group:** Establish a centralized news feed for publishing course updates, institutional announcements, and educational resources. Enable teachers to share courses , test and publication directly with students.
4. **Workshops:** Designate workshop areas within the platform where teachers can define project tasks and goals. Enable students to collaborate in these virtual spaces by sharing resources, discussing ideas, and collectively working on assignments.

Securing Data

The use of the Blockchain technology to ensure data security, protecting sensitive educational and personal data from cyber threats through decentralized and tamper-resistant storages.

4.1.3 The Team

The project will be carried out by

1. **BOUGUETTAYA Sirine :** Currently pursuing a master's degree in Computer Systems, she brings in-depth technical expertise in software development and system architecture. Her ability to design and optimize complex systems contributes to ensuring the performance and reliability of our solution. She has also engaged in the Seeds for the Future Program, where she received comprehensive training in both IT and entrepreneurship.

4.1.4 Objectives

The objectives of Safe Learn are to revolutionize educational collaboration by providing a dynamic platform that enhances group interaction and project-based learning. It aims to optimize student engagement and performance through a robust AI-driven grouping system, ensuring balanced contributions and effective communication among members. By integrating blockchain technology, Safe Learn ensures secure data management, safeguarding sensitive information and promoting transparency. The platform also aims to provide educators and students with intuitive tools like real-time dashboards, updated resources, and collaborative spaces for workshops and events, fostering continuous improvement in educational outcomes.

4.1.5 Project implementation schedule

Figure 4.2 shows the project launch plan.

4.2 Axe 02: Innovative aspects

4.2.1 Nature of the Innovations

The innovation encompasses both technological and market innovations. It addresses an unmet need in educational platforms by offering enhanced services compared to competitors, ensuring a superior user experience and innovative functionalities. By implementing blockchain technology for secure, decentralized, and tamper-resistant data storage, Safe Learn safeguards sensitive educational and personal data, thereby driving technological innovation.

4.2.2 Area Of Innovation

The innovations of our project are presented as follows:

Blockchain Security: Implementing Blockchain technology to ensure secure, decentralized, and tamper-resistant data storage, protecting sensitive educational and personal data.

AI-Driven Grouping Systems: Implementing artificial intelligence to create group formation based on student skills, and learning needs, thereby improving collaboration effectiveness.

