Supporting Students' Hands-On Understanding of Blockchain Concepts with 'The Crypto' Game

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Short Paper

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Abstract

This paper introduces 'The Crypto' game, an innovative educational tool designed to enhance students' hands-on understanding of blockchain concepts and principles. Despite the potential of blockchain technology to transform various industries, teaching its complex concepts to non-technical students remains a challenge. Developed for my teaching in business (MBA and Executive MBA) and information systems (IS) courses, 'The Crypto' game addresses this challenge. It is an active, experiential learning tool that simulates key elements of blockchain technology using a minimalist design and readily available tools such as Excel and Zoom. The paper details the game's design, rules, learning objectives, and pedagogical underpinnings and presents qualitative feedback from its implementation in my courses. The game effectively fosters a deeper understanding of blockchain principles and 'how it actually works'. By introducing 'The Crypto', this paper contributes to innovative approaches for teaching emerging technologies and offers practical support for IS, business, and other educators.

Keywords: Business Education, Information Systems Education, Blockchain, Cryptocurrency, Non-Fungible Tokens (NFTs), The Crypto Game, Digital Pedagogy, Experiential Learning, Gamification, Teaching Tool, Learning Objectives, Teaching Challenges, Learning Effectiveness, Learning by Doing, Student Engagement, Active Learning, Problem-Solving Skills, Collaborative Learning, Minimalist Design, Excel, Zoom, Distributed Ledger, Proof-of-Work, Consensus Mechanisms, Hashing, Immutable Rules, Teaching Case, Qualitative Feedback.

Introduction

This paper presents 'The Crypto' – an innovative educational game to support students' hands-on understanding of blockchain concepts and principles. Blockchain to a decentralised and distributed digital ledger system originally developed for the cryptocurrency Bitcoin (Nakamoto 2008). Blockchain has gained significant attention in information systems (IS) research and practice due to its potential to transform various industries (Beck et al. 2018; Lacity 2022; Rossi et al. 2019). However, despite its growing importance, teaching 'blockchain' at a deeper level to IS and business students remains challenging (Dettling 2018). This is mainly due to the technical complexity and abstract nature of the interwoven blockchain concept(s) (Nakamoto 2008).

Purely frontal teaching will typically fail to achieve a deeper understanding of the numerous complex and abstract technical concepts around blockchain. This has been my experience and that of many others, including this paper's reviewers (per their comments) and other educators (Dettling 2018; Kaden et al. 2021). To address this challenge, I have developed and introduced 'The Crypto' game in my teaching as a collaborative, interactive and experiential learning tool that *de facto* simulates the essential elements of blockchain technology via a deliberately minimalist 'Excel plus Zoom' approach. The purpose is to engage students actively with blockchain, 'crypto' (cryptocurrency, fungible tokens) and non-fungible tokens (NFT) for conceptual understanding 'how it actually works'. To avoid the barriers of programming skills or installation of tools, I used standard spreadsheet plus chat tools already used by students. The game has been very well received by students in multiple university-level courses and is provided game here due the interest of multiple colleagues.

This paper details 'The Crypto' game's design, rules and purpose and discusses the pedagogical underpinnings that informed its development. It also presents feedback on the implementation of 'The Crypto' game in postgraduate IS and business (MBA) courses, which has shown its effectiveness in enhancing students' comprehension of blockchain concepts. The game effectively fosters a deeper understanding of blockchain principles – such as immutable rules, blockchain, proof-of-work, consensus, hashing, etc. – while simultaneously promoting a fun yet reflective problem-solving environment for students. Hence, 'The Crypto' game offers a valuable and engaging supplement to traditional teaching methods, providing students with an effective means to grasp the complexities of blockchain technology. This paper contributes to the growing body of work on innovative educational approaches for teaching emerging digital technologies (here, blockchain) and serves as a practical tool for educators seeking to incorporate hands-on learning experiences in their IS curricula.

The paper assumes that readers are familiar with blockchain concepts and are looking for ways to teach students about these concepts (in line with the purpose of this track); the paper is not intended as a tutorial or introduction for readers unfamiliar with blockchain.

