CHAPTER ONE

INTRODUCTION

1.1 Background of Study

The blockchain technology has gained traction over the last 10 years after the emergence of the Bitcoin cryptocurrency which was introduced by a pseudonymous person (or group of people) known as Satoshi Nakamoto (Oberhaus, 2018). It is a decentralized, distributed, and oftentimes public, digital ledger consisting of records called “blocks” that is used to record transactions across many computers so that any involved block cannot be altered retroactively, without the alteration of all subsequent blocks (Armstrong, 2016). Satoshi conceptualized and improved the designs from the previous works done by Stuart Haber, W. Scott Stornetta, and Dave Bayer (Oberhaus, 2018). He worked on a solution that tackles the problem of double-spending using a peer-to-peer network, and also without the need of a trusted authority or centralized server (Nakamoto, 2008).

The Decentralization, immutability, integrity, and anonymity of the blockchain technology has led to its widespread adoption across the globe, and has since been used to develop decentralized systems which can be applied in various industries, including energy, logistics, finance, amongst others.

In centralized systems, a single entity controls the network, handles transactions, and wields the majority of power and decision-making authority (Shivang, 2020). This creates a single point of failure since the network is open to manipulation and control by the central authority. It also lacks transparency because the central authority controls the data and transactions handled on the network.

In contrast, decentralized technologies such as blockchain technology distributes the network among a large number of nodes, making it more secure and transparent (Anshika, 2021). Transactions are validated by various network nodes, resulting in a consensus-based system that is immune to censorship and manipulation. There is no single point of failure because the network runs autonomously and is maintained by the combined efforts of all nodes.

Despite the active use of the blockchain technology, it is still emerging and its whole concept is still poorly understood (Tovanich et al., 2021). According to an HSBC survey, 59 percent of consumers across the world said they have never heard of the blockchain technology (Samantha Yap, 2017). The survey, which questioned 2,000 Britons and 1,000 each from Canada, China, France, Germany, Hong Kong, India, Mexico, Singapore, the United Arab Emirates, and the United States, also discovered that 80% of individuals who have heard of blockchain do not know what it is all about.

In addition to that, there have been a lot of misconceptions also about what the blockchain technology truly entails. A lot of people often misplaces it to be the same as bitcoin or other cryptocurrencies. The blockchain technology is however vast and can be used extensively across various fields. It is a decentralized system managed by autonomous mechanisms that ensures that data is stored and maintained among peers in the network by the consensus of the network majority.

There is a sizeable collection of easily accessible resources within the blockchain scope for learners of different skill levels and interests. This includes related courses on popular learning platforms like Coursera, Udemy, Codecademy, and so on. These resources are however streamlined to different blockchain applications with no much focus spent on delineating the core technology and its encompassing concepts.

In order to clearly understand how the core blockchain technology works, we need to devise an interactive system that educates on the fundamentals and mechanisms of the blockchain technology. This system involves the coordinated and synchronized exchange of information using agreed conventions and procedures (Barker, 2006). In this context, an interactive system is a kind of system designed with interactive components. These components are frequently in the form of user interfaces, which enable the users work more efficiently with that system.

However, many blockchain-based visualization systems are focused mainly on cryptocurrency and phenomena for viewing online transaction data (Zhong et al., 2020). These traditional blockchain explorers mostly present those information in textual, tabular, graphical, or other more complex forms, which makes understanding the core blockchain technology mechanisms difficult for novice users.

This project work therefore focuses on elucidating and demonstrating how the blockchain technology works in a more basic and simpler way. Here, we work towards implementing a web application that teaches the blockchain technology. The application will provide educational resources, interactive exercises, and quizzes to help users understand the fundamentals of blockchain and its potential use cases. The web application will also include real-world examples and case studies to illustrate the practical applications of blockchain technology.

1.2 Statement of Problem

Many people are still left behind as blockchain technology develops, not because they lack interest in the technology but rather because they do not have a thorough understanding of its foundation and operation. Exploring the web or other learning resources to learn about the fundamental workings of the technology frequently produces insufficient results because the majority of those materials are based on the cryptocurrency implementation of the blockchain technology.

Therefore, this project work will be focused on designing and implementing a system that help elucidate the basis and core mechanisms of the blockchain technology.

1.3 Aim and Objectives of the Study

This work aim to design and implement a web-based interactive system for blockchain education. It provide users with an interactive and engaging way to learn about the blockchain technology, covering a wide range of topics related to this technology, and making the learning process accessible to a wide range of users. This aim will be achieved through the following objectives:

i. Design a system to educate on the core mechanisms of blockchain technology in the barest and simplest way.
ii. Implement the designed work using modern web technologies such as React.js, Next.js, Node.js, MongoDB, amongst others.
iii. Populate the application with real data and practical content.
iv. Test and evaluate the implemented system.

1.4 Significance of the study

Although blockchain technology is quickly becoming well-known and widely used in many sectors, there remains a notable lack of understanding and expertise among the general public. By creating and deploying an interactive system for blockchain education, this study seeks to close this gap. The system intends to make blockchain education accessible and clear for a larger audience by offering a dynamic learning environment.

The suggested system will be created to meet the requirements of many user groups, including students, teachers, and professionals. Additionally, the system's interactive features will help users remember information more effectively and give them chances to put what they have learned into practice.

The field of blockchain education could gain a lot from the deployment of this approach. It may be a helpful tool for educators and trainers, as well as a source for people and organizations interested in learning more about blockchain technology. The method may also aid in the growth of a more knowledgeable and educated blockchain community, which will speed up the adoption and advancement of blockchain technology.

1.5 Scope and limitations

The project intends to create and put into use an interactive blockchain teaching system. Users will be able to learn about the principles of blockchain technology and its numerous applications using the interactive modules and quizzes included in this system. The system will also have an intuitive user interface that will make it simple for users to explore and communicate with the modules.

The project however does not involve the creation of any underlying blockchain technology; rather, it is restricted to the design and implementation of the interactive system. The system will concentrate on educating people about the fundamentals of blockchain technology, it won't cover complex technical specifics or how to use blockchain in particular use cases. Additionally, it excludes any research on the system's efficacy and is restricted to the system's design and implementation.

CHAPTER TWO

LITERATURE REVIEW

2.1 Centralized and Decentralized systems

Decentralization is one of the fundamental principles upon which blockchain technology is based (Schneider, 2019), and in order to understand what decentralized systems are, we must first understand what centralized systems are before delving more into the specifics of the blockchain technology in general.

Centralized systems are networks in which the entire network is controlled by a single central authority or node (Anshika, 2021). This centralized authority has complete control over the network's data and resources, and all transactions pass through it. In traditional organizational structures, centralized systems are frequently used, with a single body in charge of network maintenance and management. Take, for example, Facebook. When you make a post, upload a photo, or share a video from a page, the data is transferred from your device to the Facebook server, where it is stored and routed to your followers. In this situation, Facebook is the central authority in charge of keeping, processing, and transmitting all data (Centralized and Decentralized Networks, 2022).

Centralized networks are currently the most prevalent type of network on the internet. Because these networks rely on a single network owner to link all of the other satellite users and devices, there is a single point of failure that malicious actors can purposely exploit (Networks: Decentralized, Distributed, & Centralized, 2021).

Decentralized systems, on the other hand, are networks in which data and resources are distributed over various nodes and there is no single central authority controlling the network. Instead, the network runs autonomously and is maintained by the combined efforts of all nodes. Decentralized systems are intended to be dispersed and transparent, with each node having equal authority and accountability (Anshika, 2021).

One of the primary advantages of decentralized systems is that they are less susceptible to faults because there is no single point of failure in the network. Furthermore, because they are not controlled by a single central authority, decentralized systems are frequently more secure, making them less vulnerable to hacking or manipulation. Decentralized systems are also more transparent because all transactions are made public and can be confirmed by numerous nodes (Xuan, 2022).

Blockchain technology is a prominent example of a decentralized system, in which the network operates on a consensus-based method, allowing for secure and transparent transactions in the absence of a central authority. As a result, decentralized systems are becoming increasingly crucial in the development of a wide range of applications, including cryptocurrency, supply chain management, and digital identity management.

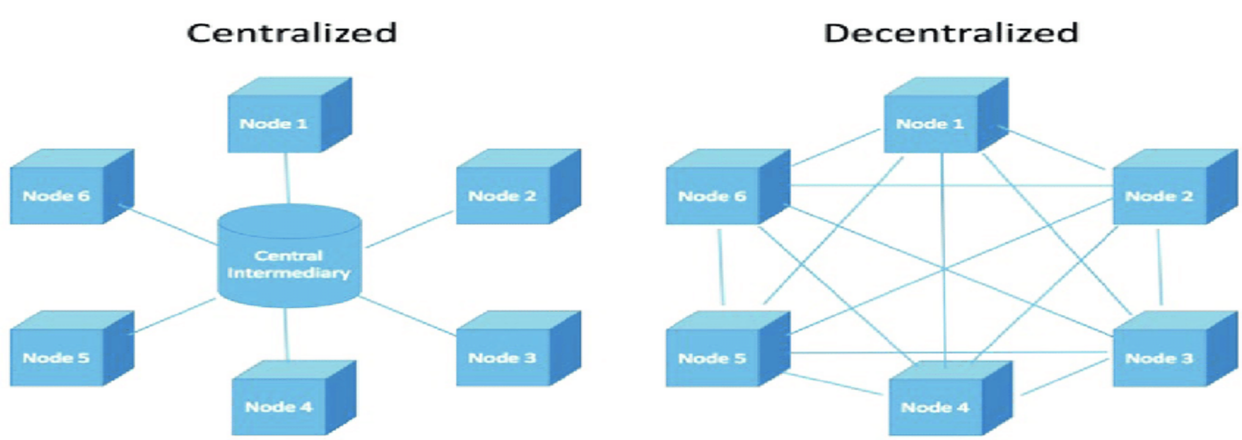

Fig 2.1. Structure of centralized system and decentralized system. (Patrick et al., 2018)

2.2 Blockchain Technology Overview

The blockchain is a technology built on the concept of decentralization. It is a distributed, and often public, digital ledger consisting of records called blocks that are used to record transactions across many computers so that any involved block cannot be altered retroactively, without the alteration of all subsequent blocks (Armstrong, 2016). In other words, the blockchain can also be defined informally as distributed digital ledgers of cryptographically signed transactions organized into blocks (Yaga et al., 2019). Following validation and consensus, each block is cryptographically connected to the previous one (making it tamper evident). As new blocks are added, older ones become increasingly difficult to change (creating tamper resistance). New blocks are duplicated across network copies of the ledger, and any conflicts are resolved automatically using predefined rules.

Blockchain technology and distributed ledgers are generating a lot of buzz and sparking a lot of projects in a variety of industries. The financial industry, on the other hand, is considered as the principal user of the blockchain concept. This is attributable not only to the fact that the most well-known use of this technology is the crypto-currency Bitcoin, but also to significant process inefficiencies and a major cost base issue, which are unique to this business.

The idea of blockchain had been in existence prior to the implementation of the blockchain technology. In his 1982 dissertation "Computer Systems Established, Maintained, and Trusted by Mutually Suspicious Groups", cryptographer David Chaum presented a blockchain-like protocol for the first time (Sherman et al., 2018). Stuart Haber and W. Scott Stornetta described additional work on a cryptographically secured chain of blocks in 1991 (Haber & Stornetta, 1991; Narayanan et al., 2016). They intended to put in place a mechanism that would prevent document timestamps from being tampered with. In 1992, the duo and Dave Bayer refined the idea by using Merkle trees, which allowed numerous document certificates to be aggregated into a single block (Bayer et al., 1992).