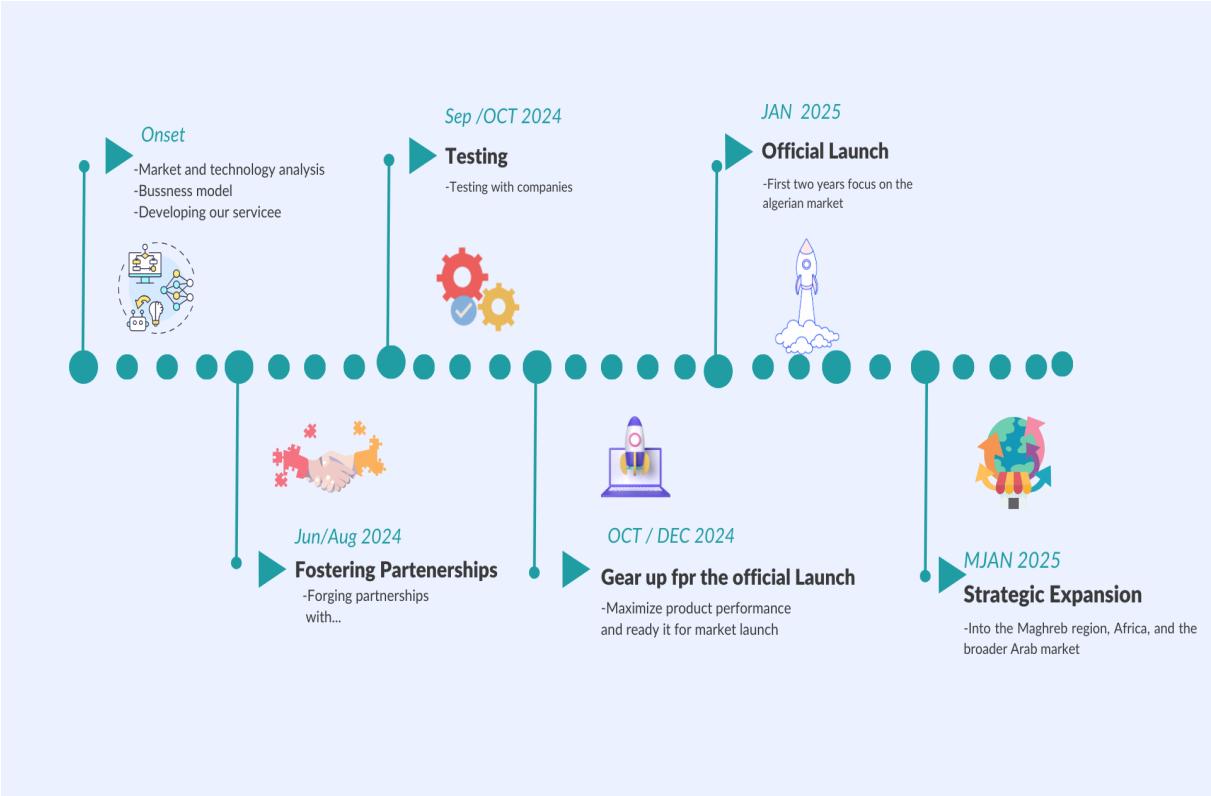


Figure 4.2 – Project Launch Plan.

Educational Collaboration and Project-Based Learning: how students collaborate on projects, fostering teamwork, and enhancing learning outcomes through dynamic group interactions.

Real-Time Dashboards and Updated Resources: by offering real-time monitoring and visualization tools, keeping educational resources up-to-date, and enhancing accessibility for users.

Updating News: by dissemination of information through dynamic updates across publications, pages, and group channels, ensuring timely and relevant communication within the educational community.

4.3 Axe 03 : Strategic Market Analysis

4.3.1 Market Segment

Potential Market

The potential market for "Safe Learn" includes a diverse group of individuals and institutions likely to demand our educational social network platform. Our primary users are educational institutions such as schools and universities, e-learning platforms, and EdTech companies. Additionally, government and educational authorities, and international markets are key segments. These entities seek to enhance online learning experiences, improve collabo-

ration,and protect sensitive educational data from cyber threats. While our initial focus is on Algeria, there is significant potential for future expansion into the MENA region (Middle East and North Africa), where the demand for secure and effective online educational solutions is growing.

Target Market (the segment)

The target market for "Safe Learn" includes specific segments within the broader potential market. We focus on educational institutions at all levels (primary, secondary, and higher education) that require advanced tools for student collaboration. E-learning platforms that aim to integrate secure and effective learning solutions are also a key target. Additionally, we target EdTech companies looking to enhance their offerings with innovative technologies. Government and educational authorities seeking to adopt secure data management solutions,are crucial segments. Our primary geographic focus is Algeria, with plans to expand into the MENA region.

4.3.2 The choice of this target market

We have chosen this target market due to several strategic reasons that align with the goals and capabilities of "Safe Learn":

1. Alignment with Educational Needs: The selected target market, including primary and secondary schools, universities, e-learning platforms, and EdTech companies, represents entities with significant needs for advanced educational tools. These institutions are actively seeking solutions to enhance collaboration, and secure sensitive educational data.

2. Market Readiness and Demand: Educational institutions and EdTech companies are increasingly investing in technology to improve learning outcomes and operational efficiency. There is a growing demand in these sectors for secure, scalable, and innovative educational platforms like "Safe Learn."

3. Strategic Fit with Product Capabilities: "Safe Learn" offers features such as dynamic group formation,tracking visualisation,updating news, and Blockchain-based data security. These capabilities directly address the pain points and requirements of our target market, making our solution highly relevant and valuable.

4. Opportunity for Growth: By focusing on educational institutions and related sectors initially in Algeria and expanding into the MENA region, we position "Safe Learn" to capitalize on a growing market opportunity. This strategic approach allows us to establish a strong foothold in the market and potentially scale our operations regionally and internationally.

4.3.3 Measuring the intensity of competition

According to research, our competitors are :

National level :

— E-Learning university : is an educational platform,it offers various course categories for different academic years, including doctoral courses and regular academic programs.

International level :

— Edmodo : A social learning platform for teachers, students, and parents. It offers classroom communication, assignment distribution, and grading, with a social media-like interface.

— Google Classroom : Part of Google's G Suite for Education, it integrates with other Google services to help manage coursework, create assignments, provide feedback, and foster communication.

— Schoology : A learning management system (LMS) that offers tools for managing and sharing academic content.

