An Interactive and Didactic Tool for Learning the Principles of Blockchain Technology

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***Abstract*— Despite the growing adoption of blockchain technology across multiple industries, a significant educational gap persists among users unfamiliar with its technical foundations. This paper presents UAM-Blockchain, an interactive web-based educational platform designed to bridge this gap through a Learning-by-Doing methodology. The platform comprises ten learning modules with real-time simulators (SHA-256 hashing, blockchain trilemma, supply chain traceability), dynamic quizzes with automated feedback, and serverless data persistence via Google Firebase. A usability evaluation with 30 participants showed that 80.1% of users reported feeling capable of explaining blockchain fundamentals to others after completing the modules, and 73.3% rated the navigation as intuitive. These results suggest that interactive simulation is an effective approach for teaching abstract cryptographic concepts to non-expert users.**

I. Introduction

Blockchain technology has emerged not only as a technical innovation, but as a fundamental paradigm shift in how we manage information and trust in digital environments. Blockchain technology has become one of the most important and transformative innovations. Blockchain is based on three fundamental pillars that distinguish it from traditional databases: immutability, which guarantees that records cannot be altered once confirmed; transparency, which allows for public auditing of operations; and traceability, which ensures the tracking of the life cycle of any asset [1]. Initially known for its use in cryptocurrencies (e.g., Bitcoin), the scope of blockchain technology goes far beyond cryptocurrencies; this technology functions as a decentralized, secure, and transparent digital ledger that guarantees data integrity and traceability without the need for intermediaries. All these features are revolutionizing sectors such as finance [6], healthcare [3], IoT [9] and logistics [5], [8] as well as helping to reduce fraud and make many processes more efficient [7]. Even with the great benefits this technology offers and the enormous potential behind large industries, there is widespread ignorance about its technical principles and applications. This educational gap limits its adoption and use. Therefore, this paper proposes an interactive didactic tool (website) that guides users from basic concepts to real-world use cases. Our proposed tool tries to facilitate learning the basic principles of blockchain, using resources such as a website. This website contains basic information for learning, practical and easy exercises to immerse the user in this topic, as well as real use cases where blockchain was fundamental for some companies.

Our main motivation behind our work presented in this paper is based on the following requirements:

1) Education: There is a significant educational gap on the subject and a lack of attractive sites for explaining it to beginners, which is the main focus of the project.

2) Labor demand: The market requires professionals with knowledge of this technology, and it is estimated that the demand for blockchain developers has increased by 22% compared to previous years.

3) Social impact: Generalizing access to knowledge about blockchain can drive its adoption in sectors such as education, government, and SMEs (small and medium-sized enterprises).

In this paper, our contributions can be summarized as follows:

1) The design and implementation of an educational tool on a website that facilitates the learning of the fundamental principles of blockchain technology through resources and practical activities.

2) An implementation that explains concepts in a clear and understandable way, while minimizing the use of technical language so that any user can understand what is being discussed.

3) Practical examples that allow users to understand real-life cases of blockchain technology.

4) Links to access to external resources to complement the topic of blockchain (such as videos, links to specialized sites, readings, and articles in PDF format).

The obtained results in this study show that our didactic tool significantly improves users' understanding of blockchain principles, even for those without prior knowledge. Likewise, people who are curious about how this technology works will also have the opportunity to compare our didactic tool with traditional teaching models. Our didactic blockchain tool has been developed in Spanish language.

The rest of our paper has the following organization. Section II gives a brief literature review about blockchain technology. Section III presents our architecture and design of the systems. In Section IV, we explain our implementation, and present our evaluation and results. Our conclusions are given in Section V.

II. Blockchain technology

Blockchain technology allows information to be stored securely, decentralized, and transparently. Rehmani [4] defines blockchain as *a data structure that is read only and data cannot be modified once it is entered into the blockchain and new data can only be appended at the end of blockchain*. Compared to traditional databases that are controlled by a single entity, in blockchain, data is distributed across multiple entities, ensuring greater trust and resistance to fraud. A block is the basic component in a blockchain network because it assembles the transactions. These blocks can be linked in linear order, or using graphs or trees. For the adoption of blockchain technologies, it is recommended to observe certain aspects and principles that can be integrated into the development framework where that technology is planned to be used [2], [3].

