Bloxxgame – A Simulation Game for Teaching Blockchain

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Abstract. Bloxxgame is a software tool evolving from a whiteboard-based blockchain game to a web-based simulation game with a variety of teaching scenarios. It is a simulation of a public blockchain, mostly similar to Bitcoin. Each player acts as a node with all possibilities of creating coin-transactions and blocks as well as the capability to experience the consensus algorithm by checking transactions and blocks. Bloxxgame supports experience-based instruction of blockchain concepts and can be used in class or for online teaching. Moreover, the simulation offers students the opportunity to experiment with all relevant operations of a blockchain such as signing, creating transactions, block building, etc. In this paper, we aim to share our practical experiences from teaching the emerging technology of blockchain to business or business information technology students on Bachelor and Master level applying a newly developed gamified teaching approach. The research was guided by the methodology of design-based research. We elaborate the process starting from problem identification, to designing the bloxxgame tool and demonstrating its applicability in the 2020 Corona lockdown.

Keywords: Teaching blockchain · Gamification · Design-based research

1 Introduction

In this paper, we present a structured analysis of five years of experimenting with various blockchain simulation scenarios in classroom. The result is a teaching solution we name bloxxgame. Bloxxgame is a software tool, which was developed from a whiteboard-based blockchain game in classroom to a web-based simulation game with a variety of teaching scenarios. It is a simulation of a public blockchain, mostly similar to Bitcoin, in which each player acts as a node with all possibilities of creating coin-transactions as well as blocks. Bloxxgame enables students to learn the consensus algorithm by checking transactions and blocks. It supports experience-based instruction of blockchain concepts and can be used in class or for online teaching. Moreover, the game offers students the opportunity to experiment with all relevant operations of a blockchain such as hashing, signing, block building, etc. The game experience supports the understanding of the abstract and complex blockchain mechanism. This is especially the case for the consensus algorithm, which bloxxgame simulates very closely.

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This paper summarizes the first teaching experiences, especially in the 2020 Corona lockdown, where it was used for instruction and as examination tool in a blockchain elective course. In addition, an outlook to further research on the impact of this tool, and to next steps in the development are provided.

2 Methodology

The methodology used to develop this teaching tool comes closest to design-based research [1]. This method is appropriate to the complexity of teaching blockchain and building artifacts. It is a common approach in information system research, which is another argument for this method, as we look at blockchain in regard of its role in this field. According to Pfeffers et al. [2], the research design consists of the following steps:

1. Problem identification and motivation; 2. Objectives of a solution; 3. Design and development; 4. Demonstration; 5. Evaluation; 6. Communication

Although the research design is nominally ordered and structured, the research process often does not follow these steps in a linear order [2]. In this ex post report of our research, the chapter sequence follows the six-step structure. Nevertheless, throughout the real research process, we made different loops and side steps. This paper is neither a general introduction to blockchain, nor a user manual for bloxxgame. The description of the software and its functions are restricted to the minimum, which is necessary for the explanation of the design process. Details about bloxxgame are available at: https://bloxx-wiki.herokuapp.com/.

3 Problem Identification and Objectives of the Solution

Although blockchain has been used and taught for a couple of years, it remains a very abstract concept, mostly described by its properties such as distributed ledger or storing transactions in blocks. To understand these blockchain elements, cryptographic functions such as hashing or signing must be introduced. When the term ‘mining’ comes up, explanations become harder. Building a block of transactions, solving a hash puzzle, attaching it to the longest valid chain and creating new cryptocurrencies, etc. are complex subjects. Finally, when the ‘consensus algorithm’ must be explained the gap between reality and abstraction grows even more. This is due to the dynamics emerging from the interaction of many independent actors following the rules of the consensus protocol. However, the mechanism or protocol of a blockchain is a complex, dynamic process, which involves many elements in various ways. Only when the interaction of the elements is recognized, the mechanism of blockchain can be fully understood.

Following Dettling [3] in “How to Teach Blockchain in a Business School”, blockchain courses can address three dimensions: First, the building blocks of blockchain, which are necessary to understand the basic mechanism of blockchain. Topics such as hashing, signatures, consensus algorithm, etc. belong to this category. Second, the relevance or the impact of blockchain in business, which is for the time being represented by topics such as cryptocurrencies, smart contracts, legal issues, etc. Third, the applications of blockchain where nowadays most blockchain startups are active and

which is a very dynamic field. Here, almost each industry has its own ecosystem requiring specific solutions for various use cases.