Background

Conceptually, the game is an exemplar of the experiential learning approach (Boud 1993; Kolb 1984) and its digital sub forms (Jiang et al. 2018; Prester et al. 2019; Schlagwein 2015). Experiential learning is an educational approach that emphasises active engagement and direct participation in learning. It is based on the idea that knowledge and understanding are developed through hands-on experiences rather than passive absorption of information via frontal teaching (e.g., 'PowerPoint slides'). In experiential learning, students actively explore, experiment and reflect on real-world situations, which helps them to connect theoretical concepts with practical applications. This immersive approach encourages students' development of personal and professional skills through reflection and 'learning by doing' in higher education (Kolb and Kolb 2005). By fostering a learning environment that prioritises discovery, experimentation and reflection, experiential learning enables students to gain a deeper and more meaningful understanding of the subject matter, ultimately resulting in better retention and application of the knowledge acquired (Kolb 1984). Many ideas of experiential learning can be traced back to Piaget or Dewey. Aligned with this paper and the tools it introduces, I have used these ideas for other forms of 'digital pedagogy' teaching innovations as well (Schlagwein 2015).

'The Crypto' game draws on and brings together ideas from several sources. The idea started when I searched for read up on the IBM blog on Christianson's at the time paper-based blockchain game (IBM

2019) when I led the development of a new course on digital work at The University of Sydney 2019-20. I drew inspiration from that game, notably the idea of using a game for teaching blockchain as well as the hash function. However, I wanted a simpler, NFT-related and purely digital game; hence, I ultimately designed almost every element of 'The Crypto' myself. While I wanted visibility of the formulas, I did not want the complexities of programming or installing code from GitHub or the like (Choi et al. 2022; GitHub 2023) as this is appropriate for computer science students but not MBA/business students (Dettling 2018; Kaden et al. 2021). Naturally, several ideas of 'The Crypto' game go back to the ideas outlined in the original Bitcoin white paper – notably, the core blockchain concept (Nakamoto 2008). In addition, I re-used Excel code from earlier digital pedagogy implementations (Schlagwein 2015).

How 'The Crypto' Game Is Played

'The Crypto' game is a deliberately minimalist version of a blockchain system, designed to be played within a single sheet of a single Excel file. The Excel sheet is "all in one": white paper, software and data (blockchain) storage. Each participant (student) receives a copy of the Excel file from the educator at the beginning of the game and then updates this file locally (i.e., in the same way that nodes of Bitcoin and other cryptocurrencies operate). Student communication occurs through chat tools (such as Slack, Teams or Zoom). The *raison d'être* of the 'The Crypto' game is not to be visually impressive or feature-rich; rather, it uses the design principles of making obvious core functions via simplicity (Norman 2013) – reducing the complexity of blockchain to its bare minimum, making its inner workings, principles and essence intuitively understandable even for non-technical audiences (as demonstrated successfully with full-time MBA and executive MBA students, see below).

I use the game after explaining blockchain and crypto concepts in a conventional manner, which typically results in some level of understanding among students. However, they often cannot fully fathom how it works in total, and technical terms are foreign to many (business) students. This is not a failure of the content of the slides of the explanation but rather the use of a limiting teaching format. 'The Crypto' is in recognition that frontal teaching in relation to blockchain will take educators only approximately as far as the 'theory' part takes driving instructors: useful to a degree, but students' 'learning by doing' is a necessary complement.

The game starts with an explanation of the Excel sheet, starting from the top.

Understanding the 'Immutable Rules' of 'The Crypto'

Figure 1 shows a part of the 'immutable rules' area of the 'The Crypto' game Excel sheet.

"The Crypto" Immutable Rules (per Programming and White Paper)
Hash = nonce (1,2,3) + a + b + c - last two digits of previous hash
nonce = arbitrary value between 1 and 3 – adjust to calculate a hash that is divisible by 3
a = value of the buyer
b = value of the seller
c = value of the item

Figure 1. 'Immutable Rules' of 'The Crypto' Excel Sheet

After distributing a copy of the Excel sheet to each student, the immutable rules of 'The Crypto' must be explained to students. The educator must explain that a blockchain is directed by a set of immutable rules that govern its underlying structure and provide a foundation for secure and transparent transactions. In real-life implementations, these immutable rules are typically outlined in a cryptocurrency or blockchain's white paper and implemented in its open-source programming code. In the Excel sheet, they are outlined in a few rules, lines of text and formulas that cannot be edited or changed. Specifically, the rules state that a unique hash for every transaction is to be generated by adding up the arbitrary nonce (1, 2 or 3) and the ASCII values of the first letters of the buyer's name (a), the seller's name (b) and the item's description (c). To calculate the full hash and to create a link between blocks of transactions, the last two digits of the previous hash are subtracted from the current hash calculation (i.e., this is the 'chain' aspect of blockchain).