Blockchain is appropriate when at least two of the following requirements are met:

- Distrust among participants: Multi-stakeholder environments without a trusted central entity (e.g., global supply chains).
- Need for immutability: Records that must not be altered (e.g., medical records).
- Verifiable traceability: Auditable tracking of assets (e.g., pharmaceuticals).
- Process automation: Execution of smart contracts [10] to reduce intermediaries (e.g., automatic payments).

However, there are cases where blockchain is not suitable:

- Traditional databases: If participants trust a centralized third party (e.g., internal company systems).
- Non-critical data: Information that does not require decentralized verification (e.g., product catalogs).

There are different consensus algorithms for implementing blockchain technology [3]. Proof-of-work (PoW) is the original consensus mechanism, used by Bitcoin. It relies on network participants (miners) competing to solve a complex mathematical problem that requires high computing power. This model provides the highest level of security and decentralization. However, its energy consumption is massive, leading to environmental criticism and scalability issues. Proof of Stake (PoS) has been proposed to mitigate the problems of Proof of Work (PoW). Instead of miners, PoS uses randomly generated validators who verify transactions and create new blocks. Validators deposit coins as collateral.The protocol pseudo-randomly selects the creator of the next block based on their stake. PoS has the advantage of not requiring expensive hardware and drastically reducing energy consumption compared to PoW. However, one of its limitations may be the risk of centralization if a few actors accumulate the majority of coins. There are other commonly used consensus algorithms for adding a block to the blockchain, such as Delegated Proof-of-Stake (DPoS), Proof of Elapsed Time (PoET), Practical Byzantine Fault Tolerance (PBFT), and Directed Acyclic Graph (DAG).

Several tools currently exist for learning blockchain concepts, each addressing different audiences and learning objectives. Most of these tools are scattered across the Internet. Below is a list of some of them and their main features. Anders Brownworth's Blockchain Demo [12] is an interactive web simulator that allows users to manipulate block data and visualize hash chaining, but it lacks theoretical coverage and structured learning progression. CryptoZombies [13] provides a gamified approach to learning Solidity smart contract programming, making it suitable for developers but inaccessible to users without prior coding knowledge. The Coursera Blockchain Specialization (University at Buffalo) [14] offers comprehensive theoretical coverage but requires payment and does not include real-time interactive simulators. On the other hand, IBM Blockchain Explained [15] provides accessible conceptual explanations but without any practical interactive components.

The main gap identified across these existing resources is the absence of a free, interactive, beginner-oriented platform that combines theoretical coverage, practical simulation, and structured progression particularly in Spanish. UAM-Blockchain was designed to address this specific gap.

III. Architecture and design

Our “UAM-Blockchain” system is designed as an interactive web-based educational platform that aims to mitigate the learning curve associated with the cryptographic concepts of Blockchain technology. Unlike traditional Learning Management Systems (LMS) that are limited to delivering static content (text and video), this system integrates real-time logic simulation engines.

Our architecture is designed considering three functional dimensions:

1) Didactic dimension: provides synthesized theoretical content on fundamentals, blockchain trilemma, and use cases.

2) Experimental dimension: provides simulation modules where the user can manipulate variables (Data, Nonce, Difficulty) to visualize the behavior of SHA-256 hash algorithms and the immutable block structure.

3) Evaluative dimension: includes data persistence mechanisms to record user progress and automatic quiz grading.

With these design dimensions in mind, we have developed a UML (Unified Modeling Language) Use Case Diagram to represent the operation and behavior of the system, which is shown in figure 1. This diagram allows us to clearly and simply represent how users interact with the system. This way, we can show the available options and functionalities. Through them, it is easier to understand the logic of use, the processes, and the experience we want to offer. In this design, users can log in/out, navigate to the modules menu, take mini-quizzes, consult the glossary, view additional resources, and submit feedback forms. Interconnectivity between applications is also evident, as the quiz application and feedback form are linked to the user's session status.