However, the notion of the first decentralized blockchain was initially proposed in 2008, with the publishing of the Bitcoin whitepaper by an anonymous individual or group operating under the alias Satoshi Nakamoto (Oberhaus, 2018). Satoshi envisioned a decentralized digital money that could be safely exchanged without the use of intermediaries such as banks in the whitepaper. The idea was implemented the following year (2009) by Nakamoto as a core component of the cryptocurrency bitcoin, and it has since grown to become the cryptocurrency industry's backbone. The technology has also grown and extended throughout time, and new blockchain-based platforms began to emerge.

The Ethereum blockchain was established in 2015, introducing the notion of smart contracts, which are self-executing contracts with the contents of the agreement explicitly inscribed into lines of code. This broadened the potential uses for blockchain technology and cleared the way for the creation of decentralized applications (dApps).

In the years thereafter, blockchain technology has continued to improve and mature, with new solutions being developed for a variety of industries, including supply chain management, digital identity verification, voting systems, and others.

In the subsequent sections, we'll explore the key features, structure and design of the blockchain technology, the various types of blockchain, amongst others.

2.3 Key features of the blockchain technology

The blockchain technology is a decentralized digital ledger that enables secure and transparent transactions. The key features of blockchain technology make it a secure, transparent, and efficient way to store and transfer data and assets. These features have the potential to revolutionize various industries, and blockchain is already being used in a variety of applications. Some of these features include Immutability, Decentralization, Enhanced security, Transparency, Distributed ledgers, Consensus, Faster settlement, amongst others (Gwyneth, 2021).

2.3.1 Immutability

There are various fascinating blockchain features, but "Immutability" is without a doubt one of the key features of blockchain technology. Immutability means something that can't be changed or altered. Once data is stored on the blockchain, it cannot be changed or removed. This capability is enabled through the use of cryptographic techniques, which secure the network and prevent manipulation.

Instead of relying on centralized authorities, blockchain operates through a network of nodes. Every node in the system has a copy of the digital ledger. To add a transaction, each node must validate it. If the majority agrees, it is entered into the ledger. This promotes transparency and makes it impervious to corruption. As a result, no one can add any transaction blocks to the ledger without the consent of the majority of nodes.

2.3.2 Decentralization

The network is decentralized, which means there is no governing authority or one individual in charge of the structure. The network is instead maintained by a collection of nodes, making it decentralized. Transactions are validated and added to the chain by a network of nodes, rather than a central authority.

With decentralization, the blockchain is highly fault-tolerant as there is no single point of failure. Because of the system's nature, it is a one-of-a-kind system for every type of person. And hackers will have a difficult time breaking it.

2.3.3 Enhanced security

To safeguard the network and prevent hacking, fraud, and other forms of tampering, blockchain employ cryptographic techniques such as public key encryption and digital signatures. Cryptography, when combined with decentralization, adds another degree of security for users. Cryptography is a complicated mathematical algorithm that serves as a firewall against attackers.

2.3.4 Transparency

All transactions on a blockchain are public and can be viewed by anyone, ensuring transparency and accountability. As a result, it is well-suited for usage in areas requiring high degrees of openness, such as finance and healthcare.

2.3.5 Distributed ledgers

Typically, a public ledger will contain all relevant information about a transaction and its participants. There's nowhere to hide because it's all out in the open. The rationale for private or federated blockchain is slightly different. However, in certain circumstances, numerous people can see what is going on in the ledger. This is because the network ledger is maintained by all other users on the system. This spread computational power across the machines in order to achieve a better result. This is why it is regarded as one of the blockchain's crucial properties. The end result is always a more efficient ledger system that can compete with traditional ones.

2.3.6 Consensus

Because of the consensus algorithms, every blockchain thrives. The architecture is ingeniously constructed, and consensus mechanisms are at its heart. Simply put, the consensus is a decision-making procedure for the collection of network nodes. Here, the nodes can reach an agreement pretty quickly. A consensus is absolutely necessary for a system to work smoothly when millions of nodes are validating a transaction. Consider it as a voting system in which the majority wins and the minority must support it.

2.3.7 Faster settlement

Traditional financial systems are rather slow. After finalizing all settlements, it might often take days to finalize a transaction. It is also easily corruptible. When compared to traditional banking institutions, blockchain allows for speedier settlement. This allows the user to transfer money more quickly, saving time in the long run.

2.4 Components and structure

Blockchain technology may appear difficult, but it can be simplified by looking at each component individually. At its most basic, blockchain technology combines well-known computer science methods and cryptographic primitives (such as cryptographic hash functions, digital signatures, and asymmetric-key cryptography) with record keeping principles (such as append only ledgers) (Yaga et al., 2019). This section goes over each major component individually: Transactions, asymmetric-key cryptography, addresses, ledgers, blocks, and how blocks are connected together are all covered.

2.4.1 Cryptographic hash functions

The usage of cryptographic hash functions for many operations is a fundamental component of the blockchain technology. A cryptographic hash function is a mathematical function that is used in encryption. Typical hash functions take variable length inputs and return fixed length outputs. A cryptographic hash function combines hash function message-passing capabilities with security features (Frankenfield, 2022). It is a function that accepts a variable-length string and encodes it as a fixed-length hash value or message digest. It accomplishes this using proper, many, and complicated mathematical processes.

The Secure Hash Algorithm (SHA), with an output size of 256 bits, is a specific cryptographic hash function utilized in several blockchain implementations (SHA-256). This algorithm is supported in hardware by many computers, making it fast to compute. SHA-256 produces 32 bytes (1 byte = 8 bits, 32 bytes = 256 bits), which is typically shown as a 64-character hexadecimal string (Yaga et al., 2019).

Highlighted below is a table showing sample text and their corresponding SHA-256 digest values.

Table 2.1: Examples of Input Text and Corresponding SHA-256 Digest Values (Yaga et al., 2019)

Input Text	SHA-256 Digest value
1	6b86b273ff34fce19d6b804eff5a3f5747ada4eaa22f1d49c01e52ddb7875b4b
2	d4735e3a265e16eee03f59718b9b5d03019c07d8b6c51f90da3a666eec13ab35
Hello	185f8db32271fe25f561a6fc938b2e264306ec304eda518007d1764826381969

Cryptographic hash functions are utilized for a variety of tasks in a blockchain network, including Address derivations, creating unique identifiers, securing the block data and the block header.

The block data is likewise secure when the block header digest is inserted in the subsequent block since the block header offers a hash representation of the block data.

2.4.2 Cryptographic Nonce

"Nonce" is an abbreviation for "number used only once." It is a four-byte number that is appended to a hashed (or encrypted) block in a blockchain that, when rehashed, meets the difficulty level constraints (Frankenfield, 2022). A cryptographic nonce can be combined with data to produce different hash digests per nonce:

$$\text{hash (data + nonce) = digest} \qquad \text{eq (2.1)}$$

Changing only the nonce value creates a way for obtaining alternative digest values while retaining the same data.

2.4.3 Transactions

A transaction refers to the exchange of value, data, or assets between two or more parties. This can include the transfer of cryptocurrencies, the exchange of goods or services, or the creation of a new digital asset. The data that makes up a transaction varies depending on the blockchain implementation, but the technique for transacting is basically the same (Yaga et al., 2019). A user of the blockchain network sends data to the blockchain network. The information delivered may comprise the sender's address (or another relevant identifier), the sender's public key, a digital signature, transaction inputs and outputs, and transaction inputs and outputs.

Once a transaction is completed and published to the blockchain, it becomes part of a permanent, publicly available record that can be used to authenticate asset transfers and trace digital asset ownership over time. Because of the Blockchain's decentralized character, transactions are visible, safe, and tamper-resistant, making it a vital tool for secure and efficient transactions.

2.4.4 Asymmetric-Key Cryptography

Blockchain technology uses asymmetric-key cryptography which involves a pair of keys (public and private) that are mathematically related to each other. The public key is public but the private key must remain secret. Asymmetric-key cryptography allows for trust between users without a prior relationship by verifying the integrity and authenticity of transactions through digital signatures encrypted with the private key. This is in contrast to symmetric-key cryptography where a single secret key is used for encryption and decryption. Asymmetric-key cryptography is often slow to compute but is improved by using a "trick" where the data is encrypted using symmetric-key cryptography and then the symmetric-key is encrypted using asymmetric-key cryptography.

2.4.5 Blocks

A block is a collection of verified and grouped data that is kept on the blockchain network as a single unit. It is a fundamental component of the blockchain and is critical to the network's integrity and security (H. Adam, 2022). A block consists of a block header and block data. This block's metadata is stored in the block header. The block data comprises a list of validated and legitimate transactions that have been published to the blockchain network.

It should be noted that each blockchain implementation has the ability to specify its own data fields; nonetheless, many blockchain implementations use data fields such as the ones listed below (Yaga et al., 2019):

- Block Header
  - The block number, also known as the block height in some blockchain networks.
  - A timestamp
  - The hash value of the previous block header.
  - A hash representation of the block data (different methods can be used to accomplish this, such as a generating a Merkle tree, and storing the root hash, or by utilizing a hash of all the combined block data).
  - The nonce value
  - The size if the block

- Block Data
  - A list of transactions and ledger events included within the block.
  - Other data may be present.

A block's transactions can be of numerous forms, including as financial transactions (such as cryptocurrency transfers), smart contract execution, or other types of data storage. Network nodes verify the transactions within a block and add them to the block after they are confirmed. When a block is added to the blockchain, its contents become immutable, which means they cannot be changed or erased. This ensures that data kept on the blockchain is secure and untampered with.

2.4.6 Chaining Blocks

Blocks are chained together by each block having the hash digest of the previous block's header, forming the blockchain. If a previously published block gets altered, it would have a different hash. As a result, all following blocks will have different hashes because they incorporate the hash of the prior block. This makes it simple to detect and reject altered blocks.

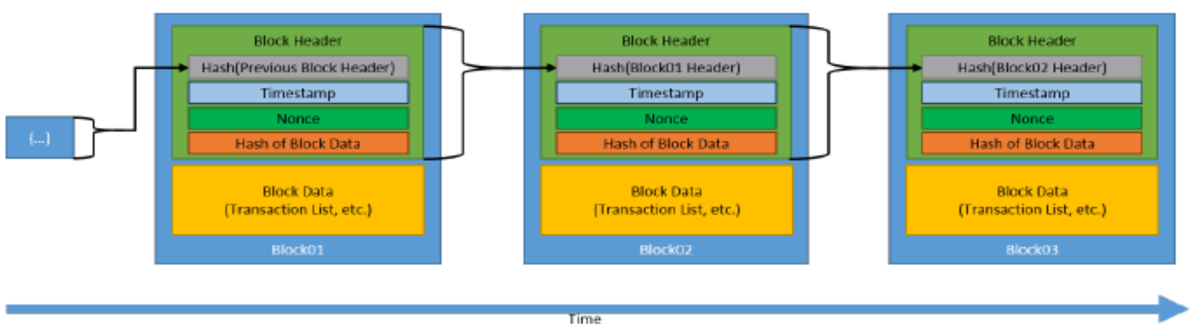

Fig 2.2. Chain of block (Yaga et al., 2019)

2.5 Types of Blockchain Networks

There are several different types of blockchain networks, each with its own unique features and characteristics. The following are some of the most frequent types of blockchain networks:

i. Public Blockchain: A public blockchain has no access limitations. Anyone with an Internet connection can send transactions to it and become a validator (i.e., participate in the execution of a consensus protocol) (Rostyslav, 2017). This form of blockchain network is open to anyone and entirely decentralized, which means that no single entity controls the network. The bitcoin blockchain and the Ethereum blockchain are two of the most well-known public blockchains.

ii. Private Blockchain: Permissions are required for a private blockchain (Rob, 2017). It is only accessible to those who have been invited by the network administrators. Access for participants and validators is restricted. A private blockchain network is often run by a single entity and is not accessible to the general public. Access to the network is restricted and requires the network operator's approval. Private blockchains are frequently utilized in enterprise applications where privacy and security are important considerations.

iii. Hybrid Blockchain: A hybrid blockchain has a combination of centralized and decentralized features (Martin, 2018). The chain's exact operation depends on which sections of centralization and decentralization are used. A hybrid blockchain network integrates components of both public and private blockchains in order to deliver the best of both worlds. A hybrid blockchain, for example, may be publicly available, but only authorized users can read sensitive information or conduct certain transactions.