— Moodle : An open-source LMS that supports customizable management of courses, content, and communication. It's widely used in educational institutions for its flexibility and extensive plugins.

— ClassDojo : A communication platform for teachers, students, and parents, focusing on building classroom communities.

In conclusion there is no competing platform in the educational social network field in Algeria.

4.3.4 Marketing Strategy

Define a target audience : We need to identify audience demographics and preferences. This gives us will help customize our marketing efforts to meet their specific needs.

Trial Testing and Discount :

— Provide a 20% discount for the first 20 users to encourage early adoption and generate initial user traction.

— Conduct free trial periods for educational institutions and organizations to demonstrate the platform's value and effectiveness.

— Gather feedback from trial users to improve the platform and build case studies for marketing purposes.

Partnerships :

A. Educational Institutions:

— Form partnerships with schools, colleges, and universities to implement SafeLearn in their curriculum and showcase its benefits.

— Offer customized solutions and support to meet the specific needs of these institutions.

B. EdTech Companies:

— Collaborate with EdTech firms to integrate SafeLearn with other educational technologies and tools.

— Leverage joint marketing efforts to reach a broader audience.

C. Government Agencies:

— Partner with government bodies focused on education and technology to align SafeLearn with national educational initiatives.

Events :

— Attend and present at national and international conferences to increase visibility and establish SafeLearn as a thought leader in the educational technology sector.

— Network with educators, and potential partners to foster relationships and explore collaboration opportunities.

— Exhibit at trade shows and expos to demonstrate SafeLearn's features and benefits to a diverse audience.

Public Relations :

— Work with journalists and bloggers who specialize in education and technology to blog posts about SafeLearn.

— Host media events and webinars to engage with the press and share insights on the platform's impact.

Advertising :

— Use social media platforms to run targeted advertising campaigns.

— Invest in TV and radio advertisements to increase brand awareness among a broader audience.

— Utilize online advertising through Google Ads, educational websites, and blogs to drive traffic to SafeLearn's website and generate leads.

— Develop engaging content, such as videos and infographics, to capture the attention of potential users and highlight the platform's unique features and benefits.

4.4 Axe 04 : Production and organization plan

4.4.1 Production Process of SafeLearn

1. Market Research and Planning :

- Conduct thorough market research to identify the needs and challenges in the educational sector.

- Define the target audience and understand their requirements.

- Plan the features and functionalities based on the gathered insights.

2. Design and Prototyping :

- Develop scenarios to guide the design process.

- Develop prototypes to test the usability and gather feedback from potential users.

- Refine the design based on feedback and ensure it meets user expectations.

3. Development :

A. Frontend Development:

- Use technologies create a responsive and user-friendly interface.

- Implement interactive elements and ensure seamless navigation.

B. Backend Development:

- Use robust technologies for server-side development.

- Develop the database structure to store user data, educational content, and interaction records securely.

- Implement the communication between the frontend and backend.

C. Blockchain Integration:

- Implement Blockchain technology to ensure data security and integrity.

- Develop smart contracts for secure transactions and data exchanges.

4. Testing :

A. Unit Testing:

- Test individual components and modules to ensure they function correctly.

B. User Acceptance Testing (UAT):

- Conduct testing sessions with real users (students and teachers) to gather feedback.

- Identify and fix any usability issues or bugs reported during UAT

5. Deployment :

- Prepare the production environment and ensure it is secure and scalable.

- Deploy the SafeLearn platform online for accessibility and reliability.

-Perform final testing to ensure everything works as expected in the live environment.

6. Launch :

- Plan and execute a launch strategy to introduce SafeLearn to the market.

- Leverage marketing channels such as social media, press releases, and events to create buzz.

- Offer promotional discounts and trial periods to attract early adopters.

7. Monitoring and Maintenance :

- Continuously monitor the platform for performance and security issues.

- Provide regular updates to fix bugs, improve features, and enhance security.

- Gather user feedback and make improvements to ensure the platform meets evolving needs.

4.4.2 Procurement

A.The Main Suppliers :

We will establish partnerships with content providers to obtain the necessary licenses to offer a wide range of content to our users. We will collaborate with leading companies in various fields to help us develop and promote our platform. Some of the main companies involved in our platform include:

- The university incubator.

4.4.3 Workforce

A. Number of Positions Offered

Our SafeLearn project, dedicated to enhancing educational experiences through advanced technology, offers approximately 19 direct job positions. These positions cover various essential areas.

