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Analysis of the Block Feature Mechanism in Anders Brownworth's Blockchain Demo

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ABSTRACT

Blockchain technology relies on cryptographic hashing and proof-of-work mechanisms to preserve data integrity and validate blocks. However, the relationship among block data, nonce, hash, and mining is often difficult to understand when presented only through theoretical explanations. This study analyzes the Block feature of Anders Brownworth's Blockchain Demo as an interactive representation of basic blockchain mechanisms. A descriptive observational method was employed. Data were collected through direct observation of the simulation, documentation of each experimental condition, and a review of recent literature on blockchain and blockchain-based learning media. The analysis focused on the function of Block, Data, Nonce, Hash, and Mine, followed by controlled observations of data modification and re-mining. The results show that the simulation represents the relationship among block components through an immediate change in hash value and block validity after data modification. In the observed case, the original nonce 72608 produced a valid hash beginning with four zeros. After the data were changed to "Galang," the block became invalid. Mining subsequently changed the nonce to 6732 and generated a new hash beginning with four zeros while leaving the data unchanged. These observations demonstrate the sensitivity of hashing to input changes and the role of nonce search in a simplified proof-of-work process. The study concludes that the Block feature provides a clear visual representation of fundamental blockchain mechanisms and has potential as a supporting learning medium for introductory blockchain instruction.

Keywords: *blockchain, block, hash, nonce, mining*

INTRODUCTION

The development of information technology has increased the need for data storage systems that provide integrity, transparency, and reliable verification mechanisms. Blockchain has become one of the widely studied technologies because it uses a distributed ledger to store information in interconnected blocks. In practice, understanding blockchain requires not only knowledge of its terminology, but also an understanding of how data are processed into hashes, how changes in data affect block validity, and how the mining process finds a nonce value that satisfies a specified difficulty level.

Hash is an important component in blockchain because it represents data through a fixed-length output. Changes to the input can produce a different hash output, allowing changes to information to be detected. Research comparing MD5 and SHA-256 hash functions also demonstrates the importance of hash characteristics in the context of data integrity and security (Rahim et al., 2023). In the proof-of-work mechanism, a nonce is used as a value that is changed

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during the search process so that the resulting hash meets the condition specified by the system. This concept also appears in the implementation of blockchain in web-based systems (Atmomintarso & Wirawan, 2021).

In learning contexts, blockchain has relatively abstract technical characteristics, so media capable of visualizing processes can help learners connect theory with system behavior. Prawiyogi et al. (2021) discussed a student-oriented blockchain learning framework, while Ocheja et al. (2022) emphasized the importance of visualization in blockchain-based educational environments. Tsang et al. (2022) showed that learning games can allow users to experience mining and blockchain formation directly. Latifah and Fauziah (2022) also demonstrated the use of simulation to provide experience with blockchain operations such as hashing and block formation.

Other studies have developed approaches to blockchain learning through games, simulators, and training frameworks. Choi et al. (2022) developed a game-based educational program using the ASSURE model, while Leung et al. (2024) developed a blockchain training framework using constructivist and pragmatic approaches. Ren et al. (2024) designed an experimental simulation platform covering block structure, networking, and consensus algorithms. Mekhovnikov and Toschev (2024) also reported the development of a blockchain simulator to help users learn basic blockchain concepts and mechanisms. These findings indicate that simulation is a relevant approach for bridging abstract blockchain concepts with visual and experimental experiences.

Nevertheless, these studies generally discuss blockchain learning more broadly, such as educational frameworks, games, simulators, or blockchain applications in educational contexts. Meanwhile, analyses that specifically describe the behavior of a single Block feature through a sequence of data changes, hash changes, and mining processes remain limited. Sari and Gelar (2024), for example, discussed blockchain concepts and implementations broadly, while Sunarya (2022) focused on the application of blockchain for certificate security. Septianda et al. (2023) also placed blockchain in the context of Islamic economics. Therefore, there is room for a more focused analysis of the basic mechanisms of block formation and validation through interactive simulation.