Each type of blockchain network has distinct advantages and disadvantages, and the network type selected will be determined by the specific demands and requirements of the application or use case. Overall, the sort of blockchain network adopted will have an impact on the network's level of security, privacy, and decentralization.

2.6 Applications of Blockchain Technology

Blockchain technology has the potential to disrupt numerous industries and applications. The following are some of the most common blockchain applications:

i. Cryptocurrencies: The most well-known (and perhaps most contentious) application of blockchain is in cryptocurrency. Cryptocurrencies are digital currencies (or tokens) that can be used to purchase goods and services, such as Bitcoin, Ethereum, or Litecoin. Cryptocurrency, like a digital version of cash, may be used to purchase everything from your lunch to your next home. Unlike cash, cryptocurrency employs blockchain to serve as a public ledger as well as an advanced cryptographic security mechanism, ensuring that all online transactions are always recorded and protected (Daley, 2022).

ii. Smart Contracts: Smart contracts on the blockchain are proposed contracts that can be partially or entirely implemented or enforced without the need for human intervention (John, 2017). A smart contract is an agreement between two people in the form of computer code (Laura, 2022). Smart contracts have several uses, including real estate transactions, financial derivatives, and online markets.

    One of the primary goals of a smart contract is automated escrow. They do not require a trusted third party (such as a trustee) to act as an intermediary between contracting entities – the blockchain network executes the contract on its own. This may lessen friction between entities when transferring value and, as a result, may pave the way for a higher level of transaction automation (Casey, 2018).

iii. Logistics and Supply chain management: Using blockchain technology to track things as they move through a logistics or supply chain network can have a number of benefits. For starters, because data is available on a secure public ledger, it facilitates communication between partners. Second, because the data on the blockchain cannot be manipulated, it provides higher security and data integrity. As a result, logistics and supply chain partners can collaborate more readily, with greater confidence that the data provided is reliable and up to date (Adam, 2022).

iv. Digital Identity: Blockchain technology can be used to securely and transparently handle personal data by storing and managing digital identities. This is especially useful in voting systems and other applications where identity verification is crucial.

v. Healthcare: Blockchain technology can be used to securely store and maintain patient health records, giving healthcare professionals with a centralized and tamper-proof source of information.

These are only a few of the multiple potential applications of blockchain technology. As the technology advances, new and novel uses for blockchain are expected to emerge, altering the way individuals, businesses, and entire industries work.

2.7 Blockchain Education

Blockchain technology has made headlines as one of the most disruptive and exciting technologies of our time. Most people compare it to the advent of the dot-com era, which transformed company operations and resulted in the development of billion-dollar industries (Aviv, 2018). Experts believe that the impact of blockchain will be as enormous as that of the internet age.

Blockchain education is the study and comprehension of the fundamental principles and technology underlying blockchain and its applications (Philipp & Felix, 2022). Blockchain education can be provided in a variety of formats. Subjects that teach learners about blockchain can be included in school and higher education curricula. Companies that develop blockchain technology, as well as those that embrace it, can also initiate projects to sensitize and educate the public about blockchain, its uses, and potential.

Special courses, similar to programming, can be designed to teach people how to create and implement blockchain. As start-ups and traditional enterprises dive into decentralized ledger technology, blockchain developers have been in great demand, and there has actually been a shortage of blockchain developers (Aviv, 2018). Traditional learning institutions do not provide blockchain development courses, and the few blockchain developers and specialists who do exist are primarily self-taught.

Blockchain education is something that individuals and corporates dealing with the technology have been attempting to do in order to not only empower individuals but also provide them with a basic understanding of how the technology works and its benefits.

In the subsequent sub-sections, we will cover some of the challenges of blockchain education, as well as, the best practices and successful approaches in blockchain education.

2.7.1 Challenges and Barriers to Blockchain Education

There are several challenges and barriers that hinder the widespread adoption of blockchain education. Some of the major challenges and barriers are:

i. Complexity of the technology: Blockchain technology is complex and difficult to grasp, making it difficult to teach and learn. The lack of a clear and precise definition of blockchain further complicates matters.

ii. Limited number of resources and qualified instructors: There is a scarcity of resources as well as people with hands-on experience developing blockchain applications and a thorough understanding of the technology.

iii. High cost of education: Many universities and institutes demand exorbitant fees for blockchain courses, making it difficult for people with low incomes to get an education in this sector.

iv. Slow adoption by traditional educational institutions: Many traditional educational institutions have been extremely slow to implement blockchain education, limiting the number of courses and programs available in this subject.

These are key obstacles that must be solved for blockchain education to attain its full potential. Nonetheless, the potential benefits of blockchain technology make it a viable topic of study, and attempts are being made to solve these difficulties and make blockchain education more accessible and standardized.

2.7.2 Best Practices and Successful Approaches to Blockchain Education

As blockchain technology gains popularity across businesses, there is an increasing demand for experts in this industry. To fulfil this demand, educational institutions are experimenting with various blockchain education initiatives. Here are some of the best practices and methods to blockchain education that have shown to be effective:

i. Hands-on experience: Providing hands-on experience in designing blockchain applications is a critical component of effective blockchain education. This allows students to comprehend technology and its applications in a practical situation rather than just learning theory.

ii. Focus on core principles: While providing students with hands-on experience is crucial, it is also critical to ensure that they have a thorough understanding of the fundamental principles of blockchain technology. Cryptography, consensus techniques, and decentralized systems are examples of such topics.

iii. Emphasis on practical applications: Blockchain technology has numerous potential uses, which should be highlighted in educational programs. This enables students to comprehend the practical ramifications of blockchain technology and its potential to alter a variety of sectors.

iv. Incorporation of real-world projects: Blockchain technology has numerous potential uses, which should be highlighted in educational programs. This enables students to comprehend the practical ramifications of blockchain technology and its potential to alter a variety of sectors.

v. Integration of blockchain technology into existing courses: A successful way to blockchain education is to incorporate blockchain technology into existing curricula. This enables students to comprehend how blockchain technology can be utilized in their particular professions, as well as to have a thorough understanding of the technology's prospective use cases.

These best practices and successful blockchain education initiatives ensure that learners obtain a full and effective education in this sector. Adopting these approaches allows people to get a thorough understanding of blockchain technology and its possible applications, which is essential for success in this industry.

2.8 Interactive Learning System

Dynamic web-based learning tools are essential in modern teaching, especially given their capacity to provide on-demand interaction as a means of motivating and engaging students (Humar et al., 2005). Modern web-based technologies can serve as a link between challenging educational programs on one hand and students that require significant incentive on the other. These tools are beneficial additions to both the traditional educational process and autonomous asynchronous learning. Dynamic displays, interaction, online calculations, music, and video can all be included. All of these characteristics might be motivating for learners (Bulic et al., 2004; Iskander, 2002).

An interactive learning system (ILS) is a form of educational technology that engages individuals in a dynamic and interactive learning experience. An ILS's primary purpose is to assist student learning by providing individualized, self-paced, and interactive learning experiences.

A good technical sketch is a basic aspect of explanation in engineering. Furthermore, equations, specific notations, and graphs are frequently used in technical writing. These elements are now well supported by web-based technologies. In compared to traditional printed books, web-based technologies have the benefit of allowing specific elements of technical sketches to appear progressively on the screen through animation, coordinated with, for example, corresponding steps in the derivation of equations. Learners can obtain a better understanding of the frequently demanding and difficult-to-imagine role and meaning of theory in a given discipline by using such web-based educational settings. Furthermore, learners have access to a wide range of practical examples that showcase even more difficult structural problems that they will have to deal with throughout further study, engineering practice, and research (Humar et al., 2005).

According to research, students learn best when they are actively involved in relevant and real activities, and technology is making this more attainable (Freeman, 2014).

Interactive learning systems are available in a range of media, including web-based platforms, mobile apps, and virtual reality environments. They frequently include multimedia content (e.g., movies, animations, simulations), gamification elements (e.g., prizes, challenges), and real-time student feedback. Interactive learning systems can also give students an opportunity to learn at their own pace, reaffirm their comprehension of complex ideas, and put what they've learned into practice through interactive exercises and activities.

2.9 Review of Related Works

This section delves into existing literature, research, and projects that are closely linked to the proposed system. It investigates the present state of blockchain education by comparing various approaches, methodology, and technology used in similar projects. By assessing the strengths and flaws of these linked efforts, we hope to uncover gaps and potential for innovation in the current project work. This part serves as the cornerstone for the system design and implementation, providing significant insights and expertise to inform the approach and contribute to the growth of blockchain education.

Table 2.2: Summary of Related Works

S/N	Author/Year	Title	Methodology	Result	Limitations
1	(Dudhat et al., 2021)	Blockchain in Indonesia University: A Design Viewboard of	The Edublocs project conducts 5 implementation evaluations	The study evaluates the implementation of the Edublocs initiative in the	Limitations of using Blockchain in the Edublocs project include

		Digital Technology Education	during the first year to analyze progress and address problems. The methodology involves gathering and analyzing information from various sources. The results are organized into two main analytical dimensions to provide a comprehensive explanation of the evidence obtained.	fourth month. Results are grouped into process analysis and remaining problems. The Edublocs Gradebook allows public record-keeping of class information, but additional steps are required for data transfer. The TEA application simplifies efforts for teachers, but the double step design has limitations. Implementing Blockchain can cause malfunctions initially but is incorporated into the platform seamlessly once deployed.	costs and acceptance from educators, scalability and customization challenges, and concerns related to information legitimization, validation, privacy, and security in a global environment.
2.	(Wu & Li, 2018)	Design of Evaluation System for Digital Education Operational Skill Competition Based on Blockchain	The methodology in the abstract involves using blockchain technology to improve competition mode in digital education. This includes studying competition mode, designing blockchain's	The blockchain-based operational skill competition evaluation system aims to simplify competition processes, improve efficiency, and ensure credibility through system transparency and data non-tampering. The evaluation model	Some of the limitations include unscientific competition, lack of transparency, and reliance on subjective evaluation. The proposed solution of a blockchain-based operational skill competition

			application mode and frame, analyzing evaluation criteria and algorithm, designing an operational skill evaluation model, and developing an operational skill competition evaluation system based on e-business sandbox. Experiments are conducted to validate the system.	and system are tested and found to be accurate and technically feasible. Further research is suggested to combine smart contract technology with the operational skill evaluation model and optimize the model using machine learning.	evaluation system aims to address these issues, but further research is needed to optimize the model using machine learning and increase data.
3	(Guustaaf et al., 2021)	Blockchain-based Education Project	The research methodology used in this study involves conducting a systematic literature review (SLR) following the guidelines provided by Barbara Kitchenham. The three main stages of SLR, namely planning a review, conducting a review, and reporting a review, was followed.	Research findings suggest that using a systematic literature approach to map out blockchain-based education projects can resolve common problems and bring decentralized benefits. However, further development is needed as the technology is still in an early experimental stage.	Potential limitations inferred include: early experimental stage, need for more extensive development, and lack of specific information on limitations.