B. The Nature and Type of Workforce

For the successful development, launch, and ongoing support of the SafeLearn platform, the following positions are offered:

1. **Project Manager (1 Position):**
   - Oversee the entire project lifecycle from planning to launch.
   - Coordinate between different teams and ensure timely delivery of project milestones.
2. **Software Developers (5 Positions):**
   - **Frontend Developers (2 Positions):**
     - Develop and maintain the user interface of the platform.
     - Ensure responsiveness and seamless user experience.
   - **Backend Developers (2 Positions):**
     - Build and maintain the server-side logic and database.
     - Ensure robust and secure data handling.
   - **Blockchain Developer (1 Position):**
     - Integrate Blockchain technology for data security.
     - Develop and manage smart contracts.
3. **UI/UX Designers (2 Positions):**
   - Design user-friendly interfaces and ensure a smooth user experience.
   - Create wireframes, prototypes, and conduct usability testing.

4. **Quality Assurance (QA) Testers (2 Positions):**
   - Conduct thorough testing of the platform to identify and fix bugs.
   - Perform unit, integration, and user acceptance testing.
5. **Marketing Specialists (2 Positions):**
   - Develop and execute marketing strategies to promote SafeLearn.
   - Manage social media, PR, and advertising campaigns.
6. **Customer Support (3 Positions):**
   - Provide technical support and assistance to users.
   - Handle user queries, feedback, and issues.
7. **Sales Representatives (2 Positions):**
   - Reach out to potential customers and partners.
   - Demonstrate the platform's features and benefits to educational institutions and organizations.
8. **Data Analysts (2 Positions):**
   - Analyze user data to gain insights and improve the platform.
   - Monitor platform performance and generate reports.

C. Retention and Talent Retention

To ensure the ongoing success of our service, it is crucial to implement retention policies aimed at ensuring the permanence and loyalty of talent. This may include social benefits, growth and development opportunities, as well as mentorship programs, among others.

Customer Support : It will be necessary to establish an efficient service to assist our users in resolving technical issues. This may involve having customer support agents available 24/7 to address user inquiries, setting up community support forums, and creating troubleshooting guides (table 4.1)

4.4.4 Key Partners

We find for our platform :

- Educational Institutions (schools, universities)
- EdTech Companies
- Government Agencies (ministries of education)
- Investors

Position	Number of Positions
Project Manager	1
Frontend Developers	2
Backend Developers	2
Blockchain Developer	1
UI/UX Designers	2
Quality Assurance (QA) Testers	2
Marketing Specialists	2
Customer Support Representatives	3
Sales Representatives	2
Data Analysts	2

Table 4.1 – Job Positions Offered for SafeLearn Project

4.5 Axe 05 : Financial plan

4.5.1 Costs and Expenses :

In the financial management of our platform, costs and expenses play a crucial role. Costs include all necessary expenditures to operate our business and provide our services. This can encompass expenses related to employee salaries, the acquisition of equipment and technologies, as well as our marketing and advertising activities.

On the other hand, expenses represent the long-term financial obligations we must assume. This includes employee salaries, rent for our premises, insurance fees, etc.

Effective management of our costs and expenses is important to ensure the profitability of our business. We must closely monitor our expenditures, identify areas where we can achieve savings, and implement measures to optimize our resources and reduce costs. This allows us to maximize our profits and remain competitive in the market.

4.5.2 Personnel Expenses :

Personnel expenses are essential to ensure the smooth operation of our platform and to maintain a competent and motivated workforce. These expenses demonstrate our commitment to our employees and our desire to create a satisfying workplace (table 4.2).

Amount	1st Year	2nd Year	3rd Year
Gross salaries	744 000,00	1 488 000,00	2 232 000,00

Table 4.2 – Personnel Expenses (in thousands of DA)

4.5.3 Statement of Overheads (Fixed and Variable) :

The statement of overheads (fixed and variable) details the ongoing expenses of the company by dividing them into two categories: fixed costs and variable costs. Fixed overheads include expenses that remain relatively constant regardless of the company's level of activity. On the other hand, variable costs fluctuate depending on the company's activity levels.

By separating these two types of expenses, we can identify which costs remain consistent and which ones fluctuate based on our business activity. This helps us understand how our expenses are allocated, enabling us to enhance profitability and effectively manage costs (table 4.3).