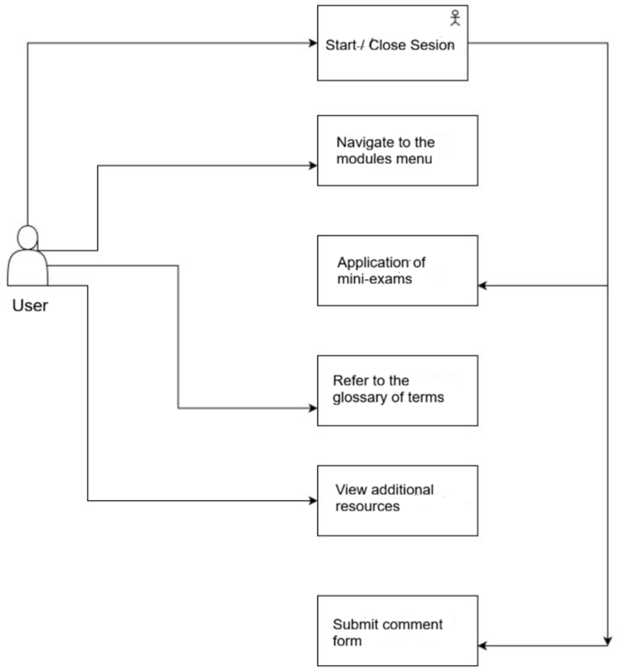

Fig. 1. System function

The operational part of the system has been designed to guide the user from complete ignorance to competency validation, following a logical sequence of four-stage: *learning, simulation, evaluation and persistence*. The *learning and simulation stages* are the core of our tool and represent the critical phase of operation. When a user accesses to the system simulator (e.g., Block Mining), it performs the following steps:

1) Data entry
2) Local Processing
3) Algorithmic execution (hash)
4) Difficult validation (whether or not the resulting hash meets the required value).

The *evaluation and persistence stages* allow the user to complete a dynamic questionnaire at the end of a theoretical module, which involves the following steps:

1) The system compares the selected answers against a vector of correct answers stored in the code (or database).
2) The percentage of correct answers is calculated.
3) A write request is sent to the database to permanently save the grade.
4) The system unlocks the next module of the roadmap if the grade is passing.

The learning and simulation stages in our architecture consist of ten modules, which are:

1) Blockchain fundamentals
2) Blockchain trilemma
3) Smart Contracts
4) Decentralised Identity
5) Blockchain in the supply chain (SCM)
6) Sensitive data management
7) Integration with IoT
8) Decision-making
9) Blockchain validation
10) Blockchain challenges

The first and second modules explore blockchain and explain the main concepts of this technology to the user. Modules three through eight explore the use of blockchain technology in different current scenarios, such as smart contracts, decentralized identity, integration with IoT and supply chain management. The ninth module allows for basic validation of the feasibility of implementing blockchain technology in a project, which could be important in investment and capital allocation environments. Finally, the last module presents some of the main challenges facing blockchain technology.

In the following, we present and explain the user diagram for two modules, which are the blockchain fundamentals module and the module that illustrates the use of blockchain in the supply chain management. The user diagram for the blockchain fundamentals module is shown in figure 2. This module presents fundamental concepts about blockchain, such as its definition, what a block contains, and how a chain works. Within the design dimensions, this part would correspond to the didactic dimension of the system. The module is complemented by an interactive visualization, which includes practical tools such as a hash simulation and a visual representation of how blockchain works. This part of the module corresponds to the experimental dimension of our architecture. Finally, the module is evaluated through an exam, which corresponds to the evaluative dimension in the design of the system (or tool).