4	(Ye et al., 2018)	Design and Implementation of an Online Learning System	The methodology used in the research involves designing an online learning system with data analysis and feedback functions. The system is used by students for online learning, and teachers can use the data feedback part of the system to understand students' overall learning situation and adjust teaching plans accordingly.	The research resulted in the design of an online learning system that meets students' needs, with added data analysis and feedback functions for teachers.	Limitations in the system include potential deterioration or crashing with a large number of users, lack of encryption for transmitted user information, and potential for further data analysis using traces of watching videos, login duration, and forum texts for obtaining course focus, difficulty, and doubts.
5	(Zafar & Tahir, 2017)	Learning Management System and its Implementation	The methodology used for this project involved utilizing Moodle, an open source learning management system based on PHP and MySQL, to create a dynamic learning environment. Moodle was used for various services in an educational	The observed results of using Moodle as a learning management system for this project include providing a dynamic learning environment, supporting blended learning, implementing e-learning, enabling teacher and student management, facilitating course management, offering exam	Limitations for this project include technical limitations of Moodle as an open-source learning management system, potential learning curve challenges for users, customization limitations, resource requirements, potential user adoption challenges, and

			institute, including blended learning, e-learning, teacher management, student management, course management, and exam management. Additionally, Moodle allowed for report generation to evaluate individual performance of teachers and students.	solutions, and allowing report generation for performance evaluation.	limitations in ongoing support and maintenance.
6	(Stoykov et al., 2017)	Demo: VIBES: Fast Blockchain Simulations for Large-scale Peer-to-Peer Networks	The methodology involves using the VIBES simulator to conduct a flexible and scalable simulation of a blockchain network, with configurable input parameters. Fast-forward computing is proposed to improve scalability by allowing nodes to skip heavy computations and simulate	The VIBES simulator provides configurable input parameters and outputs various metrics for simulations, including total time to process, throughput, and block propagation delay. The concept of fast-forward computing improves scalability by allowing nodes to skip heavy computations and simulate	Limitations of the VIBES simulator and fast-forward computing include reliance on input parameters, simplified assumptions, limited scalability, a centralized orchestrator, lack of real-world dynamics, limited metrics and outputs, and over-reliance on theoretical and empirical results.

			ahead of time. This process is repeated recursively until nodes have finished their work, resulting in more efficient simulations.	ahead of time, resulting in more efficient simulations.	
7	(Dewanti et al., 2021)	Designing a Learning Management System based on Cyber Pedagogy for Higher Education	The study used a mixed-methods approach involving quantitative and qualitative research methods. The population of the study included 53 respondents, including expert testers and student respondents. The aim was to design an LMS model called SMILE that addresses the needs of the millennial generation in higher education. The implementation involved a Blended Learning approach with virtual classrooms during the pandemic.	The study designed an LMS model called SMILE, which aims to provide an effective and efficient learning process for higher education students using multidimensional learning resources in Cyber Pedagogy. The study was conducted with 53 respondents, including expert testers and student respondents. The SMILE model is expected to address the needs of the millennial generation, who represent a large market share in current colleges and have notable characteristics in their use of information technology. During implementation,	The possible limitations of the study include a small sample size, limited generalizability due to the specific population studied, potential bias in expert testing, reliance on a blended learning approach during the pandemic, and challenges in fully addressing the needs and characteristics of the millennial generation in the context of learning.

				a Blended Learning approach was used with a live face-to-face session in a virtual classroom as a substitute for conventional classroom interaction during the pandemic.	
8	(Rahardja, 2022)	Blockchain Education: as a Challenge in the Academic Digitalization of Higher Education	The methodology used appears to be a literature review and analysis of blockchain technology and its potential applications in the field of education. It involves examining the advancement of blockchain technology for educational purposes, forecasting potential disruptions for educational institutions, and identifying apps targeted at decentralizing educational institutions using blockchain technology.	Blockchain projects focus on "Core" growth and continuous innovation, with some "Related" growth seen in integrating AI and data analytics. Sharples and Domingue propose a "Disruptive" innovation in education through a new learning platform.	The limitations of implementing Blockchain technology in education include primarily focusing on sustaining innovations, needing to resolve technical issues for full utilization, and lacking infrastructure for complete transformation of the educational institution model. These challenges are rooted in similar issues.

9	(Düdder et al., 2021)	Interdisciplinary Blockchain Education: Utilizing Blockchain Technology From Various Perspectives	The methodology used in the BlockNet project involves analyzing skill requirements, developing a domain-specific competence model through research, clustering competence items, and designing a didactical and organizational concept for an online course using active digital learning methods, with the aim to provide comprehensive skills and knowledge on Blockchain Technology.	The BlockNet project addressed essential needs in online education, international collaboration, and interdisciplinary problem-solving related to blockchain technology. It delivered an interdisciplinary online course, expanded horizons for participating partners, and generated new knowledge and experience on international and interdisciplinary cooperation.	The article does not explicitly mention any limitations of the BlockNet project or the observed results. It focuses on the positive aspects of the project, such as addressing essential needs in education, delivering new knowledge, expanding horizons, and generating experience on international and interdisciplinary cooperation. No limitations are mentioned in this article.
10	(Ma & Fang, 2020)	Current status, issues, and challenges of blockchain applications in education	The methodology used in this abstract involves introducing blockchain techniques and characteristics, summarizing recent applications in education, discussing	Blockchain technology has the potential to transform education by creating new foundations and models for teaching reform, although challenges exist. Current applications are in the nascent	The limitations observed in the application of blockchain technology in education include challenges in infrastructure and platform management, data ownership and privacy protection, and

		challenges, and providing insights on the potential of blockchain in education.	stage with limited scope, but a positive attitude and preparations are needed for its extensive and in-depth implementation in education.	limited application scope focusing on specific areas such as learning record keeping and certificates management.

2.10 Review of Existing Interactive Blockchain Education System

An Interactive Blockchain Education System is a type of learning platform that employs cutting-edge technology to offer an engaging, interactive, and secure learning environment for blockchain. This system is intended to provide students with a comprehensive education in blockchain and its numerous applications, as well as to assist them in developing practical skills and understanding in the field.

There are several existing blockchain education systems out there. The following sections examine some of these well-known systems.

Table 2.3: Review of existing Interactive Blockchain Education System

S./N	Name	Overview	URL	Weakness
1	Blockchain Education Network (Gardner, 2014)	The platform, Blockchainedu.org, is an educational platform focused on providing comprehensive learning about blockchain technology and related topics. It offers interactive courses, articles, tutorials, and tools for learners to gain practical skills and knowledge in the field. The platform covers	https://learn.blockchainedu.org/)	The limitations of the Blockchain Education Network platform include a focus on the financial application of blockchain technology, with limited emphasis on core components of

		fundamental concepts and applications of blockchain technology, and includes a learner community for interaction and resource sharing. It is a valuable resource for individuals interested in learning more about blockchain technology.		the technology. It lacks interactive simulations of blockchain technology and does not provide quizzes or exercises for learners to test their understanding.
2	Blockchain Demo (Anders, 2016)	Blockchaindemo.io is a blockchain simulation application that provides users with a visual, interactive interface to create and test various blockchain networks. It is a valuable resource for learning about blockchain technology, but it is important to note that it is a simulation and does not reflect real-world blockchain networks. Nonetheless, it can provide insights and understanding of the technology and its applications.	https://blockchaindemo.io	The application lacks educational resources on the underlying mechanism of blockchain technology and requires prior knowledge of the basics, making it less beginner-friendly as it focuses primarily on simulating the technology.
3	101 Blockchains (Aviv, 2017)	101blockchains.com is a comprehensive blockchain teaching and research portal with articles, tutorials, news updates, a database of companies/projects, and event listings. It is a valuable resource for individuals and companies interested in learning about blockchain technology and staying updated with industry advancements.	https://101blockchains.com/	The platform lacks focus on the fundamentals of blockchain technology and does not include an interactive simulation of the technology.
4	Anders Brownworth's demo	The website provides a visual, interactive introduction to the fundamentals of blockchain	https://andersbrownworth.com/blockchain/	The website offers a basic introduction to blockchain

	(Anders, 2011)	technology, making it a great resource for beginners who want to learn how blockchains work.		technology, but lacks comprehensive and in-depth resources. The user interface is basic and not visually appealing.
5	ConsenSys Academy (Lubin, 2016)	ConsenSys Academy, a renowned Ethereum development company, offers a comprehensive blockchain education portal with online courses, workshops, and certificates. It covers various topics related to blockchain technology and provides hands-on, practical learning experience to build real-world applications on the Ethereum network.	https://consensys.net/academy/	The platform lacks in-depth content on the underlying mechanism of blockchain technology and does not provide an interactive simulation of the technology. It is more focused on the applications of blockchain rather than its fundamentals.

2.11 Summary of Review

The blockchain technology is still emerging and has the potential to be incredibly beneficial in a variety of different context. As the technology continues to mature and more applications are developed, it is likely that blockchain technology will become increasingly valuable for individuals and organizations alike.

This chapter covers an overview of the blockchain technology with details on the types, features, structure, and applications. It also covered a review of what blockchain education is, the challenges to blockchain education, interactive learning systems, and an analysis on some popular interactive blockchain education systems.

Despite increased demand for blockchain education, there is still a major knowledge gap in this field. This knowledge gap is especially noticeable among individuals and organizations that are new to technology and want to broaden their understanding and skills. To close this gap, it is critical to create effective and easily accessible educational resources that may assist individuals and businesses in learning about technology in a comprehensive and engaging manner. While a lot of work has already been done, there is still much more to be done.

An examination of the most popular blockchain education systems reveals that they are either content-based or simulation-based, but not both. Blockchain educational resources such as articles, books, and courses are examples of content-based blockchain education platforms. While simulation-based solutions are primarily concerned with simulating the core mechanism of blockchain technology.

As a result, this project effort takes advantage of the strengths of both platforms in order to design and implement a more innovative interactive system for blockchain education.

CHAPTER 3

SYSTEM ANALYSIS AND DESIGN

3.1 Introduction

Blockchain technology has emerged as a disruptive force with the potential to transform many industries, including education. As the demand for blockchain expertise grows, innovative educational solutions that effectively educate and engage learners in this complex field become increasingly important.

The second chapter focused on the literature review and conceptual framework that formed the basis for the system's design and implementation. However, in this chapter, emphasis will be on the methodology and implementation specifics, demonstrating how it was constructed to satisfy the research aims of improving blockchain education through an interactive online platform.

This chapter begins with a description of the overall architecture of the web-based interactive system, which includes information about its components, modules, and interactions. Following that, it discusses the design and development strategy, covering the methodology, frameworks, and technologies used. It also describes the system's features and operation in detail, emphasizing how it improves the learning experience. After that, it goes over the implementation specifics, delving into the programming languages, libraries, and technologies used.