Designation	**1st Year**	**2nd Year**	**3rd Year**
Opening fees (electricity, telephone line)	19 580,00	0	0
Service establishment fees	17 000 ,00	0	0
Communication sign	1 121 000 ,00	2 242 000,00	2 242 000,00
Notary or attorney fees	30 000,00	0	0
Insurance	480 000,00	480 000,00	480 000,00
Electricity/Gas/Water	200 000,00	200 000,00	200 000,00
Phone/Internet subscription	192 000,00	192 000,00	192 000,00
Advertising and communication budget	175 000,00	175 000,00	175 000,00
Total	**2 234 580,00**	**3 289 000,00**	**3 289 000,00**

Table 4.3 – State of Fixed General Expenses (in thousands of DA)

4.5.4 The Investments state :

The investment statement presents the capital expenditures made by the company. These investments include the acquisition of new equipment and other assets used in the company's activity. This statement allows for the evaluation of the efficient use of company resources and enables measures to optimize their utilization (table 4.4).

4.5.5 Methods and Sources of Funding

To ensure the smooth operation of our startup, we plan to utilize various methods and sources of funding. This includes obtaining bank loans. Additionally, we have opted for self-financing by using a portion of our own profits to fund our ongoing activities and certain investments. By using this combination of funding methods and sources, we can obtain the necessary financial resources to develop our platform, improve our services, and provide a better experience for our users (table 4.5).

Element	Quantity	Amount (DA)
Whiteboard or Paperboard	1	7 000.00
Office Supplies	5	125 000.00
Lease Right	-	240 000.00
Printer / Scanner	2	126 000.00
Office Software	5	150 000.00
Office Furniture (per desk)	5	1 000 000.00
Computers	5	400 000.00
Internet Connection	-	120 000.00
Total	-	**2 168 000.00**

Table 4.4 – State of Depreciation and Investments (in DA)

Nature of financial contributions	Funding rate	Amount (DA)
Personal contribution	0,30	1 800 000,00
Credit	0,70	4 200 000,00
Total	**1,00**	**6 000 000,00**

Table 4.5 – Nature of Financial Contributions

4.5.6 Revenue

After a thorough market analysis, our platform SafeLearn expects an increase in its revenue over the first three years based on estimates of the number of views. It anticipates revenue growth over the next three years(table 4.6).

Service	Year 1 Amount	Year 2 Amount	Year 3 Amount
$\text{Safe}_{L}earnservicerevenue$	409 000.00	1 576 200.00	8 038 475.00
Advertising service revenue	0.00	1 440 000.00	4 200 .00000
Total Annual Revenue	**409 000.00**	**3 016 200.00**	**12 238 475.00**

Table 4.6 – Revenue (in thousands of DA)

Comment: The revenue from the SafeLearn service is expected to experience remarkable growth, increasing from 409,000.00 DA in the first year to 8,038,475.00 DA in the third year. This reflects the growing demand for online learning services and demonstrates the increasing success and popularity of this service.

The revenue from the Advertising service has shown significant growth, rising from 0.00 DA to 4,200,000.00 DA. This illustrates a successful expansion of this service and its ability to generate advertising revenue.

