How collaboration and distribution of responsibilities can be the key to victory in a scholastic board game

Group dynamics in a board game to teach blockchain at school based on collaboration and distributed

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Abstract

The development and testing of an innovative educational board game, designed to teach basic blockchain concepts while fostering collaborative skills, is described. The game simulates a simplified blockchain network, with small groups of students representing nodes that build and validate a distributed archive by computing cryptographic hashes. Testing with a small group of primary school students found that the game effectively provided an intuitive understanding of key blockchain principles such as decentralisation, distributed ledger integrity and the strength of network consensus. Importantly, it also promoted the development of socio-emotional skills through its emphasis on cooperation between player nodes. Statistical analyses and qualitative observations suggest significant improvements in collaborative problem solving, communication and teamwork skills. The interdisciplinary design, combining STEM, cryptography and social skills, encourages holistic thinking. This low-tech but engaging edutainment approach shows promise for introducing complex technical topics while reinforcing desirable learning behaviours aligned with 21st century skills. Further randomised evaluations are planned to more rigorously quantify cognitive and affective learning outcomes.

Keywords

Blockchain, Cryptography, Education, Collaborative learning, 21st century skills, Board game

1. Introduction

A board game that teaches the principles of blockchain at school was invented, prototyped and brought into the classroom [1]. Given the complexity of the subject, we wanted the game to be fundamentally analogue (with web support) and based on the concept that the team, the group, is the strength. Blockchain technology underpins the phenomenon of 'decentralization' of IT services, basing its strength on the distribution of power across a large number of nodes. The greater the number of nodes, the greater the security of the chain. In recent years, there has been an increasing recognition of the significance of collaboration in the field of computing [2] and its role in promoting effective learning and problem-solving skills. As such, educators and researchers have explored various approaches to incorporate collaborative learning experiences into educational settings. A return to boxed role-playing games has become fashionable again

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among young people [3]. In this context, the development of educational board games has emerged as a promising strategy to engage students in interactive and immersive learning activities. This scientific article aims to explore the collaborative aspect between students aside the design, implementation, and evaluation of an educational board game that not only imparts the basic principles of blockchain but also fosters the acquisition of essential behavioral skills, including teamwork, collaboration, and organizational abilities. Drawing inspiration from the seminal work of Roschelle and Teasley in 1995 [4], who define collaboration as a coordinated, synchronous activity aimed at constructing and maintaining a shared understanding of a problem, this study seeks to investigate the impact of collaborative board game experiences on students' learning outcomes and their ability to collaborate effectively to "save" the information contained in the distributed archive from the hacker attack. Realizing that the only possible defense is working in teamwork. By examining the interplay between teaching blockchain principles and fostering behavioral skills, this research contributes to the growing body of knowledge on collaborative learning in computing education. Furthermore, this study will explore the interdisciplinary nature of collaboration, encompassing aspects of technology, teamwork, communication, problem-solving, and decision-making. By investigating the effects of this educational board game on students' learning outcomes and their collaborative behaviors, this research aims to inform educational practices and contribute to the ongoing discourse on effective pedagogical approaches in computing education.

2. The structure of the game

The design of the game involved a hands-on learning approach with a focus on simplify the complex concepts of blockchain and enhance various skills, such as collaboration, computation, processing, communication, and manipulation, for students of different age groups. The game involves a group of 25 to 30 students divided into heterogeneous odd sub-groups of four or five students each, representing nodes in the blockchain network. Each student assumes a specific role within the team, such as the messenger responsible for communication, the compiler for storing data in blocks, and the calculator for calculating hash functions. The blocks of data are represented by chainable plastic bricks, manipulated and linked together by students to build the blockchain. The data itself is represented by a sentence, with individual words written on special cards and inserted into the chain, one per block. To simulate cryptography and hash function calculations, a simple system is introduced where each letter corresponds to a value based on its position in the alphabet, as you can see in Figure 1. Students assign values to each letter and calculate the total value for each word using this coding system, then they add the value of the previous block (a.k.a. "HASH IN") to the value of the current data block to calculate the next hash value (a.k.a. "HASH OUT"). The output hash value increases with each block and depends on the content of the preceding blocks.

Once the sentence is recorded, the students compare the final hash values between subgroups to check data accuracy and integrity. If all the hashes obtained are the same, the blockchain and the information it contains are considered valid and unalterable. In case of different results, the hash calculated by most teams is considered correct, any discrepancies were resolved by aligning data and hashes with the majority. This activity aims to introduce students to the

Figure 1: How we build the hash.

concepts of decentralization and archive integrity.

Following the data integrity check, a corruption attempt is introduced where a teacher or student attacks the archive by replacing a word in a particular block. This alteration causes all subsequent hashes to be recomputed, resulting in a different final hash value in the corrupted node. To completely corrupt the archive, the hacker must replace data in the majority of nodes. To simulate continuous communication between nodes, a game process is devised that requires messengers from each group to communicate at regular intervals and verify the final hash value. During each time cycle, any data and hashes recorded in nodes with a final hash value different from the majority are realigned to match the majority. By simplifying the operations of real-world blockchain technology, scaling them in time and size, and using game-based learning techniques, this simulation makes abstract concepts tangible and facilitates understanding of blockchain technology. The game has a digital version to support the interaction that takes place in the classroom. Via the website created specifically for the game, students can check the correctness of the hashes, simulate a hacker action and organize working groups.