3.2 Overall Architecture

The general architecture of the web-based interactive system for blockchain education is intended to provide students with a smooth and user-friendly experience while harnessing the benefits of blockchain technology for increased security, transparency, and trust. The system is made up of numerous components that work together to provide the needed functionality. The system's high-level architecture includes the following components:

i. Frontend: The system's frontend is in charge of the user interface and user experience. It is usually constructed with web technologies like React and Next.js. The frontend is in charge of rendering the user interface, interacting with users, and communicating with the backend for data retrieval and changes. To offer an excellent user experience across different devices and browsers, the frontend design adheres to usability, accessibility, and responsiveness principles.

ii. Backend: The system's backend is in charge of handling business logic, processing frontend requests, and managing interactions with other system components. It is constructed with server-side programming languages such as Node.js and a backend framework such as Express. The backend communicates with the frontend to retrieve and update data, as well as to process requests.

iii. Database: The database system is responsible for storing and managing the data of the web-based interactive system. It uses a NoSQL database like MongoDB, depending on the requirements of the system. The database system stores various types of data, including student profiles, course information, educational resources, and transaction records related to the blockchain operations. The backend communicates with the database system for data retrieval, storage, and management.

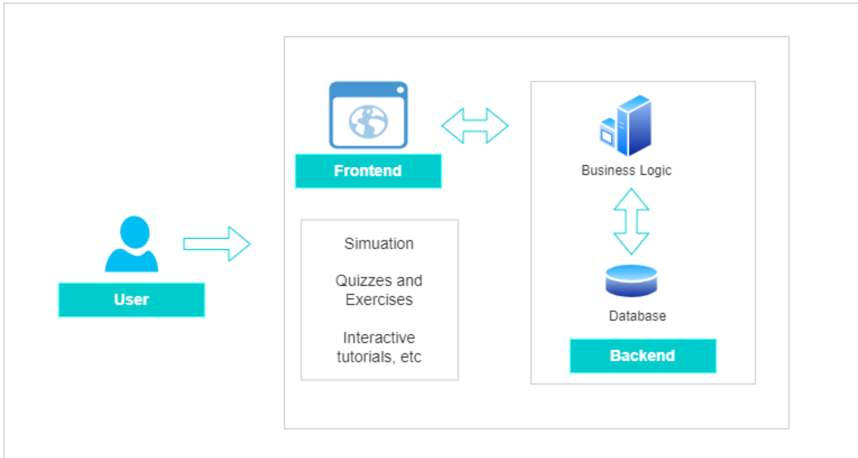

Fig 3.1. Architecture of the System

The multi-tier architecture of the web-based interactive system for blockchain education includes a frontend, backend, and database system. The frontend is in charge of user interactions, whereas the backend is in charge of business logic and communication with the database system. The system provides educational contents, simulation of the Blockchain technology, interactive tutorials, amongst others.

3.3 Methodology

The methodology provides a structured way for ensuring that the application is properly designed and developed, satisfying the needs and expectations of its users and stakeholders. This section will detail the methods used in the design and development of the web-based interactive system for blockchain education, highlighting the important steps involved in the process.

3.3.1 Requirements Analysis

This process entails determining the specific needs and requirements of the blockchain education application's target users and stakeholders. It entails gathering data on instructional material, user roles and permissions, interaction features, authentication and authorization needs, and other pertinent elements. These requirement are classified into functional and non-functional as specified in the following sub-sections.

3.3.1.1 Functional Requirements

1. User Registration and Authentication: Users should be able to register and create accounts using the application, which should include proper authentication methods such as email verification, password hashing, and role-based access control.
2. Simulation feature: Users should be able to access the Blockchain simulation on the platform, whether they are authorized or not. The system should demonstrate how hashing works, what an individual block looks like, and how blocks are connected together to form a blockchain. It should also demonstrate how a distributed or decentralized blockchain works.
3. Assessment and Grading: The program should allow online assessments including quizzes and assignments, as well as automatic grading capabilities and feedback.
4. Interactive and Educational Contents: A "Blockchain Explained" page that uses visual components to provide an explanation of Blockchain technology should be included in the system. The system should also include other blockchain related resources, links to external articles, blogs, videos, etc.

3.3.1.2 Non-Functional Requirements

1. Performance: The application should be developed and implemented to ensure rapid response times, minimal latency, and effective resource utilization in order to give a seamless and responsive user experience even with high user loads.
2. Security: To secure user data, prevent unwanted access, and ensure the system's integrity and confidentiality, the application should include strong security methods such as encryption, authentication, authorization, and data privacy.
3. Scalability: The application should be scalable, allowing for easy growth and adaption to support growing numbers of users, resources, and content while maintaining performance and dependability.
4. Usability: To ensure ease of use and accessibility for users with various technical skills and backgrounds, the application should be developed with a user-friendly interface, intuitive navigation, and clear instructions.

3.3.2 System Design

Once the requirements are identified, the system design phase begins. This step involves creating a blueprint of the application's architecture, including the frontend design, backend design, and database design. It also includes designing the user interface, navigation flow, and interaction design, as well as selecting appropriate technologies and frameworks for implementation.

3.3.3 Development and Testing

The development and testing phases begin after the system design is finalized. This process entails writing code and implementing the frontend, backend, and database system per the design specifications. It also comprises extensive application testing to identify and resolve any problems or issues, as well as ensuring that the application performs as planned.

3.3.4 Integration and Deployment

The application is integrated into a working system after development and testing are completed. This comprises connecting the database system and integrating the frontend and backend. Following successful integration, the application is deployed on appropriate servers or cloud platforms, complete with the necessary configurations and security measures.

3.3.5 Maintenance and Updates

Once the application has been deployed and accepted by users, it will require regular maintenance and updates to keep the system functioning properly. These could include bug repairs, security patches, feature additions, and updates to stay up with the changing technological world and educational needs.

3.4 Underlying Technologies and Tools

1. React.js

React.js, popularly known as React, is a well-known JavaScript library for creating user interfaces. React.js, which was created and is maintained by Facebook, is widely used in modern web development for developing interactive and dynamic user interfaces. It adheres to a component-based architecture, in which user interface components are created as reusable building blocks that may be combined to create sophisticated user interfaces.

The virtual DOM for rapid rendering, component-based design for constructing reusable UI components, declarative approach to UI development, and huge ecosystem with a large community and various third-party libraries and tools are key features of React.js.

2. Next.js

Next.js is a well-known open-source framework for developing server-side React applications. Next.js, created by Vercel, offers a set of features and conventions that make it easier to create modern web applications with React. It is intended to improve React applications' performance, scalability, and SEO capabilities, making it a popular alternative for developing production-ready online applications.

3. Node.js

Node.js is a well-known open-source JavaScript runtime environment that enables developers to run JavaScript code on the server. Node.js, which was built on Google's V8 JavaScript engine, provides an event-driven, non-blocking I/O architecture that makes it highly scalable and efficient for building server-side applications.

4. Mongo DB

MongoDB is a well-known open-source, NoSQL, document-oriented database that offers a flexible, scalable, and high-performance solution for data storage and retrieval. It is intended to manage massive amounts of data in a flexible and schema-free way, making it applicable to a wide range of applications.

5. Visual Studio Code

Visual Studio Code (VS Code) is a free, open-source code editor created by Microsoft that offers a sophisticated and versatile development environment for creating a variety of apps. It is well-known for its lightweight and rapid performance, as well as its numerous customization possibilities and feature set. VS Code supports a broad variety of programming languages and frameworks, as well as features such as syntax highlighting, code completion, debugging, version control integration, and a built-in terminal.

6. Vercel

Vercel is a cloud platform that provides serverless functions and static site hosting for modern web applications.

3.5 Database design

Users, Courses, and Quizzes tables are among the tables in the database for the proposed web-based interactive system for blockchain education. Below is a list of some of the database's tables.

Table 3.1: User Login Table

Field name	**Data type(value)**	**Constraint**
Email	String	unique key
Password	String	Not null

Table 3.1 displays the user log in information, such as email, and password, as well as data kinds and limitations.

Table 3.2: User Registration Table

Field name	**Data type(value)**	**Constraint**
Name	String	Not null
Email	String	Not null
Password	String	Unique key

Table 3.2 shows the details required for user registration such as the Name, Email, and password alongside their data types and constraints.

Table 3.3: Individual course Table

Field name	**Data type(value)**	**Constraint**
ID	String	Unique key
Course_name	String	Not null
Content	Array	Not null

Table 3.3. Shows details about an individual course, containing fields such as the ID, name, and content. The content field is an array of objects denoting each sections of the course.

Table 3.4. Individual Quiz Table

Field name	**Data type(value)**	**Constraint**
ID	String	Unique key
Question	String	Not null
Options	Array	Not null
Answer	String	Not null

Table 3.4. Shows details about an instance of the Quiz, consisting of fields such as the ID, question, options, and answer.

3.6 Use case diagram

A use case diagram depicts the interactions between actors (users or systems) and the system under consideration. Use case diagrams are used to capture a system's functional needs from the standpoint of the user. They represent the interactions and relationships between actors and the system's functionality by displaying various use cases (or interactions) between actors and the system. The use case diagram for the interactive system for blockchain education is depicted below.

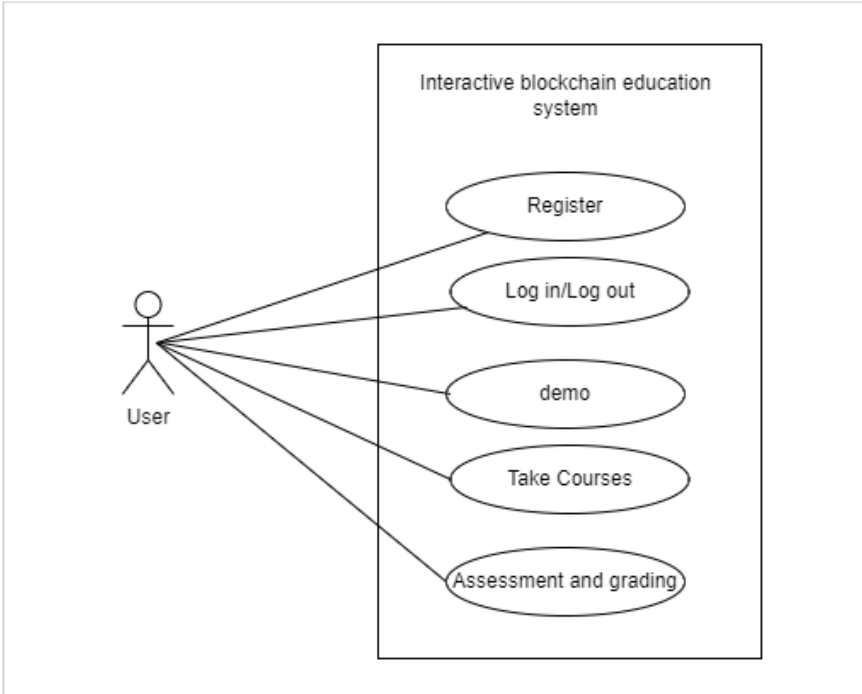

Fig 3.1. Use case diagram for the system

3.6.1. Register

Table 3.5: Register Use Case Description

Use Case Name	**Register**
Brief Description	The registration process involves creating records by getting the Users name, email, and password.
Flow of Events	The User clicks on the call-to-action button to load the Register page. The Register page opens up and prompts the user to enter their details. The User enter the details and click on the Register button. The system creates a record for the User
Actor	User
Preconditions	Non

Post conditions	Users should be able to Register on the System

3.6.2. Log In/Log Out

Table 3.6: Log In/Log Out Use Case Description

Use Case Name	**Log In/Log Out**
Brief Description	This involves the processes of collecting the User's email and password, and authenticating the validity of the User. It also involves the process of ending the User's session.
Flow of Events	The User routes to the Log in page. The Log in page opens up and prompts the user to enter their details. The User enter the details and click on the Log in button. The system authenticates the User and log the User in. Also when the Log Out button is clicked, the system logs the User out.
Actor	User
Preconditions	Non for Log in. For Log out, the User should already be logged in.
Post conditions	Users should be able to Log in and Log Out of the System

3.6.3. Demo

Table 3.7: Demo Use Case Description

Use Case Name	**Demo**

Brief Description	This involves the process of interacting with the Simulator in the Demo page.
Flow of Events	The User routes to the Demo page. The Demo page opens. The User can then have a feel of how hashes, blocks, individual blockchain, and distributed blockchain works.
Actor	User
Preconditions	Non
Post conditions	Users should be able to interact with the Demo

3.6.4. Take Courses

Table 3.8: Take Courses Use Case Description

Use Case Name	**Take Courses**
Brief Description	This involves the processes of enabling the Users take courses on Blockchain fundamentals
Flow of Events	The User routes to the Courses page. The Courses page opens up and a list of available courses get rendered. The User can then start a particular course.
Actor	User
Preconditions	The User must be logged in.
Post conditions	The User should be able to take any out listed course.