This study aims to analyze the mechanism of the Block feature in Anders Brownworth's Blockchain Demo by examining the functions of Block, Data, Nonce, Hash, and Mine, as well as changes in block status before and after data modification and mining. The scope of the study is limited to the Block feature and does not discuss the Blockchain, Distributed, Tokens, or Coinbase features. The novelty of this study lies in a structured observational analysis of a single Block feature by comparing the conditions before data modification, after data modification, and after mining, allowing the relationship among data, hash, nonce, and block validity to be explained sequentially.

METHOD

The study employed a descriptive method with an observational approach to an interactive simulation. The research focused on the behavior of the Block feature in Anders Brownworth's Blockchain Demo. Observation was selected because the study aimed to describe mechanisms visible through the interface rather than measure improvements in learners' outcomes. This approach is consistent with blockchain learning studies that position simulation and direct experience as part of the process of understanding technical concepts (Tsang et al., 2022; Latifah & Fauziah, 2022).

The research object was the Block feature, which displays the block number, nonce, data, hash, and Mine button. In the observed simulation, a block was considered valid when the hash value began with four zeros (0000). Observations were conducted under three main conditions: the initial valid condition, the condition after data modification, and the condition

after the mining process. The nonce and hash values displayed under each condition were also recorded.

Data were collected using three techniques. First, direct observation was conducted by opening the Block feature and recording its components and the changes that occurred after specific actions. Second, documentation was conducted by saving screenshots of the initial condition, after data modification, and after mining. Third, a literature review was conducted to compare the observations with related studies on blockchain, blockchain education, simulation, hashing, and proof-of-work.

The analysis was conducted sequentially. The first stage was to identify the components of the Block feature. The second stage was to record the initial condition and the hash value that satisfied the difficulty. The third stage was to change the Data to the text "Galang" without changing the Block and Nonce. The fourth stage was to record the change in Hash and validity status. The fifth stage was to activate the Mine button and record the new Nonce and Hash values. The final stage was to compare the three conditions and relate them to the concepts of hash, nonce, and proof-of-work discussed in the literature.

Table 1. Observation stages of the Block feature

Stage	Activity	Observed Data
1	Open Blockchain Demo and select the Block feature.	Initial display and validity status.
2	Identify Block, Nonce, Data, Hash, and Mine.	Function and value of each component.
3	Change Data to "Galang".	Change in Hash and block status.
4	Press Mine on the invalid block.	Change in Nonce and Hash.
5	Compare the conditions before and after mining.	Data, Nonce, Hash, and validity status.