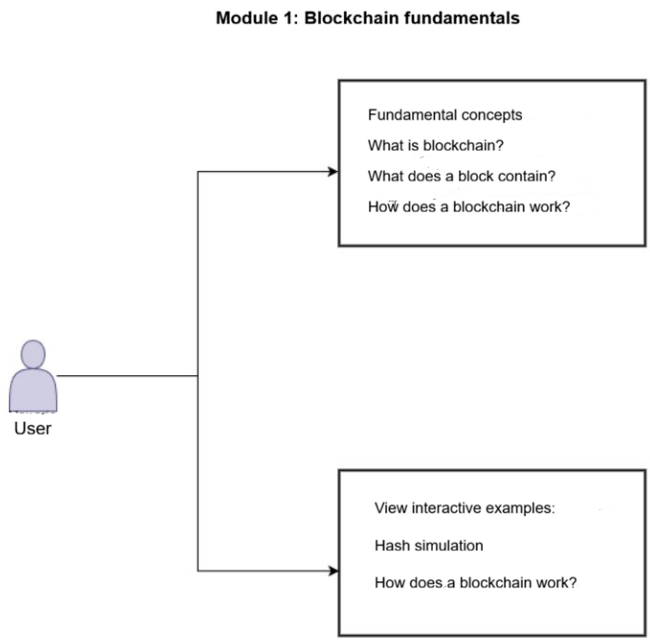

Fig. 2. Blockchain fundamentals module

On the other way, the module explaining the use of blockchain in the Supply Chain Management (SCM) shows the application of blockchain technology in logistics and traceability. In the case of logistics, it shows the flow of a process, explaining how an integrated supply chain with blockchain works. Similar to the module described above, this part addresses the educational dimension of the system. The module also includes a traceability simulator, which allows the user to verify a product to determine, through immutable records, whether it is a certified product or a counterfeit product. This part aligns with the experimental dimension of the system design. To conclude the learning of the module, the user can take an exam to pass the module, which corresponds to the evaluative dimension of our architecture.

IV. Implementation and Evaluation

Our technological solution has been built on a modern stack based on open web standards, avoiding dependence on heavy frameworks that compromise mobile performance. Our implementation considers the following architectures:

Web architecture: The system architecture transcends the traditional web model by implementing the PWA (Progressive Web Application) pattern. The central component of this architecture is the Service Worker. Technically, the Service Worker is a programmable network proxy that sits between the web application, the browser, and the network. Its function in this architecture is to intercept network requests and serve assets from the local cache if there is no internet connection.

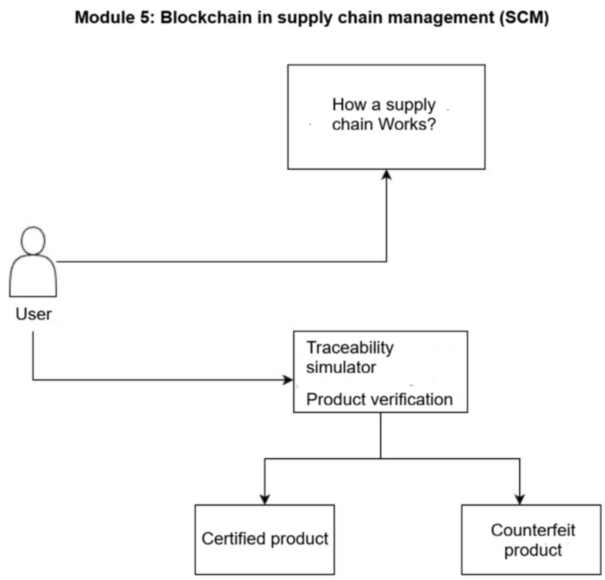

Fig. 3. Blockchain fundamentals module

For the cache strategy, a strategy known as Cache-First is implemented for static files (images, styles), ensuring instant loading on repeat visits.

For the web application, we use a JSON file (manifest.json) that allows the browser to “install” the web page on the mobile device's home screen, removing the browser interface (URL bar) to provide an immersive full-screen experience.

Data architecture: This architecture was designed to optimize fast reading of NoSQL data, given that it is an educational system. The model has two parts:

- *Users collection*: Stores the student's profile. The primary key is the UID generated by Firebase Auth.
- *Quiz_results collection:* Stores each assessment attempt. It includes references to the user ID, the grade obtained, the module assessed, and a server timestamp. This separation allows the exam history to be scaled without overloading the user profile.

Infrastructure and Data: For this layer, a serverless architecture was chosen using the Google Firebase suite [11], eliminating the need to manage physical servers or virtual machines. This layer has the following parts:

- *Firebase Authentication:* manages the identity lifecycle. It uses JWT (JSON Web Tokens) to securely validate user sessions, allowing registration via email and password.
- *Cloud Firestore (database):* unlike traditional SQL databases (such as MySQL) that use rigid tables, Firestore is a document-oriented NoSQL database.
- *Data structure:* information is organized into “collections” (e.g., users, attempts) and “documents” (JSON objects). This allows for complete flexibility to modify exam fields without altering the entire database schema.
- *Firebase Hosting:* Provides a global content delivery network (CDN), ensuring that static files (HTML, JS, images) are served from the server closest to the user, with SSL (HTTPS) certification included by default.