3.6.5. Assessment and Grading

Table 3.9: Assessment and Grading Use Case Description

Use Case Name	**Assessment and Grading**
Brief Description	This involves the processes of enabling the Users take assessments and have them graded instantaneously.
Flow of Events	The User routes to the Assessments page. The Assessment page opens up. The User can then take an assessment with the result displayed at the end of each leap.
Actor	User
Preconditions	The User must be logged in.
Post conditions	The User should be able to take an assessment and also be graded.

3.7 Summary

This Chapter covers the analysis and design of the proposed system, thereby achieving one of the objectives of the study.

CHAPTER 4

SYSTEM IMPLEMENTATION AND TESTING

4.1 Introduction

This chapter focuses on the practical aspects of bringing the system to life. It digs into the specifics of system implementation, such as hardware and software requirements, user interface designs, system functionality, testing, and quality assurance measures.

4.2 Software Requirements

Below is a list of the required software for developing the subject system.

I. Code editor of any kind, preferably Visual Studio Code

II. Node.JS v17+

III. Minimum of a windows 7 operating system.

IV. Web browser (preferably Google Chrome)

4.3 Hardware Requirements

I. laptop PC or a desktop computer

II. Minimum hard disk space of 250 GB

III. At least 4GB of RAM

IV. Processor speed of at least 1.0 GHz

4.4 System Implementation Menu

This section covers an overview of the output menus of the Interactive System for Blockchain Education. The various components and pages that constitutes the whole platform will be briefly reviewed in the following sub sections.

4.4.1 Home Page

The Home Page is the first page that appears when the program is loaded and rendered for the first time. It serves as the entry point for users to access the platform and get an overview of its features and offerings. It includes a Navigation bar, Call-to-action buttons, Hero section, Footer, amidst others. Shown below is what the Home Page looks like.

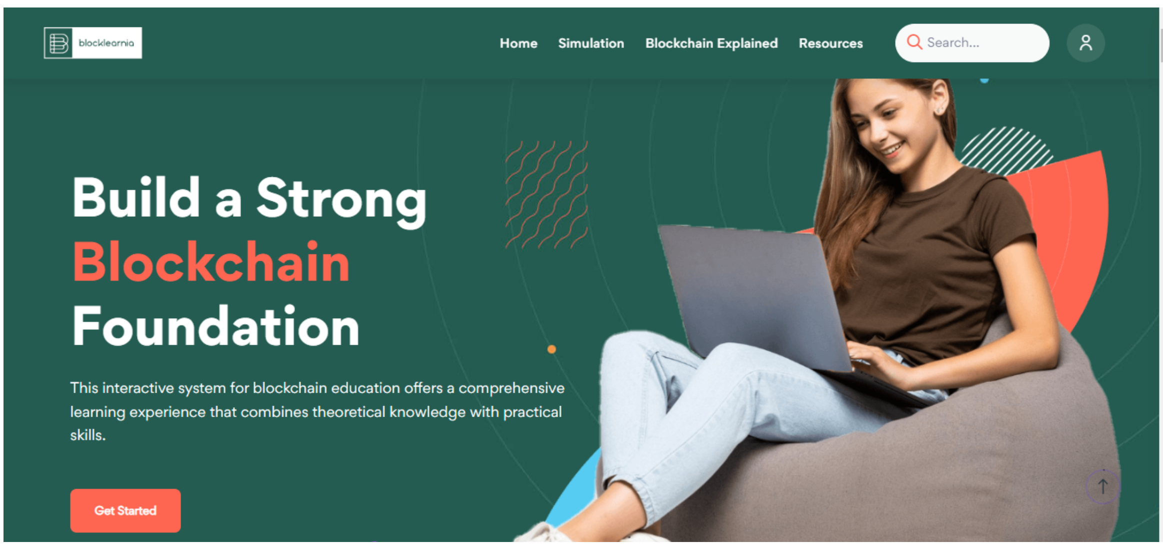

Fig 4.1. Home Page

4.4.2 Register Page

It is required to register before a particular User can access exclusive features of the system such as taking a course, assessment and grading. The Register Page renders three form input fields to get the Name, Email, and Password. It also renders a button which when clicked, sends the form values to the backend to create the User record.

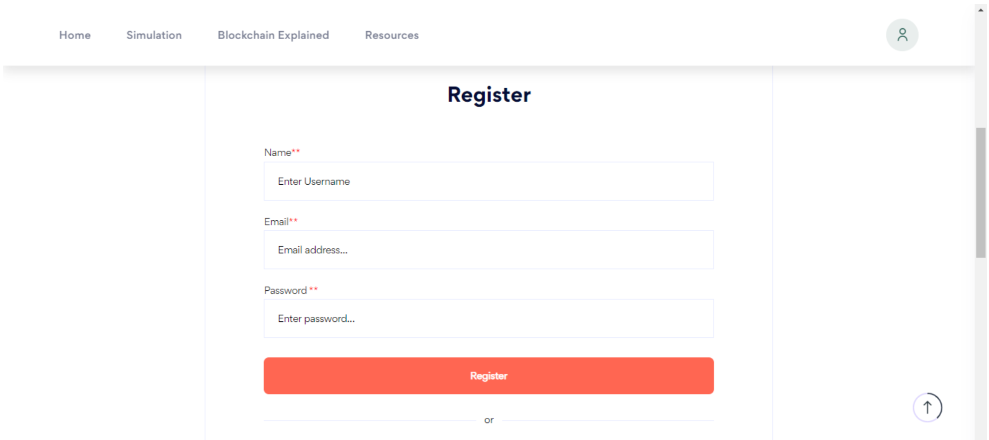

Fig 4.2. Register Page

4.4.3 Log in Page

The Log in Page serves as the gateway to handle User's authentication in the application. The Log in Page renders two form input fields to get the Email, and Password. It also renders a button which when clicked, sends the form values to the backend to finish up the authentication process.

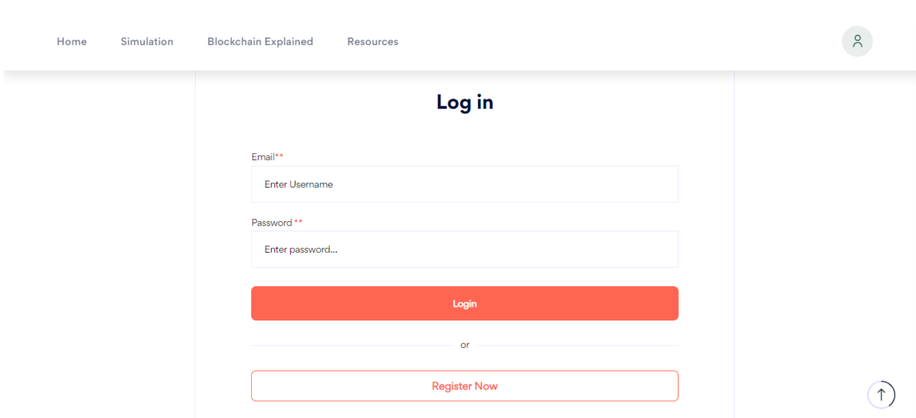

Fig 4.3. Log in Page

4.4.4 Demo Page

To make the learning experience more engaging, the application includes an interactive simulation in the Demo Page that allow users to experiment with different fundamentals of the Blockchain Technology. This Page is sub-divided to demonstrate how hashes, a block, blockchain, and distributed blockchain works.

4.4.4.1 Hash Demo

This section has an interface where a User can enter a data value see its corresponding hash value.

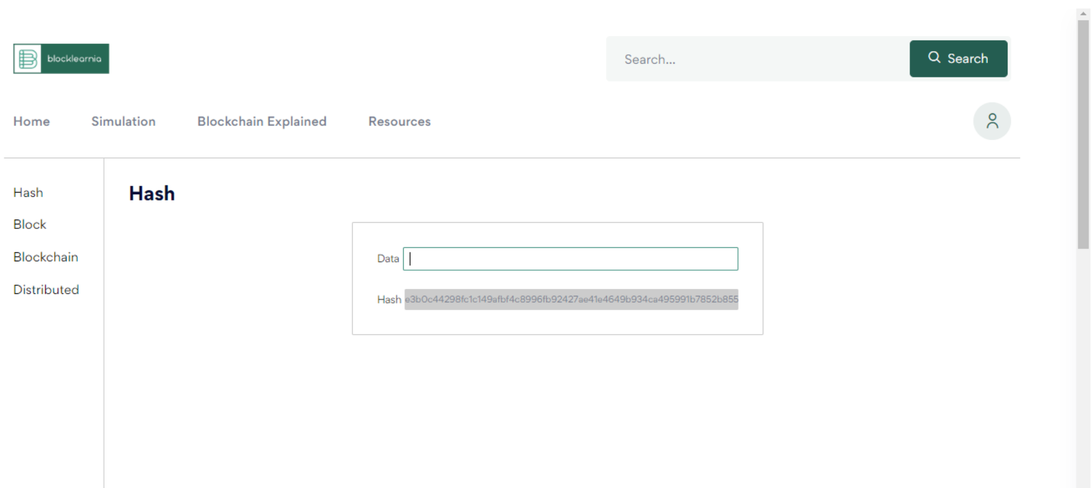

Fig 4.4. Hash Demo

4.4.4.2 Block Demo

This section visualizes the behaviour of an individual block. A User can see how new hashes are generated when the block's data is changed, and how a new nonce is generated when the block is mined.

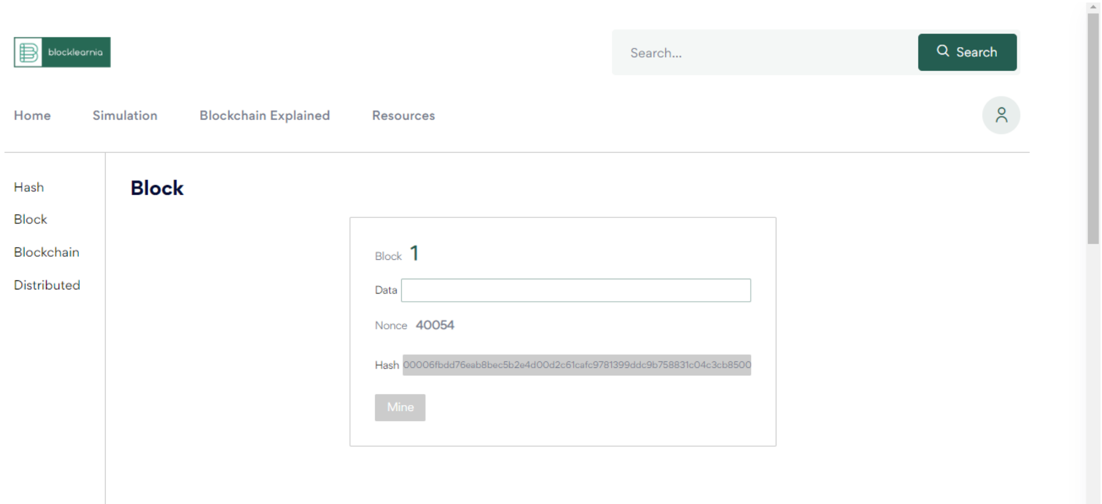

Fig 4.5. Block Demo

4.4.4.3 Blockchain Demo

This section demonstrates how blocks come together to form a Blockchain. The behaviour when some blocks are tampered with and how a block is appended to the chain.