To have this value for the first transaction, the blockchain must start with a ‘genesis’ (zero, first, initial) transaction block, which the educator can create as he/she sees fit. The nonce is to be chosen so that the hash is divisible by 3.

Students typically are somewhat confused at this point and want to know: ‘What are a, b and c in the hash function… where do those values come from?’ The answer is that these values represent transactions generated by the real-life trading of NFT art by the students of the course. The hashes cannot be pre-calculated, as no single party knows who will want to trade which item with whom in which order in the future (and hashes for new blocks are recursively linked to prior hashes).

The NFT art to be traded is generated live in class, which is the next step.

Creating NFTs to Trade via ‘The Crypto’

Figure 2 shows sample ‘NFT art’ – my signature “Schlagweinian Rabbit” (left) and “The Bell” drawn by one of my students (right).

Figure 2. *Impromptu* ‘NFT’ Art Pieces Created by Participants

The “creating NFTs” step of the game involves creating a few NFTs to be traded on 'The Crypto' blockchain. This engaging and creative aspect of 'The Crypto' game encourages students to draw a piece of art on either a digital or physical whiteboard or even sticky notes.

The artworks are then digitalised into JPGs, regardless of their initial format and their ownership is traded on the blockchain. This activity helps students understand the distinction between the (replicable) art piece and its (unique) ownership; every student has the NFT art as a JPG file (freely shared on the chat), but the ownership of the art piece is represented by a blockchain entry. Only one student is the socially recognized legitimate NFT art owner at any point in time. The drawing exercise injects a fun element into the learning experience, as it provides an opportunity for professors/educators to humorously display their lack of artistic skills and occasionally allows students to showcase their surprising artistic talents. Through this entertaining approach, the concept of NFTs and the idea of separation of ownership from the actual artwork becomes more comprehensible to students.

With some NFT art as items to trade, the trading and mining can begin.

Mining Solutions on ‘The Crypto’

Figure 3 shows a part of the ‘mining solutions’ area of the ‘The Crypto’ game Excel sheet.

Step 1: Work Out Correct Hash/Nonce Solution – Div-By-3 Must Turn Green!

"The Crypto" Work Area ("Mining" the Solution)

Transaction:	**Seller**	**Buyer**	**Item**
	Nathan	Kalle	LEO

Nonce?	**a (Seller)**	**b (Buyer)**	**c (Item)**	**Last Two Digits of Previous Hash**	Hash	Div-By-3?	
1	78	75	76	11	219		73.0
2	78	75	76	11	220		73.3
3	78	75	76	11	221		73.7

Look up a, b, c (First Letters of Seller, Buyer and Item)	
A	65
B	66

Previous hash? See blockchain!

Figure 3. Mining/Work Area of 'The Crypto' Excel Sheet

In the Excel sheet, this is called 'Step 1,' as it is one of two steps that keep repeating in each round (the earlier steps of explaining principles and creating art are performed once only). The mining step in 'The Crypto' game involves working out the correct hash/nonce solution – ensuring that the hash calculated above divides by 3 (and hence the Div-By-3 indicator turns green). This process takes place within the designated 'work area' of the Excel sheet, with the yellow cells editable. That is, students 'mine' the solution (correct hash) in this work/mining area through doing work.

First, we need a transaction to process. In the chat (or via discussion in the room), the educator and the students agree on which item is to be traded. In Figure 3, for example, Kalle has decided to buy the LEO artwork from Nathan. Once the next transaction has been decided, all students try to process this transaction by looking up the ASCII value of the first letters of the three elements of this transaction (N for Nathan, K for Kalle, L for LEO), entering them in the work/mining area, looking up the 'last two digits of the previous hash' (in the blockchain, see next section) and eventually figuring out the correct nonce and hash solution. In the example, the correct solution is '219' (calculated as: N=78 + K=75 + L=76 + 11 [last two digits of the previous hash] + 1 [trial-and-error correct nonce]). The first player to post the correct solution in the chat wins the round! With more and more students posting the correct solution (and occasionally some incorrect ones, which does not matter), it soon becomes clear what the correct solution is and who the first student to post it was. The educator can end the round by saying something like: 'As we can all see and test for ourselves, hash 219 and nonce 1 is the correct solution, and Sharna was the first one to post it in the chat! Right? Do we all agree? So, we have achieved 'consensus'! Sharna wins the coin just mined, and the Nathan-Kalle-LEO transaction can now be written into the blockchain by each of us'. The point of these lookups and calculations is to simulate the proof-of-work concept fundamental to the original blockchain concept and show the competitiveness – and the overhead! – of each round of mining. The educator is free to award "one Crypto", worth some gummy bears, free coffees or the like, to students winning the rounds (as a stand-in for being awarded Bitcoin mined or whatever the token of the blockchain). As one would expect, students get very competitive in this step as soon as the rules of the game are understood.