The front-end has been developed and designed under the Single Page Application (SPA) standard, which means that the application does not reload the entire document when browsing, but dynamically rewrites the DOM (Document Object Model). For this, Semantic HTML5 was used, which structures the information using tags that give meaning to the content, improving accessibility. CSS3 and Flexbox/Grid design are used as a custom stylesheet without external frameworks to reduce network transfer weight. JavaScript is also used to manage client-side routing, simulator logic (such as hash calculation), and asynchronous communication with cloud services.

The operational basis of the UAM-Blockchain system depends on robust identity management and conditional navigation. The logical and visual implementation of some of these components is described below.

A. Authentication (Login/Registration)

For access control, a centralized user interface was developed that uses DOM manipulation to switch between the “Login” and “Register” forms without reloading the page, improving fluidity through the use of interactive tabs. This scenario is shown in figure 4, where texts are depicted in Spanish.

In the logic layer, authentication is managed through the Firebase Authentication SDK (version 10.7.1). The Registration field is used when a new student submits the form, then the system invokes the asynchronous *createUserWithEmailAndPassword* function. If validation is successful, a credential is generated and, simultaneously, a write operation is executed in the Cloud Firestore database. This creates a document in the users collection where the name, email, registration date are stored, and sets an initial progress level of 1, preparing the profile for academic tracking. The Login field is used by existing users. In this case, the *signInWithEmailAndPassword* method is used, which validates the encrypted credentials and automatically redirects to the route map (Modules). The navigation bar in the system is implemented using a reactive architecture.

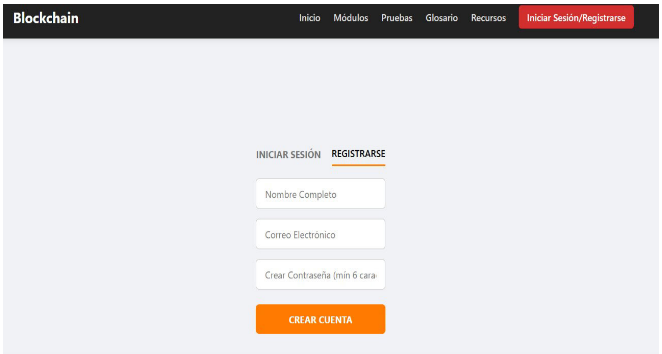

Fig. 4. User authentication and registration interface

B. Implementation of Interactive Educational Modules

The platform architecture was designed so that logical processing is executed on the client side (Client-Side Rendering) using Vanilla JavaScript (ES6+). This decision eliminates server wait times and allows for real-time feedback, which is essential for interactive learning. The technical implementation of the simulators is detailed below for the blockchain fundamentals and supply chain management modules.

B.1. Implementation of Module 1: Blockchain Fundamentals

This module introduces the fundamental data structure and was structured using semantic HTML5, employing <section> tags to separate the concepts of decentralization and the anatomy of a block. The critical component of this module is the “Hash Simulator.” To ensure that the simulation was true to the reality of networks such as Bitcoin, no predefined text strings were used. Instead, the actual SHA-256 cryptographic algorithm was implemented using the web browser's native API (Web Crypto API). The user view of the execution of the already implemented module is shown in Figure 5. Texts are shown in Spanish language.

B.2. Implementation of Module 5: Supply Chain Management

This module includes a simulator that makes traceability (Supply Chain Management) tangible and demonstrates how blockchain prevents the alteration of physical data throughout a product's journey. To create the Static Data structure, a master JSON object (simData) was declared to serve as the immutable ledger. This object contains the metadata (Batch, Temperature, Seals) from five logistics phases. To simulate the execution of the flow controller, a main function is created which accepts a Boolean value in its tag indicating whether the user scanned the genuine or counterfeit product. For anomaly detection, if the flow controller detects that the tag has a false value, then the script intentionally forces a divergence in step 4 (Aduana). Thus, instead of injecting the correct data, the structure (whose seal does not match) is read, the flow is interrupted, and a security alert (“FRAUD ALERT”) is issued, effectively illustrating cryptographic validation at each link. Figure 6 shows the operation of this module, with the texts displayed in Spanish.