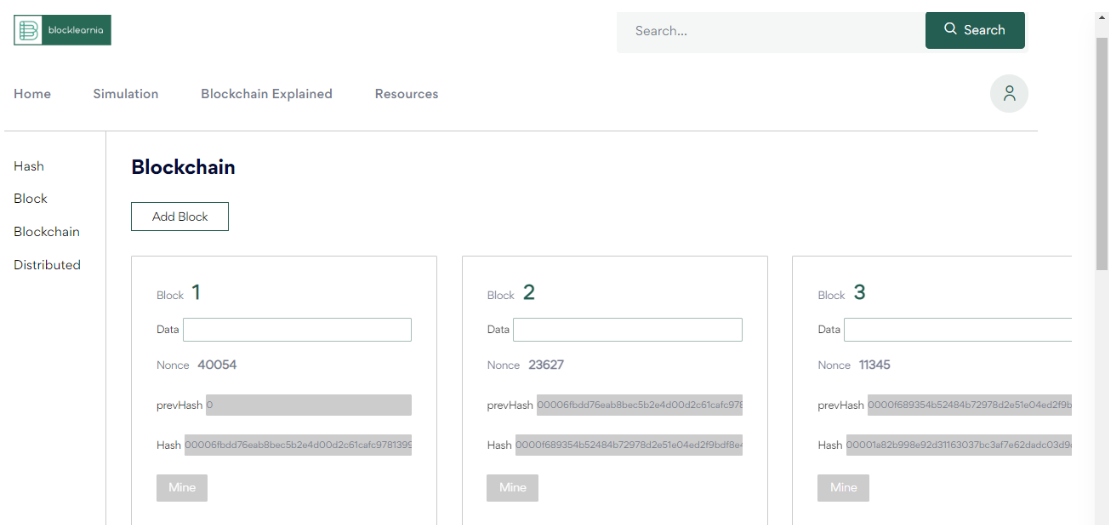

Fig 4.6. Blockchain Demo

4.4.4.4 Decentralization Demo

This section demonstrates the decentralized and distributed behaviour of the Blockchain Technology.

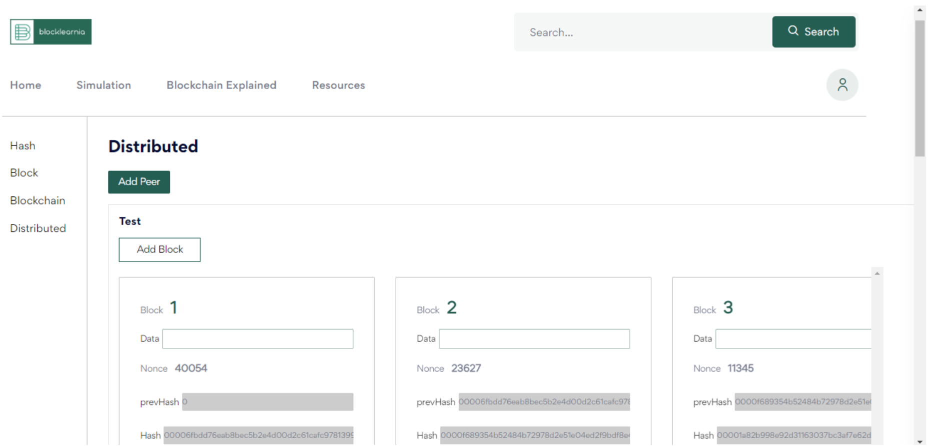

Fig 4.7. Decentralization Demo

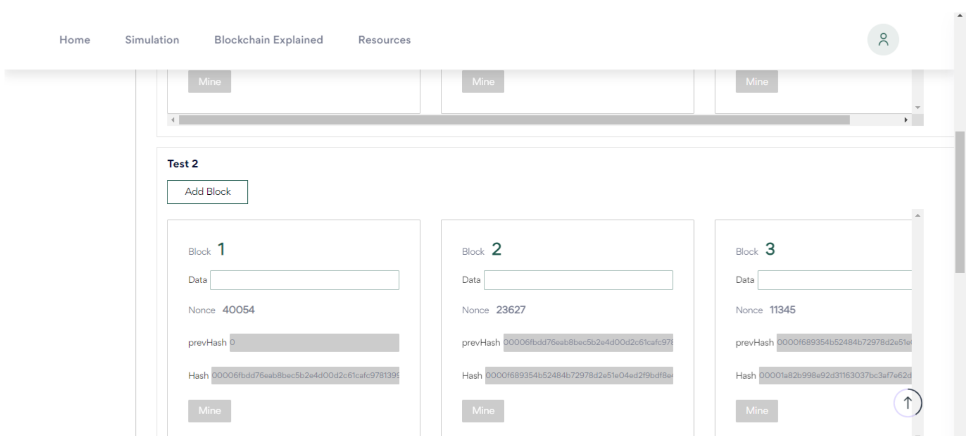

Fig 4.8. Decentralization Demo (other peer)

4.4.5 Visual Guide (Blockchain Explained) Page

This page is made up of visual illustrations that brushes briefly over the fundamentals of the Blockchain Technology and its encompassing concepts.

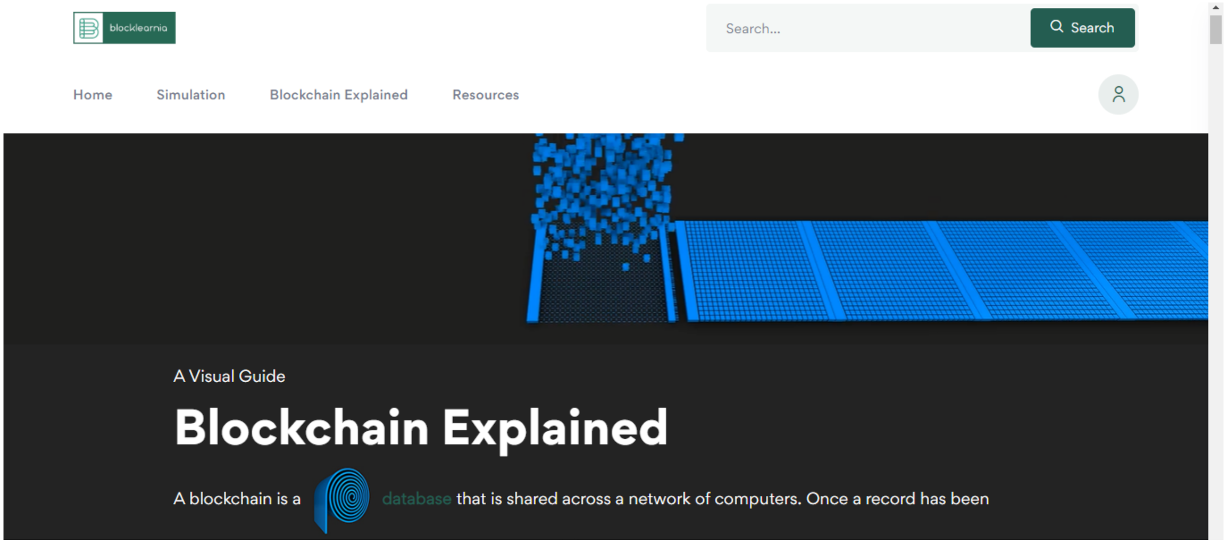

Fig 4.9. Visual Guide

4.5 Usability Testing

Usability testing is a critical aspect of software development as it provides valuable insights into how users interact with the system and identifies likely areas for improvement (Steury et al., 2005). In the context of our research work, "design and implementation of a web-based interactive system for Blockchain Education", it was important to conduct usability tests to ensure that the system meets the needs of the users and allow for great user experience.

For our purpose, a System Usability Scale (SUS) test was carried out using the “Weave.ly” tool. The pre-built SUS calculator (built with weave.ly) offers a ready-to-use questionnaire. It generates a link that can be sent to individual users, their response will be collected and the score will be calculated automatically.

The tool used specific usability criteria, such as ease of use, learnability, efficiency, memorability, error recovery, user satisfaction, etc. to evaluate the system's performance.

To carry out this test, the application was deployed to Vercel and became accessible via “https://blocklearnia-2.vercel.app/”. Next, the hosted link was made the subject of the questionnaire and the link was sent to randomly selected users. Fig 4.10 shows excerpts from the usability test.

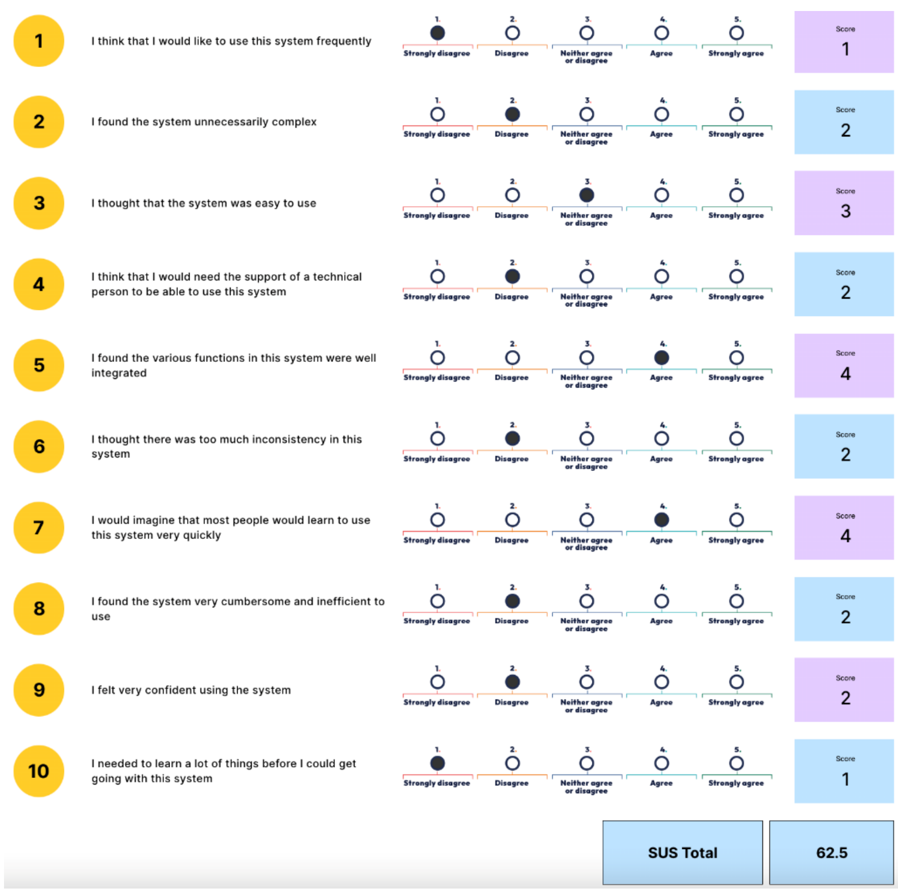

Fig 4.10. Usability Test

An average score of 62.5 was obtained from the test and lapses such as suboptimal user interface design, confusing navigation, unclear instructions, lack of user feedback, slow response times, and/or difficulty in learning or using the system effectively was observed.