(The above represents, of course, deliberate simplifications against real-life blockchain systems such as Bitcoin, where: a) transactions are picked automatically based on transaction fees (not manually decided), b) the consensus mechanism is fully digital (not a partially social consensus), c) more than one transaction is stored per block and d) the overhead waste is the use of electricity (not the use of mind time). However, for the sake of scaffolding understanding, I suggest explaining these details, if not obvious to students, in the discussion *after* the game.)

Having successfully created a new block (of a single transaction), we can now update the blockchain.

Writing the 'The Crypto' Blockchain

Figure 4 shows a part of the 'blockchain' area of the 'The Crypto' game Excel sheet.

Step 2: Enter Transaction Data (Seller, Buyer, Item and Nonce Solution) – Div-By-3 Must Turn Green!
"The Crypto" Blockchain (Immutable Legder)

Block	Seller	Buyer	Item	Nonce	Prev Hash	a	b	c	Hash	Div-By-3?
0									0	
1	Na	Daniel	Lion	3	0	78	68	76	225	
2	Daniel	Nathan	LEO	1	25	68	78	76	198	
3	Kalle	Bo	Abacus	3	98	75	66	65	111	
4	Nathan	Kalle	LEO	1	11	78	75	76	219	
5					19	#N/A	#N/A	#N/A	#N/A	
6					#N/A	#N/A	#N/A	#N/A	#N/A	

Figure 4. Blockchain Area of 'The Crypto' Excel Sheet

As all participants have reached a consensus about the correct next block to enter (transaction details including nonce), everyone now locally updates their Excel sheet in 'Step 2'. The checksum field will turn from red to green (the Excel sheet checks if the hash is correct), indicating a valid block. Students failing to update their blockchain are unable to compete in the next round as they are missing the correct hash. They will need to download a copy of the most up-to-date (longest blockchain) file from the network.

At this point, the participants are asked for the next transaction. The first valid proposed transaction broadcast in the chat is then processed – which means going back to step 1 above and working on the (next) transaction block, etc.

After 5-10 rounds, students have understood key blockchain concepts including transactions (= trading a NFT piece between students), broadcasting (=announcing publicly on the chat), blocks (=the transactions stored in the blockchain part of the sheet), blockchain (=blocks linked together mathematical), consensus mechanism (=the principles of arriving at agreement), protocol/immutable rules (=rules that cannot be changed), proof-of-work, hashing and mining (=the calculation and search for the correct solution which involves unavoidable work), and the separation of 'ownership of a' and 'ability to use' for an NFT/digitalised art. On the last token, the educator may ask: 'Who can use Abacus.jpg?' Answer: 'Everyone.' 'Who can you buy ownership of Abacus.jpg from?' Answer: 'Only from Bo!' [in the example] 'How do you know Bo is the owner?' Answer: 'Because the blockchain says so; we all know this'.

The final pedagogical element I use: once the above principles are clear to all students, I ask a student, say Na in the example in Figures 4 and 5, to try to change the blockchain record after the fact and manipulate the ownership transfer of Lion.jpg so that it goes to herself instead of to Daniel (cheating him, the 'double spending' problem). When Na tries to do this, she realises that suddenly all hashes (all 'checksums') of the blockchain turn red. In other words, the hashes are all incorrect and would need to be recalculated one by one starting from the beginning. This means redoing the entirety of the work, even if all later transactions remain unchanged. All the while, the rest of the class keeps playing the game and keeps extending the real blockchain. As new participants – such as the educator going out of the classroom for a coffee break – will only accept the longest valid blockchain, it is hence necessary but practically impossible to catch up and overtake the real blockchain with a manipulated blockchain (i.e., getting the manipulated blockchain accepted as 'truth' by any other participant, including new participants entering the game).