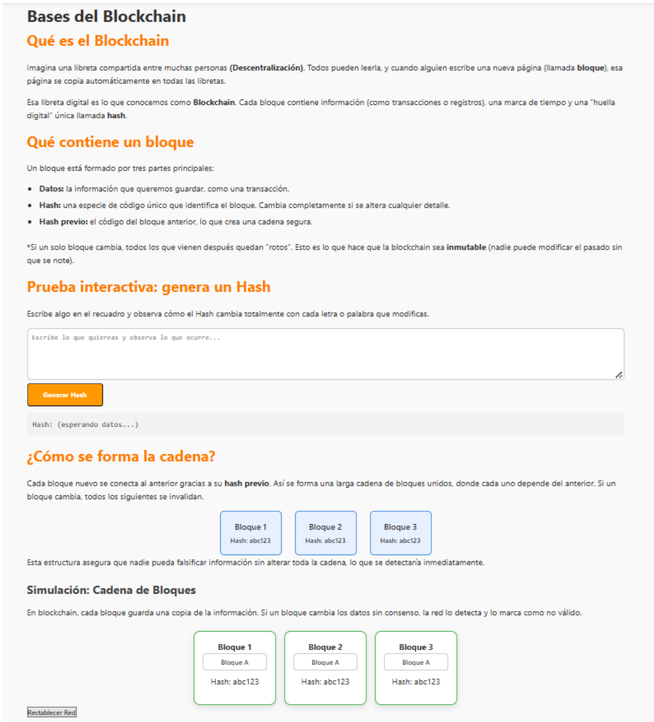

Fig. 5. Module 1 interface showing the linked structure of the blocks and the hashing simulator.

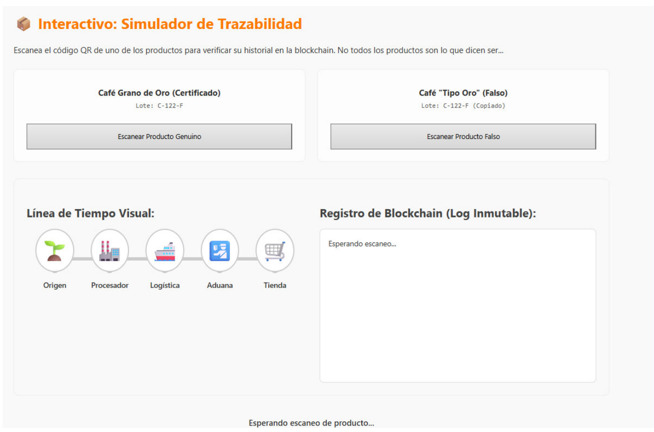

Fig. 6. Logistics simulator displaying supply chain disruption upon detection of a cryptographic inconsistency in Module 5.

C. Evaluation

To validate the usability, technical performance, and pedagogical impact of the “UAM-Blockchain” platform, a user testing phase was carried out. A quantitative assessment tool was designed based on a 5-point Likert scale (where 1 represents a poor experience and 5 an optimal experience). This instrument was applied to a sample of 30 individuals, including students and users with no prior experience in web development or decentralized technologies. The main objective was to measure the clarity of the graphical interface (UI), the technical stability of the system, and the effectiveness of interactive simulators for retaining complex concepts.

The first metric evaluated focused on information architecture and user fluidity when navigating the system, specifically through the modules' Roadmap. Results are shown in figure 7. As we can see, the results show a high success rate in the interface design. A solid 73.3% of the sample rated navigation positively (adding up the 43.3% who considered it “Very intuitive” and the 30% who considered it “Easy”). This validates the design decisions made and confirms that the modular structure and menu layout allow users to find content without cognitive friction. Only 6.7% reported frustration, suggesting areas of opportunity for future accessibility updates.

To evaluate the impact of the teaching tool, where simulators are the functional core of the project as they replace static reading with interactivity. In this case, we evaluated how much value the simulators (e.g., Hashing, Trilemma, Budget) added to the understanding of the theory.