We focus on the first dimension, the mechanism of blockchain. This by the conviction, that a basic understanding of blockchain is a necessary precondition to fully understand the impact and application of blockchain. This assumption could change in the future, when blockchain has been universally adopted and seamlessly integrated into software systems. Today, software developers and business strategists are still searching for another 'killer' application besides Bitcoin. Consequently, qualified knowledge is still necessary to make strategic business decisions aiming at the use of blockchain. As our developed teaching approach incorporates gamification, the next section will focus on reviewing the relevant literature in this field.

3.1 Literature Review

Background of Gamification as Teaching Approach

To understand the term gamification, it is necessary to turn to the origin of this concept, namely the play. Piaget [4], a pioneer and enduring influencer in educational research, laid the foundations for integrating the idea of 'play' into didactic scenarios. He was the first to introduce the theory of constructivism, a learning situation in which the learners' knowledge and meanings are 'constructed' through the interaction of their ideas and experiences. Constructivist learning presupposes the necessity of experiential learning through social interaction with the environment and peers [5]. A statement of Piaget [4] confirms this: "You cannot teach concepts verbally; you must use a method founded on activity". One such activity may be 'playing', and the play is regarded as one central pattern for active and spontaneous children's learning.

Transferring the idea of 'play' to adult education and the corporate learning setting has led to the term gamification. As additional concept, the term serious games has gained relevance and it denotes games designed to convey learning material [6].

State of Gamification as Approach to Teach Blockchain

A systematic literature review of studies published in the scientific databases Web of Science, IEEE Xplore, ACM Digital Library, google scholar and SpringerLink was performed. The term 'blockchain' was combined with the keyword 'gamification' and subsequently with keywords like 'teaching', 'learning' and 'education'. From the result set we excluded studies that investigate the use of blockchain technology as a means of supporting processes in the education sector or that use blockchain technology as a technological basis for virtual games. We focused on studies in English language that deal with the question of how blockchain can be taught or learned as a subject. Furthermore, only studies that are available online as full text were considered for this review.

Most of the identified publications examine ways in which blockchain can be integrated into existing curricula of higher education institutions. Toleva-Stoimenova et al. [7] share their experience concerning the incorporation of blockchain content into existing data science curricula for master's programs. Purden et al. [8] generally advocate using a blockchain application in the cloud for classes thus avoiding the need for hardware; Dettling [3] proposes specific subject structures for teaching business students. In

line with the latter, teaching blockchain to non-technical students is the focus of Negash and Thomas [9]. They developed seven use cases from industry (e.g. aviation, healthcare car, supply chain) to achieve the learning objectives. Kursh et al. [10] evaluate blockchain as a topic in Fintec curricula and offer categorization according to several dimensions such as level of detail, format, and emphasis.

Few more detailed approaches towards blockchain teaching can be found in recent publications. The first example is a role play combined with 3D animations [11]. The game simulates a classroom and offers a puzzle to the learners, where questions related to blockchains have to be answered to get to the next levels. A second research result is a Java application called 'ChainTutor', enabling users to experiment with important blockchain concepts through a graphical user interface [12]. The application is capable of simulating low-level details of a blockchain such as the generation of keys, hashes, transactions, blocks and wallets. As a third approach, Rao and Dave [13] explain how they developed a hands-on lab using a Raspberry Pi to instruct students on embedded systems with elements of cloud and blockchain technology.

3.2 Application of Gamification Theory in Bloxxgame

As evidenced by the literature research, the application of gamification to the topic of blockchain is still in its infancy. Adding game elements to a learning situation does not per se add value; rather an appropriate didactic concept is an important prerequisite for successful implementation [14]. For this reason, we proposed different teaching scenarios, which have been developed based on practical experience.

In all scenarios, bloxxgame offers a simulation of a blockchain. A simulation can be defined as a method of implementing a representation of a system, an entity, a phenomenon, or a process over time [15]. Simulations attempt to capture relevant aspects of a topic or phenomenon to allow learners to interact in order to observe the effects of their interactions [16]. These simulations are not only effective in situations where real-world contact is dangerous or expensive (e.g., flight simulators), but also in situations where the topic in focus is very abstract or complex (e.g., [17]). Blockchain is a highly challenging subject that requires the learner to understand concepts in the field of economics, finance, and information technology, in particular cryptography. In addition, the mechanisms of blockchain are inherently very abstract, given that they occur in cyberspace. Therefore, it is very promising to simulate the essential operations of blockchain to help individuals 'experience' the technology and see the impact of own actions.