RESULTS AND DISCUSSION

Initial Display of the Block Feature

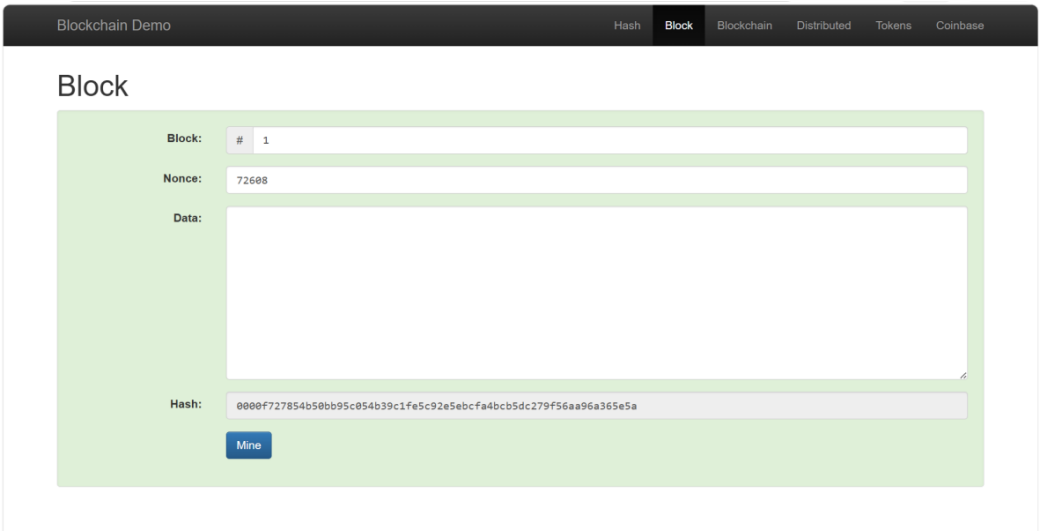


Figure 1. Initial display of the Block feature in Blockchain Demo

In the initial condition, the Block feature displays block number 1, Nonce 72608, a Data area, the Hash value, and the Mine button. The block background is green and the hash value begins with four zeros. This condition indicates that the generated hash satisfies the difficulty criteria in the simulation. The interface directly illustrates the relationship between block inputs and hash output, allowing users to observe the result when one of the inputs is modified.

The initial display also shows that validation does not depend solely on the presence of data, but on whether the hash satisfies the established rule. This concept is consistent with blockchain simulations that display a visual change when a previously valid condition is no

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longer satisfied. MIT explains that a demo based on Anders Brownworth's concept displays a block in red when the hash no longer begins with 0000 and returns it to green after re-mining.

Analysis of the Structure and Functions of the Block Components

Based on the observation, five components are directly visible in the Block feature: Block, Nonce, Data, Hash, and Mine. Block functions as the block identifier. Data serves as the information being processed. Nonce is a value that can be tried repeatedly during mining. Hash is the output of the hashing function applied to the input components. Mine automatically performs the nonce search. The relationship is summarized in Table 2.

Tabel 2. Structure and functions of the Block feature components

Component	Function	Role in the Block Feature
Block	Indicates the block number or identifier.	Identifies the observed block.
Nonce	Numeric value searched during mining.	Searches for a hash that satisfies the difficulty.
Data	Stores information in the block.	Serves as an input in hash formation.
Hash	Hash function output based on the block contents.	Indicates whether the block is valid or invalid.
Mine	Automatically performs the nonce search.	Generates a hash that again satisfies the validity criterion.

This structure illustrates concepts that are also used in simulator-based blockchain learning. Ren et al. (2024) explained that experimental blockchain simulations can be used to introduce block structures and consensus mechanisms gradually. In the simpler context observed in this study, the Block feature focuses only on the relationship among data, hash, nonce, and mining, allowing the mechanism to be observed without the complexity of a complete blockchain network.

Data Modification Testing on the Block

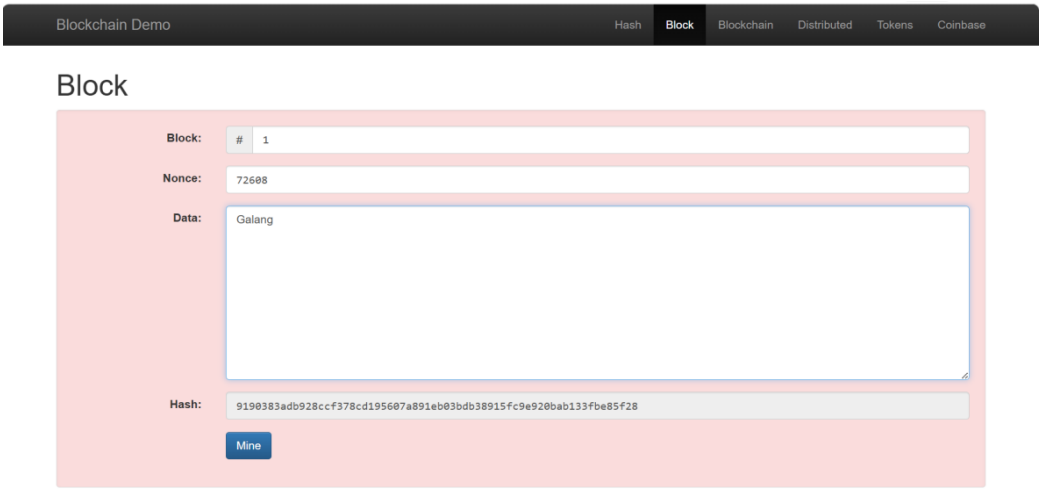


Figure 2. Block condition after the data was changed to "Galang"

The next test was conducted by adding the text "Galang" to the Data field. Block and Nonce were kept unchanged, while the system recalculated the Hash based on the modified input. The observation showed that the Hash changed to 9190383adb928ccf378cd195607a891eb03bdb38915fc9e920bab133fbe85f28. The hash did not begin with four zeros, causing the block to become invalid and the background to change from green to red.