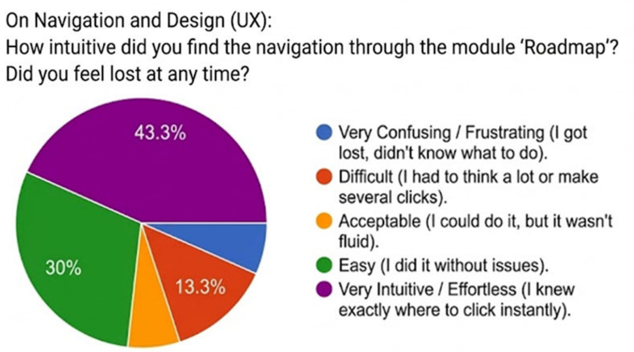

Fig. 7. Percentage distribution based on navigation intuition and user experience (UX)

The results are presented in Figure 8, and we can see that the data presented strongly supports the central hypothesis of this proposed interactive and didactic tool. 66.7% of the evaluators determined that the simulators facilitated their learning (40% “Very intuitive” and 26.7% “Easy”). This result shows that the execution of algorithms on the client side (such as the SHA-256 generator or the Traceability simulator) effectively makes abstract concepts tangible, justifying the technical effort invested in development.

Finally, we evaluated the perception of learning. This evaluation sought to measure the confidence gained by users after completing the 10 modules of the platform, assessing their self-perceived ability to explain blockchain technology to third parties. Results are shown in figure 9.

From figure 9, we can see that 53.4% of participants (36.7% + 16.7%) feel highly capable of transmitting the knowledge they have acquired. In addition, 26.7% achieved an acceptable level of understanding. Together, they indicate that 80.1% of the sample managed to internalize the fundamental bases of the technology. A minority of 16.7% still has difficulties. These results reaffirm that the platform fulfills its purpose.

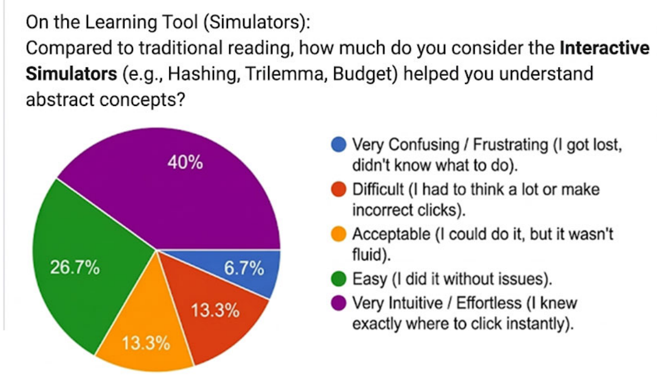

Fig. 8. Users' perception of the usefulness of interactive simulators compared to traditional reading methods

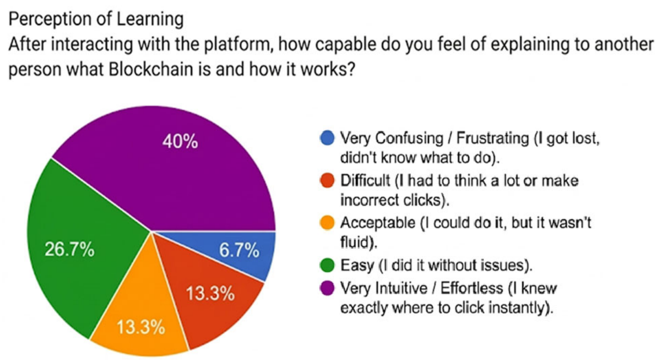

Fig. 9. Level of confidence acquired by users to explain the fundamentals of blockchain

It is acknowledged that the current evaluation represents an initial validation phase. The sample size (n=30) and the self-reported perception methodology are limitations of this study. Future work will incorporate pre/post knowledge assessments and a comparative baseline group to provide stronger evidence of the pedagogical effectiveness of the platform.

V. Conclusion

The development and implementation of the "UAM-Blockchain" platform suggests that the technical barrier to entry for learning decentralized technologies can be mitigated through the design of interactive interfaces and real-time simulation, as supported by an initial user evaluation. Our proposed interactive and didactic tool achieved its main objective by transitioning from a passive (purely text-based) educational model to an active (Learning by Doing) model. The results show that around 80% of test users said they felt capable and confident in explaining how blockchain works to third parties after using the tool. For this reason, we believe that "UAM-Blockchain" is positioned as a robust introductory tool that successfully bridges the gap between academic theory and real-world adoption, guiding the user from the conception of a block to business decision-making (feasibility assessment).

As future work, our interactive and didactic tool can be improved and expanded in different directions, such as optimizing performance on mobile devices, integrating Web3, and developing an administration panel for teachers.

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