3. Collaborative dynamics and interdisciplinarity

According to the World Economic Forum report New Vision for Education: Fostering Social and Emotional Learning Through Technology, social and emotional skills are critical to the workforce of the future [5]. By blending conventional skills with social and emotional aptitude, students will be well-prepared to thrive in the ever-changing digital landscape. Among the 14 learning strategies identified by the WEF to promote the development of social and emotional skills such as collaboration and cooperation, we find game-based learning and group work. Collaboration and cooperation are essential skills that enable individuals to engage effectively in social interactions and achieve common goals. The importance of fostering these skills during childhood cannot be overstated, as they lay the foundation for successful teamwork and interpersonal relationships later in life. Collaborative board games such as the game we prototyped, which require players to work together, communicate and make joint decisions, have emerged as a valuable tool for promoting cooperative behavior in students. In this game, where working groups represent the communicating nodes of the blockchain, the collaboration

aspect emerges strongly. If the groups do not organize themselves and talk to each other in an orderly manner, the lonely hacker will win and the team will lose. Here we can clearly see how a collaborative board game contributes to the development of students' skills in cooperation, collaboration, peer communication and shared decision making, and draws on authoritative sources to support these claims, while learning how blockchain works. A study by [6] investigated the effects of cooperative board games on social behavior in children aged 5-7. The findings revealed that collaborative gameplay significantly increased cooperative behaviors, such as sharing resources, offering assistance, and taking turns, compared to competitive games. This suggests that the cooperative nature of board games encourages children to understand the value of teamwork and reinforces the importance of working together towards a common objective. Going into the specifics of the game for which we created the prototype, it is interesting to highlight that there is a strong parallelism between the operating principle of the blockchain, which by its nature is a distributed system where nodes constantly collaborate with each other, and the board game, where students, divided into groups and also collaborating continuously, have to calculate the hash of the assigned sentence in the first part and defend themselves against hacker attacks in the second part by communicating the correct hash value to each other and verifying the integrity of each node.

When running the game in class, teachers said they were pleasantly surprised at how engaged the children were in their roles and how diligently they worked in groups. The pupils realized during the game that they would not be able to calculate the hash quickly on their own, let alone defend a node. This is where the 'group' factor and the strength of collaboration becomes crucial. During the two hours in which the game takes place, we have always experienced total student involvement and strict respect for roles, making the collaborative aspect of primary importance, as we can see in Figure 2.

This board game, played in a school environment, which focuses on the computation of a cryptographic code through mathematical calculations and requires group work, has an important role to play in reinforcing laboratory teaching and promoting interdisciplinary learning. By playing this game, students are not only exposed to the practical aspects of computing cryptographic codes and blockchain, but also develop important skills such as problem solving, critical thinking and effective communication in a team environment. The game's emphasis on group collaboration encourages students to pool their diverse knowledge and expertise, fostering a sense of shared responsibility and collective learning. Furthermore, the integration of mathematics and cryptography in a board game format provides a dynamic and interactive learning experience that bridges the gap between theoretical concepts and real-world applications. This approach facilitates a deeper understanding of the subject matter and strengthens the connection between different disciplines, fostering interdisciplinary thinking and promoting holistic learning experiences for students. In the classroom, it was noticed that the aspects related to civic education were constantly raised, starting from the questions asked by the pupils who were playing the game. Moreover, by discussing IT security, finance, cryptocurrencies, risks of fraud, a debate is created which can be managed, for example, with the Debate methodology [7] or simply by organizing a round table where each student expresses his or her observation, thanks to the role of the teacher as a mentor.

Figure 2: Students collaborate together.

4. Conclusions

In conclusion, the utilization of the new board game as an educational tool to teach blockchain technology in schools has been found to have a positive impact on reinforcing important social skills, including peer collaboration, communication, and organizing work in groups. Scientific research in the field of education [8] has consistently highlighted the effectiveness of game-based learning approaches in promoting collaborative and cooperative behaviors among students. This qualitative evidence underscores the potential of integrating innovative and interactive teaching methods, such as board games, to enhance both cognitive and social aspects of learning in educational contexts. The collaborative nature of the educational intervention, coupled with its focus on enhancing critical thinking and problem-solving skills, has shown promise in educational settings. However, to further validate the impact of the prototype and obtain more comprehensive insights, future research endeavors will expand the testing to a larger number of schools. This expanded study will include the incorporation of quantitative measures through entrance and exit assessments, which are currently undergoing development. These forthcoming quantitative tests will provide valuable data to assess the effectiveness of the prototype, enabling a more robust evaluation of its impact on student learning outcomes.

By combining both qualitative and quantitative measures, we aim to strengthen empirical evidence and contribute to the advancement of educational interventions in a meaningful and evidence-based manner.

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