3.3 Objectives of the Solution

The solution we were looking for was a teaching method and/or a tool, which enables learners to gain a profound understanding of the basic blockchain mechanism. We expected that after the instruction, students should be able to describe the main elements and give a coherent explanation of the mechanism of a blockchain. At best, the tool should also provide means to evaluate this understanding. Once the tool was developed, we recognized that it was more than just a demonstrator or teaching lab in the classroom, but that it could also be used as a blockchain simulation game. Therefore, another

objective of this solution could be added: It should provide an authentic experience of the consensus algorithm.

4 Design and Development of the Solution

When designing bloxxgame, it was important to reduce complexity, without neglecting relevant aspects of the topic. We decided to focus on a public blockchain, which issues coins and only allows transactions of integer coins from one address to another. This comes very closely to Bitcoin although there are some important differences to the Bitcoin protocol.

4.1 Design of the Software

In the beginning, we used paper and whiteboards to simulate coin transactions and build blocks with them. It helped the students to visualize the different steps of the blockchain algorithm, but the necessary reduction of reality was disadvantageous since many important things such as hashing, or signing were left out. Thus, the idea of a software-based simulation became imminent. The main elements of the software were derived from the classroom experience.

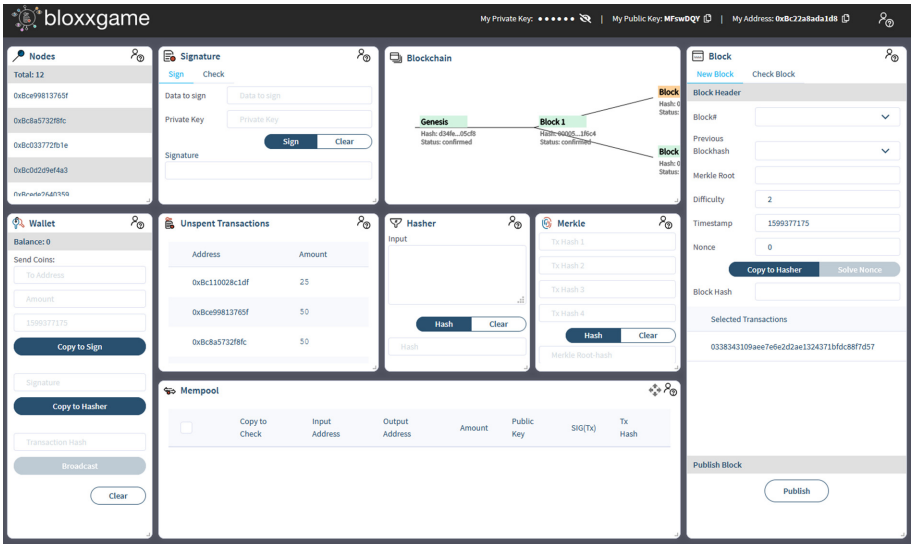

Fig. 1. Bloxxgame Play-Board. Nine boxes represent all relevant functions for blockchain transactions and display the status of the active blockchain seen as a node in real-time.

Normally, simplicity in software design is achieved by automating processes to help the user easily accomplish complex tasks. In bloxxgame we aimed at the opposite. No automated operations are implemented; only basic functions such as hashing, asymmetric

encryption and decryption, as well as broadcasting data to the blockchain network are provided as encapsulated functions.

All design decisions were based on two main criteria – simplicity, and transparency.

The result of this was a one-screen-board containing a complete set of functions, which are used in blockchains (Fig. 1). These functions are organized in logical units, which are called boxes. In total, nine boxes comprise the game front-end: Nodes, Wallet, Signature, Unspent Transactions, Mempool, Blockchain, Hasher, Merkle, Block. Each box consists of a set of data and functions, which can be treated as a single learning topic.

There is a second screen (called 'admin') only for teachers (Fig. 2). The admin can reset or initiate a new blockchain by sending coins to the wallets of each player when creating the genesis block. The difficulty and reward for mining can also be adjusted. When the admin marks a new block as 'confirmed', all related transactions get the same status for all players. There is also a 'view'-mode where the admin can see all nodes and the transactions initiated or received by them. In bloxxgame, the students stay anonymous, only the node address of active players is shown to the teacher.