This change demonstrates the sensitivity of the hash function to its input. Although the data modification consisted only of adding one word, the hash output changed entirely. This

characteristic is relevant to the discussion of hash functions in Rahim et al. (2023), while the simulation shows the consequences of data modification visually. At this point, an invalid block status does not mean that the data are lost; rather, the available hash no longer satisfies the difficulty criterion used by the simulation.

The result also clarifies the different functions of Data and Nonce. Data represents the information that is intended to be preserved, whereas Nonce is a value that can be changed to search for a hash that satisfies the rule. Therefore, when Data is changed, the previous hash cannot be maintained simply by keeping the same Nonce.

Testing the Mining Process on the Block

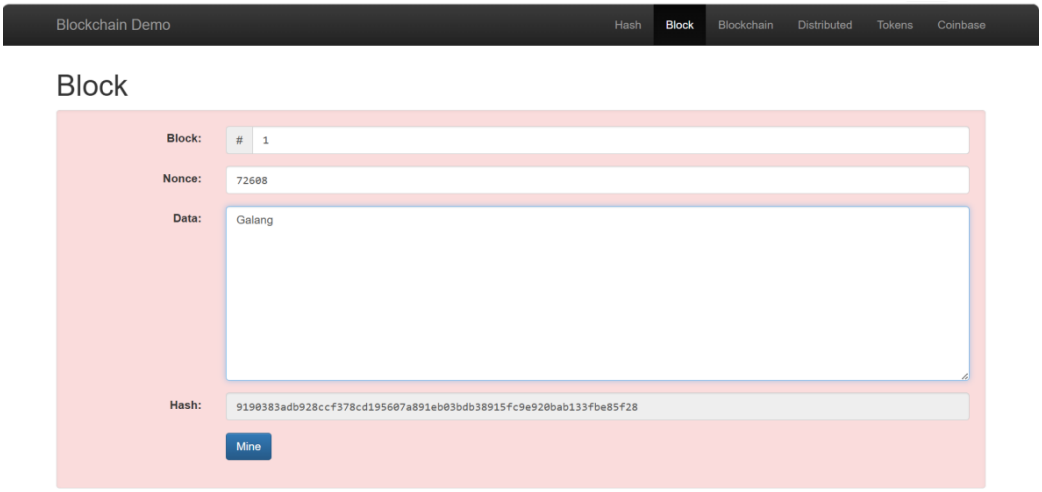


Figure 3. Block condition before the mining process

Before mining, the block was in an invalid condition. The Nonce remained 72608 and the Hash did not satisfy the difficulty. The Mine button was then used to initiate the search for a new Nonce value. During this process, the system did not change the Data content but searched for a value that produced a hash satisfying the specified criterion.