Figure 5 below shows how a change in an earlier block (1) invalidates all following blocks.

Step 2: Enter Transaction Data (Seller, Buyer, Item and Nonce Solution) – Div-By-3 Must Turn Green!
"The Crypto" Blockchain (Immutable Legder)

Block	Seller	Buyer	Item	Nonce	Prev Hash	a	b	c	Hash	Div-By-3?
0									0	
1	Na	Na	Lion	3	0	78	78	76	235	
2	Daniel	Nathan	LEO	1	35	68	78	76	188	
3	Kalle	Bo	Abacus	3	88	75	66	65	121	
4	Nathan	Kalle	LEO	1	21	78	75	76	209	
5					9	#N/A	#N/A	#N/A	#N/A	
6					#N/A	#N/A	#N/A	#N/A	#N/A	

Figure 5. Attempt to Manipulate Blockchain of 'The Crypto' Excel Sheet

This final step makes students understand 'immutability', (solution of) the double spending problem, maintaining 'truth' socially (in a peer-to-peer network without central authority) and the nature of '51% attacks'. (As above, the paper assumes that readers are familiar with those concepts).

At this point, I usually conclude the game after about 45 minutes of play. The principles are understood, and students are typically in a good mood, particularly those who were convinced that they would never be able to wrap their heads around blockchain. The key blockchain principle is now understood. As usual, it is important not to overstay your welcome. However, the game now provides a great opportunity to link the elements 'played' back to earlier conceptual explanations and slides. Based on the conceptual understanding of blockchain, better-informed debates and discourse about the sense and nonsense around blockchains are then possible.

Results and Feedback from Teaching

So far, findings from my teaching as well as feedback from student and of colleagues (e.g., in Australia, Germany and the UK) has been very positive. An IS professorial colleague remarked to me that the game is a *'rather clever and strikingly simple'* way to teach blockchain. An IS PhD student commented that the game was *'better and clearer than anything [he] could ever find on social media'*.

While those comments might be positively skewed, anonymous student feedback – as collected by The University of Sydney independently and anonymously on all my courses – would not be expected to skew in this way. For the 'Crypto Game', these comments have also been very positive.

In a Master-level IS course (INFS6060), students commented: *'Daniel's way of explaining how people get to write the next block after solving a math problem is one of the easiest to understand'* and *'Daniel had a crypto game designed for us which helped us to actually understand what cryptocurrency is and how blockchains work'*. Students from my PhD course even asked permission to attend class in an entirely unrelated course as they had heard about 'The Crypto' game.

Non-IS Business students reacted similarly, with feedback from an Executive MBA (SMBA6109) course including *'loved the crypto Excel example. I think it really connected the dots for me on how blockchain and crypto worked'* and *'The blockchain Excel document was such a great way to demonstrate how blockchain worked'*. While a full-time MBA (FMBA501) student wrote: *'Daniel's blockchain activity was a lot of fun and educational'*.

Based on such feedback, as well as student's educational results seen in later essays, debates and exams, I conclude that 'The Crypto' game fulfils my original pedagogical and educational aim in developing it: to make blockchain concepts intuitively understandable in a fast, fun and innovative manner. As such, I hereby make the game available to the community of IS educators in the hope that it helps their teaching practices in a similar manner. While there are other tools available that involve more functions but are also far more complex (GitHub 2023), for the purposes of understanding blockchain (in) principle(s) in a limited amount of time and without technological barriers (such as programming knowledge or need for installing tools), 'The Crypto' is very effective.

Conclusion

This paper introduced 'The Crypto' game, an innovative educational tool that teaches blockchain concepts to students. Using a minimalist Excel and chat approach, the game enhances understanding of blockchain technology, cryptocurrencies and NFTs in an interactive and gamified style. The game offers a valuable supplement to traditional teaching methods, fostering a deeper comprehension of blockchain in a fun and experiential manner.

Game Materials

To get 'The Crypto' game and documentation, please get in touch with me. I acknowledge that there are natural limitations in explaining a process, such as a game, in static documents (this is the very premise of learning by doing). As such, I will try to offer a live video introduction or video recording thereof to colleagues on an 'as-needed' basis.

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