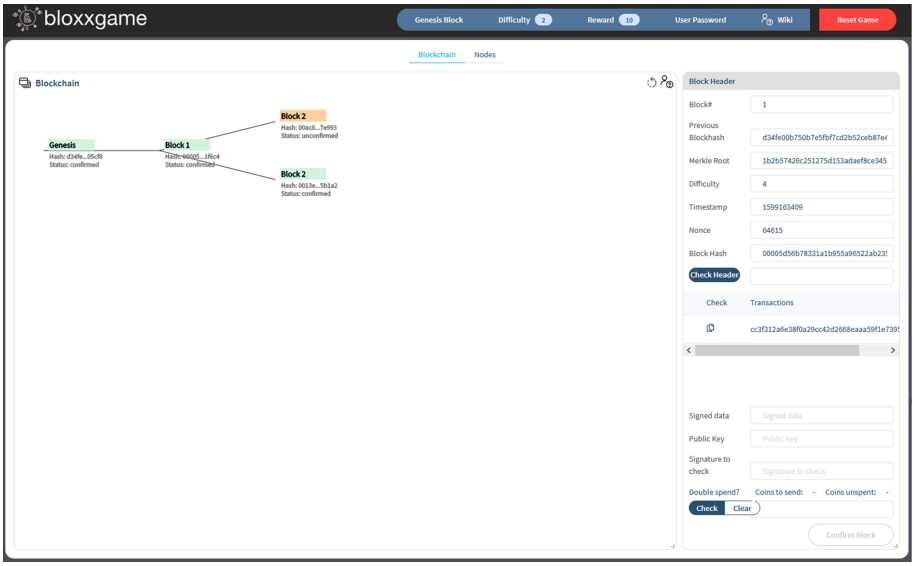

Fig. 2. Bloxxgame Admin-Board. Teacher can start, overview and influence the outcome of a bloxxgame session within the limits of the bloxxgame consensus algorithm.

4.2 Teaching Scenarios with Bloxxgame

We propose three elementary teaching scenarios when applying bloxxgame. For students with little or no knowledge in blockchain, it is recommended to start with scenario 1, before trying scenario 2 or 3. However, it would also be possible to start immediately

with a blockchain-building session without instructions. In any case, all scenarios are suitable for class instruction or for online teaching.

Scenario 1: Understanding the Basic Elements of Blockchain
In this initial scenario, the boxes can be used for explanation or experimenting with the various core concepts of blockchain, e.g. hashing, signing data, building a Merkle tree, etc. One important aspect is the 'check function', which shows up in several boxes. The check function supports the comparison of hash values or is executed to confirm the validity of signed data. Students using the bloxxgame tool for the first time can be supported by teachers in different ways. For example, teachers can start with bloxxgame as a demonstrator tool for instruction and then let the students have their own experiences. In class, this can be done either in groups or each student can work on a separate node.

Scenario 2: Interacting with the Blockchain
After a first inspection of the basic boxes (Fig. 1), the next step would be to use functions, which have an impact on the blockchain status. Before students can start with this activity, the teacher must create the genesis block. The main operations at this level are the creation of transactions or blocks. Both operations are complex activities with several steps and involve multiple boxes simultaneously. At this point, each player will get in contact with the activities of other players. For example, transactions, which are broadcast, will show up in the mempool box of each player, and blocks, which are published, will be attached to the existing blockchain in the blockchain box. At this level latest, the learning process takes on a dynamic of its own for each player.

After experimenting, different topics can be reflected in class: In addition, the creation of transactions and blocks, the most important topics are the checking of transactions in the mempool, the checking of blocks as well as the process of block confirmation. The role of teachers in this scenario can vary from individual coaching to additional class instructions on topics such as forking or double spending. In addition, the teacher must decide on the block status. Only when a block gets the status 'confirmed', the transactions in the block are considered in the mempool, in the wallets and in the unspent transactions. In this scenario, individual or group work is possible.