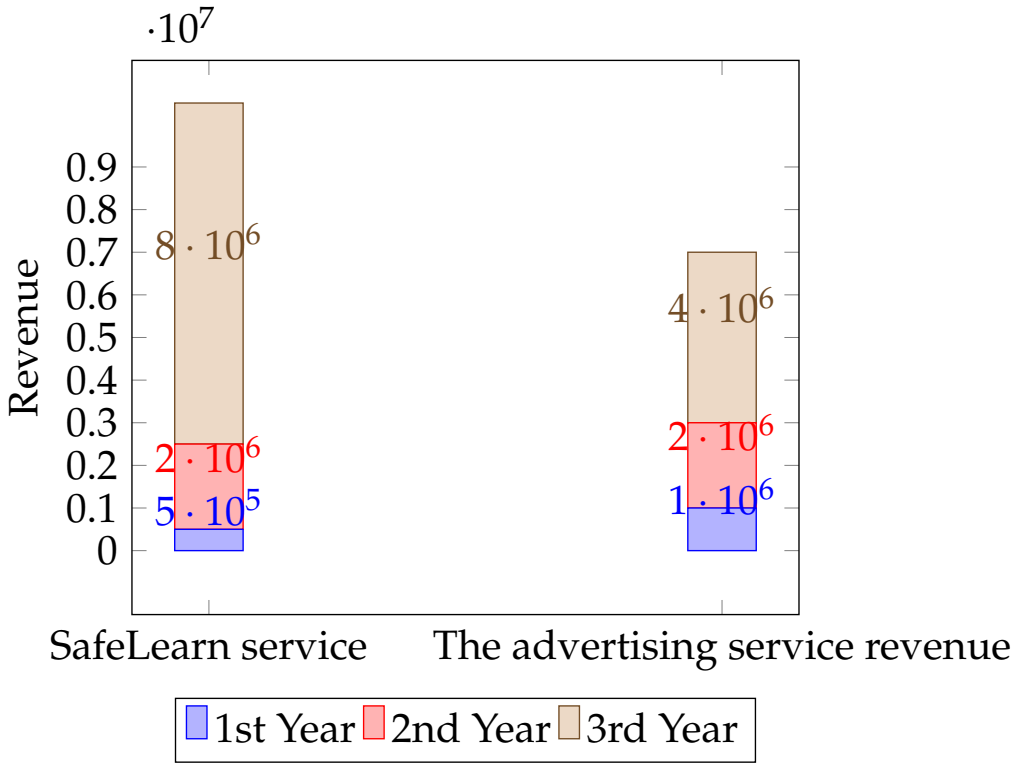


Figure 4.3 – The revenue of each service offered during the first three years

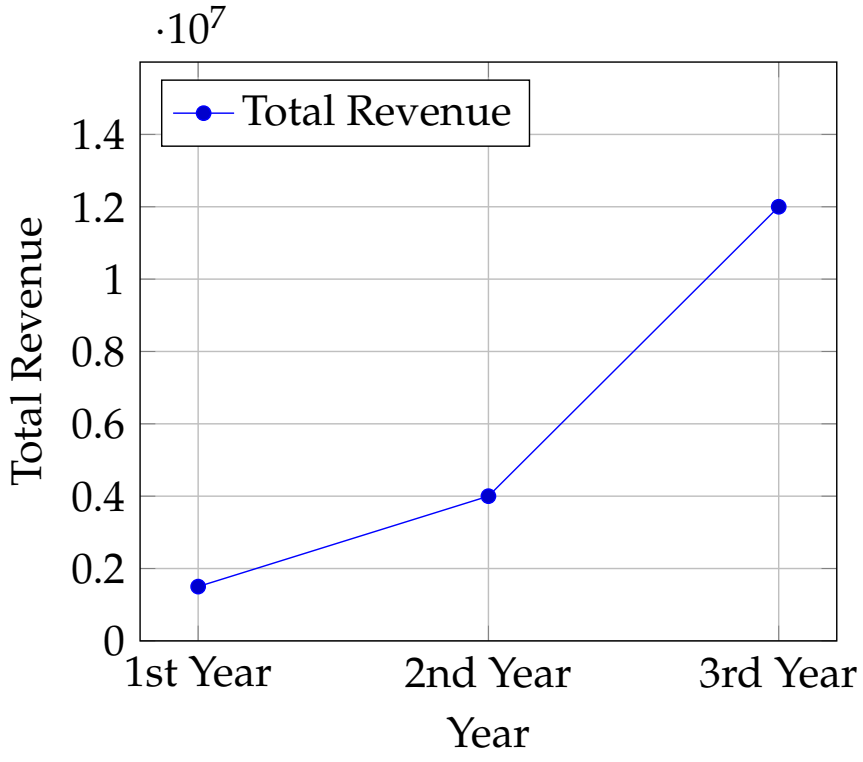


Figure 4.4 – Total revenue from services offered during the first three years

Comment : Over the next three years, the company will experience an overall growth in its revenue, increasing from 409 000.00 DA to 12 238,475.00 DA. These positive results reflect the company's ability to retain its customer base and effectively meet market demands.

4.5.7 Initial Financing Plan

Our initial financing plan is based on a diversified strategy to ensure the necessary resources for our startup. It relies on a combination of our own contributions and external financing. We plan to invest an amount of 1,800,000.00 DA from our own resources and secure an additional financing of 4,200,000.00 DA through bank loans.

From this combination of our own contributions and external financing, we are confident in our ability to fund our initial operations and achieve our ambitious growth plan (table 4.7).