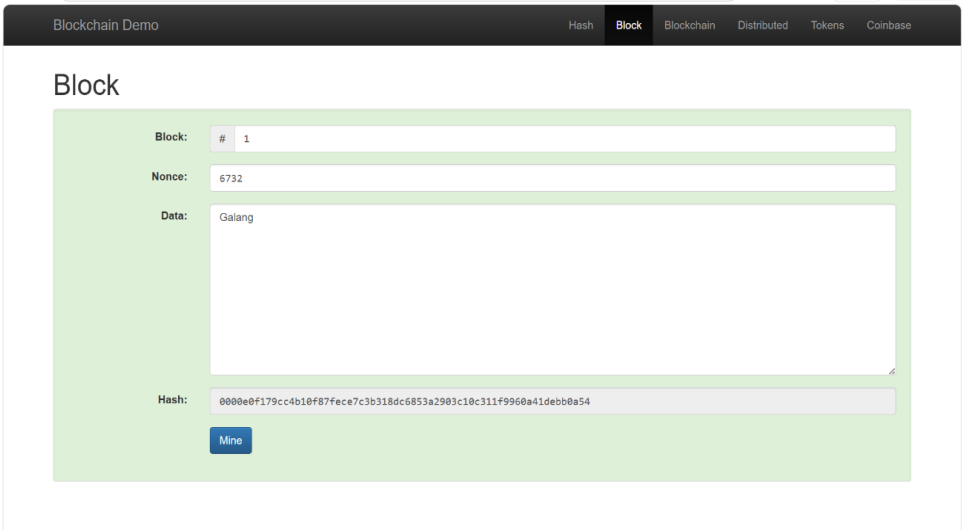


Figure 4. Condition Of The Block After The Mining Process

After the Mine button was pressed, the Nonce changed from 72608 to 6732. The Hash changed to 0000e0f179cc4b10f87fece7c3b318dc6853a2903c10c311f9960a41debb0a54. Because the hash again began with four zeros, the block status became valid and the background returned to green. The Data remained “Galang”, showing that the mining process searches for an appropriate nonce value without replacing the stored information.

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Table 3. Comparison Of Block Conditions Before And After Testing

Condition	Data	Nonce	Hash	Status
Before modification	Empty	72608	0000f727854b50bb95c054b39c1fe5c92e5ebcfa4 bcb5dc279f56aa96a365e5a	Valid (green)
After data modification	Galang	72608	9190383adb928ccf378cd195607a891eb03 bdb38915fc9e920bab133fbe85f28	Invalid (red)
After mining	Galang	6732	0000e0f179cc4b10f87fece7c3b318dc 6853a2903c10c311f9960a41debb0a54	Valid (green)

Table 3 shows a consistent pattern of change. Data modification affects the Hash and causes the valid condition to be lost. Mining then changes the Nonce until a Hash satisfying the difficulty is obtained, while the Data remains unchanged. This mechanism is a simplified form of proof-of-work. Blockchain literature also explains that simulation can be used to demonstrate the relationship between block structure and consensus algorithms, both in basic learning and in more complex experiments (Ren et al., 2024; Mekhovnikov & Toschev, 2024).

Discussion and Relationship to Previous Studies

The results show that the Block feature can be understood as a simple observation unit for demonstrating three important relationships. First, Data serves as an input that affects the Hash. Second, Hash is used as an indicator of whether the block satisfies the specified condition. Third, Nonce is the parameter searched during mining. These three relationships appear sequentially and can be observed without building a complete blockchain network.

From a learning perspective, this visual approach is related to studies using blockchain games and simulators. Tsang et al. (2022) developed BlockTrainHK so users could experience mining and blockchain formation. Latifah and Fauziah (2022) showed that experience-based simulation can be used to introduce blockchain operations to learners. Choi et al. (2022) used game-based learning to introduce blockchain, while Leung et al. (2024) emphasized the need for learning approaches that combine theory and application experience. Thus, the findings of this study reinforce the position of interactive simulation as a supporting tool for explaining blockchain mechanisms, although this study did not measure improvements in users' learning outcomes.

The main difference between this study and previous research lies in the focus of analysis. Previous studies have largely developed platforms, frameworks, or learning games, whereas this study does not develop a new application. Instead, it focuses on interpreting the mechanism already available in the Block feature and describing it through data-modification and mining experiments. This narrow focus allows each value change to be explicitly traced from the initial condition, through the invalid condition, to the restored valid condition.

The practical implication of these findings is that the Block feature can be used as a demonstration material in introductory blockchain technology instruction. Lecturers or instructors can ask students to record the Data, Nonce, and Hash values before modification, then change the Data, observe the Hash change, and activate Mine. This sequence provides students with an opportunity to connect hash and proof-of-work concepts with directly observable system behavior. The finding is consistent with literature that positions simulation as one strategy for reducing conceptual barriers in blockchain learning (Ocheja et al., 2022; Prawiyogi et al., 2021).