Scenario 3: Immerging into the Blockchain
When students are familiar with the functions and operations of bloxxgame, the next level is a scenario where the whole blockchain is reset and all players acting as nodes have to login again. After the creation of the genesis block, the students can start to create transactions and blocks. Teachers can guide the students by announcing tasks they should perform, e.g. sending coins to a specific address, creating a block with a specific number of transactions, identifying inconsistent transactions in the mempool, etc. There is no fixed 'finish line' in the game, so it would make sense to either limit the number of blocks, which should be built or the time until the game is closed. In this scenario, the teacher only must observe the block creation and decide, on which branch the blockchain will grow. Normally students behave competitively without further instruction. The fact that they can earn coins by coinbase transactions with each block they create, and which is confirmed, results in a high intensity for all participants.

In a later chapter, we will show that scenario 3 gives ground for further analysis and development of bloxxgame. Again, this approach enables individual as well as group work.

5 Demonstration of Bloxxgame

The demonstration phase in the research process should prove that the solution works and achieves the objectives set for this solution [2]. So far, we have used bloxxgame in different classes with students of varying technical skills (bachelor in business economics, in business information technology, and executive master). We always could properly work with the software and focus on the teaching experiences. Exemplarily, we describe the case of one class in the next paragraphs.

In spring 2020, bloxxgame was used for teaching an elective class for students of information systems. We used bloxxgame to instruct and train the understanding of underlying algorithms and the mechanism of using a blockchain for distributed transaction handling. After four sessions in class, the Corona lockdown forced distance teaching in this course. The combination of online-teaching software with the web-based playground of bloxxgame was a good setting for this new situation. Especially the one-screen design was helpful for online classes. Students could follow the instructions in the teacher's screen and experiment in a separate window on their own node of bloxxgame. Teachers and students agreed on using a game session (scenario 3) for the final grading of the practical part of the course. The students had to perform a couple of actions such as hashing, signing, creating, and checking transactions, as well as creating an own validated block in the blockchain. The grading based on the blockchain data, which could be linked to the students by their submission of the respective node address with hashes of transactions or of the performed actions. The outcome was positive and allowed a clear distinction between different levels of blockchain understanding.

6 Evaluation

Once the demonstration of the solution proved its feasibility, a formal evaluation of the outcome of bloxxgame becomes necessary. Gamification, which was not in focus of the solution at the beginning emerged as an important characteristic of bloxxgame. Especially in teaching scenario 3, students began to engage more emotionally. In discussions after the game, students showed more interest and awareness regarding networks or the social aspect of cooperation. This opened the field for advanced teaching topics about the role of blockchain in society. Additionally, feedback from students was used for the further development of the game. For example, the possibility to change the difficulty for mining was induced by students' wish for more competition. So far, formal feedback from students about bloxxgame was part of the overall evaluation of blockchain courses. Now, having a tool which can be used for a stand-alone activity, a systematic evaluation can be considered. For a formal evaluation, the following aspects are of interest: Topic mastery, entertainment, socialization. The next paragraph elaborates on more information about planned research.

7 Communication and Outlook

Communication in design science research has the purpose to expose the result of the study to other experts and researchers to prove or improve the result. So far, bloxxgame has only been communicated within a small group of teachers and blockchain experts. With this paper, we hope to increase attention and receive feedback from other teachers, which could help to improve our solution. The order of reaction and the grade of interest in this teaching approach will also be relevant for further development, such as making bloxxgame publicly available.

Bloxxgame will need further improvement if it should become a publicly available teaching tool. The following activities are ongoing or planned. A research project examines the impact of bloxxgame on the learning success of students. With pre- and post-game surveys we will compare the knowledge increase induced by different learning scenarios. In addition, students will be asked about their subjective learning experience and for ideas to improve the outcome. A second project will extend the technical infrastructure of bloxxgame. So far, bloxxgame is only usable in one instance. To become a multi-teacher, multiclass software and some additional programming will be necessary.

8 Conclusion

By exploring, experimenting, and playing bloxxgame, students will learn and understand how the most elementary components of an information system, the transaction, is handled in the blockchain. Although this looks like a very technical perspective, it will be understandable for everybody through the demonstrative form.

The second thing learners should experience and understand is the social and economic aspect of a public blockchain. For most people, the term ‘consensus algorithm’ is very abstract. When playing bloxxgame, they can experience the role of (social) interaction implied by the consensus algorithm. In bloxxgame each player will experience how the behavior of all participants decides on the outcome of the game.

For teachers, bloxxgame also offers many opportunities for discoveries and experiments. Bloxxgame is a playground with transparent functions and no automated checks or autofill functions, etc. Like in a board game, users are free to follow the suggestions of the game manual or to define own actions and procedures, as long as they are possible within the existing framework.

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