Assets	**Amount**	**Liabilities**	**Amount**
Whiteboard or Paperboard	7 000,00	Personal contribution	1 800 000,00
Office Supplies	125 000,00	Credit	4 200 000,00
Lease Right	240 000,00		
Printer / Scanner	126 000,00		
Office Software	150 000,00		
Office Furniture (per desk)	1 000 000,00		
Computer	400 000,00		
Internet Connection	120 000,00		
Total Assets	**2 168 000,00**	**Total Liabilities**	**6 000 000,00**

Table 4.7 – Initial Financing Plan (in thousands of DA)

4.6 Deployment and Test

After developing the system, we deployed it for test by users from different universities. The platform is available on the next link: SafeLearn lin
After using the platform, we have created an online questionnaire on Google Form in order to collect the feedback from our users.
Figure 4.5 presents the percentage of the users whom tested our system.

Figures 4.7 and 4.6 presents the responses about Safe Learn system interfaces and functionalities respectively.

From figure 4.6, we observe that the users of Safe Learn system whom test it that : The majority of users find the system easy to use (figure 4.6a), the system is efficient (figure 4.6b). They appreciated the system interface (figure 4.6c) and they are satisfied by their spaces (figure 4.6d).

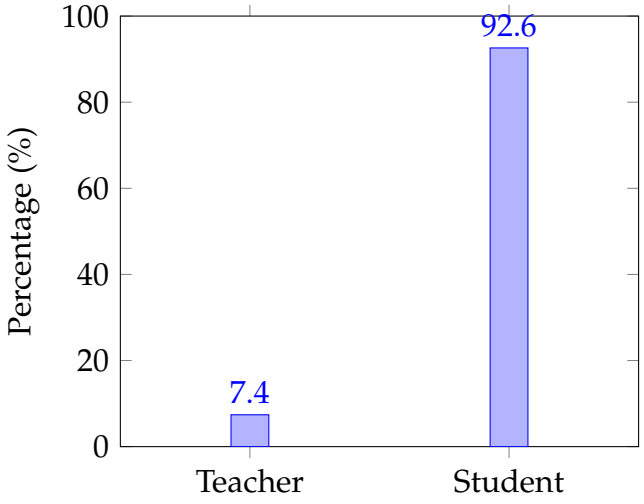
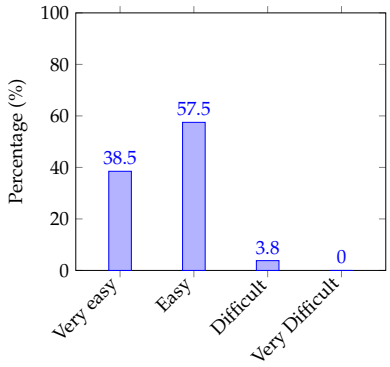
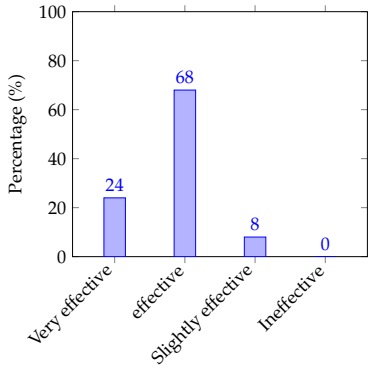


Figure 4.5 – Response to Question 1: Are you?

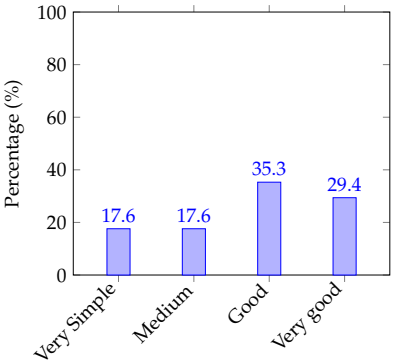
Also, from figure 4.7, we conclude that the users are satisfied and appreciated the new functionalities of Safe Learn system.



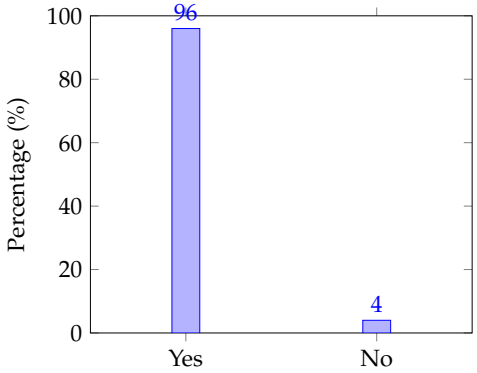
(a) Question 2: How do you find using this system?



(b) Question 3: How do you see the efficiency of the system?