However, there are important limitations. This study observed only one feature in one simulation and did not involve students as respondents. Therefore, the conclusion regarding the potential of the medium as a learning tool cannot be treated as evidence of improved learning outcomes. Future studies could test the feature in a classroom using pre-tests and post-tests, measure conceptual understanding, and compare it with text-based or lecture-based learning.

Learning Implications and Limitations of the Analysis

The findings can be translated into a simple demonstration activity for blockchain technology learning. The activity can begin by asking students to observe the initial values of Block, Nonce, Data, and Hash. Students are then asked to modify one part of the Data and record the resulting hash change. The next step is to run Mine and record the new nonce. Through this sequence, students do not merely receive definitions of hash and proof-of-work but can observe the causal relationship between changes in input and system output. This activity pattern is consistent with blockchain education research that places interactive experience as one approach for clarifying abstract technical concepts (Tsang et al., 2022; Leung et al., 2024).

The activity can also be developed into a practical worksheet. The worksheet can include columns for recording the initial values, Data modification, Hash before mining, Nonce after mining, Hash after mining, and validity status. Students can then be asked to explain why changing the Data causes the hash to change and why mining does not need to change the Data to restore validity. This strategy can make the observation process more structured and enable lecturers to evaluate students' conceptual understanding rather than merely their ability to follow application steps.

In terms of content, the Block feature is sufficient to introduce the concepts of hash, nonce, difficulty, and proof-of-work, but it does not represent the entire blockchain mechanism. The feature does not show communication among nodes, the complete chain structure, ledger distribution mechanisms, transactions, or consensus mechanisms beyond the simplified form of proof-of-work. Therefore, the Block feature should be positioned as an introductory stage before students study the Blockchain and Distributed features. This gradual approach is consistent with educational blockchain simulators that separate block structure, networking, and consensus concepts so that the material can be learned progressively (Ren et al., 2024).

This study also has limitations in its observation data. The recorded Nonce and Hash values came from a single simulation session, so the study was not intended to measure the average number of mining attempts, computation time, or the mathematical relationship between difficulty and computational workload. The study also did not experiment with different difficulty levels. Therefore, the findings should be understood as a demonstration of the mechanism under the observed simulation configuration, rather than as a performance measurement of the proof-of-work algorithm in a real blockchain network.

Another limitation is the absence of user evaluation. Although the Block feature provides a clear visual display, this study did not measure whether students actually experienced improved understanding after using the simulation. This is important because blockchain education research indicates that media development and learning evaluation are two different aspects. Ocheja et al. (2022) highlighted the need for visualization that supports learning activities, while Leung et al. (2024) used a combination of quantitative and qualitative approaches to evaluate blockchain learning processes. Therefore, future research should include student respondents, conceptual understanding instruments, and learning outcome analysis so that the educational benefits can be tested empirically.

Overall, the contribution of this study lies in simplifying the explanation of the Block mechanism through a replicable sequence of observations. The study does not propose a new blockchain algorithm or a new simulator, but provides a structured interpretation of the behavior of an existing feature. This approach can serve as a basis for future research that develops blockchain practical modules, learning comprehension instruments, or comparisons of several blockchain learning simulators.

CONCLUSION

Based on observations of the Block feature in Anders Brownworth's Blockchain Demo, it

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can be concluded that the feature represents the basic mechanism of block formation and validation through the relationship among Block, Data, Nonce, Hash, and Mine. The initial condition showed a valid block with Nonce 72608 and a hash beginning with four zeros. When the Data was changed to "Galang", the hash changed to a value that did not satisfy the difficulty, causing the block status to become invalid. The mining process then changed the Nonce to 6732 and generated a new hash that again began with four zeros, while the Data remained unchanged. This sequence visually demonstrates that changes in input affect the hash and that a nonce can be used to search for a hash output that satisfies the proof-of-work rule in the simulation. From a learning perspective, the Block feature has potential as a demonstration medium for helping connect abstract blockchain concepts with directly observable system behavior. However, this study was limited to observation of one feature and did not measure its impact on student learning outcomes. Future research can test the medium with learners using pre-tests and post-tests, extend observations to the Blockchain and Distributed features, and compare several forms of blockchain learning media.

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