4.6 Conclusion

Through the use of modern web technologies such as React.js, Next.js, Node.js, and MongoDB, the system has been built with a robust and scalable architecture that enables users to engage with blockchain education in an interactive and user-friendly manner.

To assure the system's functionality, stability, and security, the implementation process included extensive testing and debugging. Numerous development and refinement cycles were carried out in order to maximize the system's performance and user experience. To maintain code quality and assure future maintainability, best practices and coding standards were adhered to.

CHAPTER 5

SUMMARY, CONCLUSION AND RECOMMENDATIONS

5.1 Summary

People are still left behind as the blockchain technology develops because they do not have a thorough understanding of its foundation and operation. However, this project pushed hard to create a web-based platform that allows learners to engage in blockchain education in an interactive and user-friendly environment. To design and implement a strong and scalable system, the project used modern web technologies such as React.js, Next.js, Node.js, and MongoDB.

The project used a systematic approach, beginning with a thorough analysis of the target users' goals and requirements. The system architecture has been carefully built to guarantee that different components, such as user authentication, course enrolment, content delivery, and assessment, work together seamlessly. Throughout the implementation phase, the system was rigorously tested and debugged to assure its functionality, reliability, and security.

Ultimately, the project sought to promote blockchain education by creating a cutting-edge system that provides learners with an engaging and dynamic learning experience. The project has shown technical expertise, attention to detail, and a commitment to creating a high-quality system that satisfies the needs of the target users.

5.2 Conclusion

The project "Design and Implementation of a web-based Interactive System for Blockchain Education" was a complete and successful attempt that included several stages of planning, analysis, design, implementation, and testing. The project has used modern web technologies to build a strong and scalable system that serves the demands of blockchain learners.

As described in Chapter 3, the requirements and needs of the target users have been carefully considered throughout the project. The system architecture, which is also explained in Chapter 3, has been intended to provide smooth integration of various components, resulting in a user-friendly and engaging environment in which learners may engage with blockchain education. The implementation process, as described in Chapter 4, included extensive testing and debugging to validate the system's functionality, stability, and security.

The project has followed best practices and coding standards to maintain code quality and future maintainability. The system's performance and user experience, as described, have been optimized through several iterations of development and refinement.

The successful completion of this project represents a big step forward in the realm of blockchain education. As mentioned in Chapter 1, the system developed in this project has the ability to provide learners with an interesting and dynamic learning experience.

To conclude, this project was a huge initiative that resulted in a viable system with the potential to improve the learning experience for blockchain education.

5.3 Recommendations

The following recommendations are suggested for future enhancements and improvements:

i. User Feedback and Evaluation: Gather user input to acquire insights about their system experience. Evaluate the input to discover areas for improvement in usability, functionality, and performance.

ii. Documentation and Training: Provide extensive documentation and training materials for users to provide information on how to utilize the system efficiently. Update the documentation on a regular basis to reflect system changes and to give continuous support to users.

iii. Accessibility: Consider including accessibility features to ensure that people with impairments can use the system. To make the system inclusive for all learners, adhere to accessibility standards and rules such as the Web Content Accessibility Guidelines (WCAG).

iv. Security Measures: Continue to prioritize system security measures such as strong authentication and authorisation procedures, sensitive data encryption, and frequent security audits. Maintain current knowledge of security best practices and put them into action to protect against potential security threats.

REFERENCES

Adam, H. (2022, September 27). *Blockchain Facts: What Is It, How It Works, and How It Can Be Used*. https://www.investopedia.com/terms/b/blockchain.asp

Adam, levy. (2022, July 13). *15 Applications for Blockchain Technology | The Motley Fool*. https://www.fool.com/investing/stock-market/market-sectors/financials/blockchain-stocks/blockchain-applications/

Anshika, B. (2021, June 22). *What is Decentralization in Blockchain?* https://www.blockchain-council.org/blockchain/what-is-decentralization-in-blockchain/

Armstrong, S. (2016, November 7). *What is the blockchain and why should people use it? | WIRED UK*. https://www.wired.co.uk/article/unlock-the-blockchain

Aviv, L. (2018, July 28). *Blockchain Education- The Key To Economic Growth*. https://101blockchains.com/blockchain-education-the-key-to-growth/

Bayer, D., Haber, S., & Stornetta, W. S. (1992). *Improving the Efficiency and Reliability of Digital Time-Stamping*.

Bulic, E., Humar, I., & Sinigoj, A. (2004). Solved problems of fundamentals of electromagnetics on the web: System usage evaluation,. *Electrotech. Rev*, *71*, 40–44.

Casey, M. (2018, July 16). *The impact of blockchain technology on finance : a catalyst for change*.

Centralized and decentralized networks - Bitstamp Learn Center. (2022, August 4). https://www.bitstamp.net/learn/blockchain/centralized-and-decentralized-networks/

Daley, S. (2022, September 12). *What Is Blockchain Technology? How Does It Work? | Built In*. https://builtin.com/blockchain

Dewanti, P., Candiasa, I. M., & Made Tegeh, I. (2021). Designing a Learning Management System based on Cyber Pedagogy for Higher Education. In *International Journal of Computer Applications* (Vol. 183, Issue 27).

Düdder, B., Fomin, V., Gürpinar, T., Henke, M., Iqbal, M., Janavičienė, V., Matulevičius, R., Straub, N., & Wu, H. (2021). Interdisciplinary Blockchain Education: Utilizing Blockchain Technology From Various Perspectives. *Frontiers in Blockchain*, *3*. https://doi.org/10.3389/fbloc.2020.578022

Dudhat, A., Lestari Santoso, N. P., Henderi, Santoso, S., & Setiawati, R. (2021). Blockchain in Indonesia University: A Design Viewboard of Digital Technology Education. *Aptisi*

Transactions on Technopreneurship (ATT), *3*(1), 68–80. https://doi.org/10.34306/att.v3i1.146

Frankenfield, J. (2022, May 20). *Cryptographic Hash Functions: Definition and Examples*. https://www.investopedia.com/news/cryptographic-hash-functions/

Freeman, S. et al. (2014). Active learning increases student performance in science, engineering, and mathematics. *Proceedings of the National Academy of Scientists*, 841–810.

Guustaaf, E., Rahardja, U., Aini, Q., Maharani, H. W., & Santoso, N. A. (2021). Blockchain-based Education Project. *Aptisi Transactions on Management (ATM)*, *5*(1), 46–61. https://doi.org/10.33050/atm.v5i1.1433

Gwyneth, I. (2021, November 24). *6 Key Blockchain Features You Need to Know Now*. https://101blockchains.com/introduction-to-blockchain-features/

Haber, S., & Stornetta, W. S. (1991). How to Time-Stamp a Digital Document. In *Journal of Cryptology* (Issue 2).

Humar, I., Sinigoj, A. R., Bešter, J., & Hagler, M. O. (2005). Integrated component web-based interactive learning systems for engineering. *IEEE Transactions on Education*, *48*(4), 664–675. https://doi.org/10.1109/TE.2005.858396

Iskander, M. (2002). *Technology-Based electromagnetic education*.

John, W. (2017). *Understanding Bitcoin: Cryptography, Engineering and Economics*.

Laura, M. (2022, November 20). *What is a Smart Contract and How do Smart Contracts Work*. https://www.bitdegree.org/crypto/tutorials/what-is-a-smart-contract

Martin, W. (2018). *Distributed Ledger Technology: Hybrid Approach, Front-to-Back Designing and Changing Trade Processing Infrastructure*.

Ma, Y., & Fang, Y. (2020). Current status, issues, and challenges of blockchain applications in education. *International Journal of Emerging Technologies in Learning*, *15*(12), 20–31. https://doi.org/10.3991/ijet.v15i12.13797

Narayanan, A., Bonneau, J., Felten, E., Miller, A., & Goldfeder, S. (2016). *Bitcoin and cryptocurrency technologies: a comprehensive introduction*. Princeton: Princeton University Press.

Networks: Decentralized, Distributed, & Centralized | Gemini. (2021, July 12). https://www.gemini.com/cryptopedia/blockchain-network-decentralized-distributed-centralized

Oberhaus, D. (2018, August 27). *The World's Oldest Blockchain Has Been Hiding in the New York Times Since 1995*. https://www.vice.com/en/article/j5nzx4/what-was-the-first-blockchain

Patrick, L., Scott, N., Bradley, M., & You, C. (2018). *DMMS: A Decentralized Blockchain Ledger for the Management of Medication Histories* .

Philipp, S., & Felix, B. (2022, April 13). *How Should We Teach Blockchain? | AACSB*. https://www.aacsb.edu/insights/articles/2022/04/how-should-we-teach-blockchain

Rahardja, U. (2022). Blockchain Education: as a Challenge in the Academic Digitalization of Higher Education. *IAIC Transactions on Sustainable Digital Innovation (ITSDI)*, *4*(1), 62–69. https://doi.org/10.34306/itsdi.v4i1.571

Rob, M. (2017, August 30). *Blockchain: The Invisible Technology That's Changing the World*. https://au.pcmag.com/enterprise/46389/blockchain-the-invisible-technology-thats-changing-the-world

Rostyslav, D. (2017, December 27). *Private Blockchain • How Companies Can Leverage Private Blockchains*. https://perfectial.com/blog/leveraging-private-blockchains/

Schneider, N. (2019). Decentralization: an incomplete ambition. *Journal of Cultural Economy*, *12*(4), 265–285. https://doi.org/10.1080/17530350.2019.1589553

Sherman, A. T., Javani, F., Zhang, H., & Golaszewski, E. (2018). *On the Origins and Variations of Blockchain Technologies*.

Stoykov, L., Zhang, K., & Jacobsen, H. A. (2017). Demo: VIBES: Fast blockchain simulations for large-scale peer-to-peer networks. *Middleware 2017 - Proceedings of the 2017 Middleware Posters and Demos 2017: Proceedings of the Posters and Demos Session of the 18th International Middleware Conference*, 19–20. https://doi.org/10.1145/3155016.3155020

Wu, B., & Li, Y. (2018). Design of Evaluation System for Digital Education Operational Skill Competition Based on Blockchain. *Proceedings - 2018 IEEE 15th International Conference on e-Business Engineering, ICEBE 2018*, 102–109. https://doi.org/10.1109/ICEBE.2018.00025

Xuan, L. (2022, December 20). *Decentralization is the future. Decentralization is a concept that has… | by xuanling11 | Coinmonks | Dec, 2022 | Medium*. https://medium.com/coinmonks/decentralization-is-the-future-c0498d4ce074

Yaga, D., Mell, P., Roby, N., & Scarfone, K. (2019). *Blockchain Technology Overview*. https://doi.org/10.6028/NIST.IR.8202

Ye, J., Bin, X., Luo, D., Wang, Z., & Shu, C. (2018). Design and Implementation of an Online Learning System. *Proceedings - 2nd International Conference on Data Science and Business Analytics, ICDSBA 2018*, 259–262. https://doi.org/10.1109/ICDSBA.2018.00054

Zafar, S., & Tahir, N. (2017). *LEARNING MANAGEMENT SYSTEM AND ITS IMPLEMENTATION* (Issue 1).