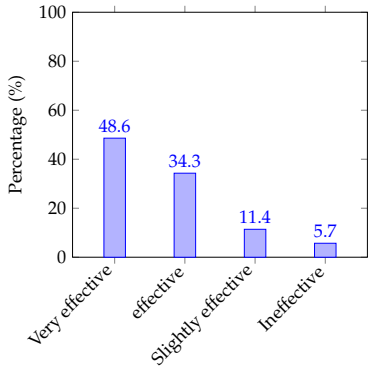


(c) Question 4: How do you find the system interface?

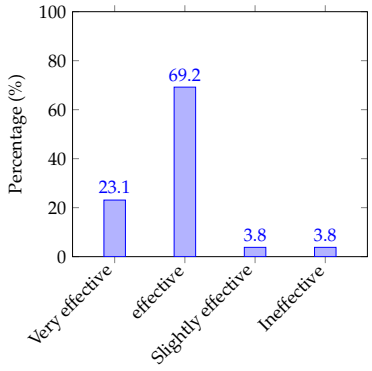


(d) Question 5: Are you satisfied with your space?

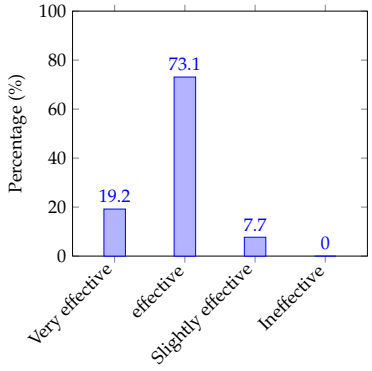
Figure 4.6 – Responses about Safe Learn System Interface.



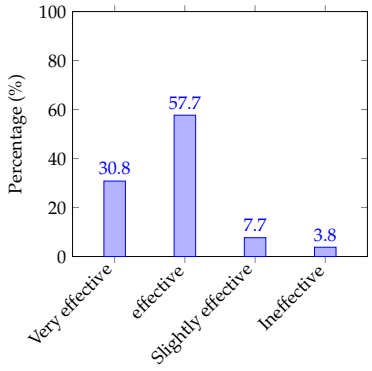
(a) Question 6: How do you find the updating news ?



(b) Question 7: How do you find the dynamic regrouping?



(c) Question 8: How do you find the Traces visualization?



(d) Question 9: How do you find the online test and it's security?

Figure 4.7 – Responses about Safe Learn System Functionalities.

General Conclusion

The significant increase in the use of social networks and their integration into educational environments highlights the evolution of online learning. Despite the advantages, educational social networks (ESNs) face critical issues in real-time student monitoring and data security. In this work, we have addressed these issues by proposing an innovative platform, SAFE LEARN, which integrates advanced tracking and analysis of learner behavior, as well as blockchain technology to ensure robust data security through a subsystem, SECURE Chain. The developed platform not only enhances the ability to monitor students in real-time but also secures sensitive data, thus promoting a safer and more effective learning environment. By integrating these technologies, we have provided a comprehensive solution that addresses the current limitations of ESNs.

As a Future work, we will focus on refining the platform's functionalities such as whiteboard for more interaction between members groups, exploring further applications of blockchain in education, and conducting experiments with real samples to validate its effectiveness.

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Appendix: Questionnaire after Deployment and Test of SAFE LEARN System

In order to improve the quality of services offered in the Safe Learn system, we ask you to seriously answer this questionnaire.

— **1. Are you?**

☐ Teacher

☐ Student

— **2. How do you find using this system?**

☐ Very easy

☐ Easy

☐ Very difficult

☐ Difficult

— **3. How do you see the efficiency of the system?**

☐ Very effective

☐ Effective

☐ Slightly effective

☐ Ineffective

— **4. How do you find the system interface?**

☐ Very simple

☐ Medium

☐ Good

☐ Very good

— **5. Are you satisfied with your space?**

☐ Yes

☐ No

— **6. How do you find the updating news?**

☐ Very effective

☐ Effective

☐ Slightly effective

☐ Ineffective

— **7. How do you find the dynamic regrouping?**

☐ Very effective

☐ Effective

☐ Slightly effective

☐ Ineffective

— **8. How do you find the trace visualization?**

☐ Very effective

☐ Effective

☐ Slightly effective

☐ Ineffective

— **9. How do you find the online tests and their security?**

☐ Very effective

☐ Effective

☐ Slightly effective

☐ Ineffective