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Infusing Blockchain in accounting curricula and practice: expectations, challenges, and strategies

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Abstract. Blockchain, or distributed ledger technology, is acknowledged as the most significant and disruptive innovation in accounting since the double-entry system. All the 'Big Four' accounting firms and several major S&P500 companies have invested considerable resources in developing blockchain technologies. Some maximalists of this technology have even hinted that it will fundamentally change accounting and auditing if all transactions can be captured in an immutable blockchain. It is a daunting task for accounting academics to determine how to infuse blockchain in accounting curricula since the body of knowledge in this area spans several disciplines, such as, accounting, economics, finance, computer science, and engineering. It is also difficult for accounting practitioners to know what aspects of this technology are relevant to accountants for the same reason. In this paper, using the diffusion of innovation theory, I help explain why we need to incorporate the accounting-relevant aspects of blockchain in accounting curricula and practice and how we can accomplish that goal without introducing unnecessary technological complexity and jargon. I also provide eight case studies, which were successfully trialled by me at CPA organization/association conferences, that can be used to communicate the accounting relevant aspects of blockchain in the domains of accounting, tax, and audit services.

Keywords: Blockchain, distributed ledger technology, crypto, practice, teaching

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"An important scientific innovation rarely makes its way by gradually winning over and converting its opponents: What does happen is that the opponents gradually die out."

- *Max Planck, Physicist & Nobel Prize (1918) Winner*

1. INTRODUCTION

The recent FTX crypto exchange debacle has ignited conversations on how accountants can play a larger role in the blockchain space from a 'governance and controls' standpoint. In one of their non-authoritative guidance papers in 2017, American Institute of Certified Public Accountants (AICPA) and Chartered Professional Accountants of Canada (CPA Canada), suggested that "*Both the role and skill sets of CPA auditors may change as new blockchain-based techniques and procedures emerge*" (Deloitte, 2017, p. 2). However, post this guidance, very little has been done to guide the accounting profession or academia about what specific blockchain-related skillsets they need except the establishment of some certificates, courses, programs, and workshops on blockchain, which are dated, and the continuation of some very generic conversations on blockchain over webinars.[1] In this paper, using the diffusion of innovation theory, I help explain why accountants need to take better ownership of blockchain technology and how accounting academics and practitioners can be at the forefront of this process. I also provide eight case studies, which were successfully conducted by me in CPA organization/association conferences with working and aspiring CPAs, that can be used to communicate the technology-, audit- and tax-related aspects of blockchain to students and practitioners without incorporating unnecessary technological complexities and jargon.

Recently, there have been articles arguing how blockchain technology is going to disrupt the accounting and auditing profession. Some argue that blockchain is going to be a death knell for the traditional accounting and auditing profession, while others argue that it is an untapped opportunity that accountants need to capitalize on. For example, an article in MarketWatch (2018) suggested that blockchain will

[1] See Annex 1 for details on these certificates, courses, programs, and workshops on blockchain by leading accounting institutes around the world.

make today's accountants obsolete, while another article in Forbes (2018) in that same period argued that blockchain was not a threat to accounting but an opportunity. I believe a lot of this paranoia about blockchain is resulting from a poor understanding that the accounting profession has of the nature of blockchain technology and its use cases. In this paper, I have attempted to explain the accounting-relevant aspects of blockchain from a non-technical perspective that would be useful for accounting educators and practitioners and provided case studies that can be used in the domains of accounting, tax, and audit services.

In conference proceedings where I have been invited to speak on blockchain, I usually begin by asking the attending academics and industry professionals on who has a good understanding of what a *ledger* is, and every hand goes up at once indicating a 'yes' response. Then, I ask the next question of who has a good understand of what a *distributed ledger* is, and almost no hand goes up – there is just a dead silence in the room. There have been some embarrassing incidents taking place around Tax Day 2022 when some accountants had no idea on how to go about tax reporting for cryptocurrencies (Desai, 2023). There has also been a growing trend in accounting programs, whereby blockchain is pawned off to the information systems faculty as something they need to teach students or students simply end up taking blockchain-inclusive courses from other disciplines, such as computer science.[2] However, these courses do not cover blockchain from an accounting perspective and are not quite useful for accounting professionals.

Several accounting students, academics and industry professionals also have the misconception that blockchain is a new technology. As a first step, they need to be informed that blockchain is not a new technology, and it has existed since the mid-1990s. Stuart Haber and Scott Stornetta, who worked at Bell Labs, are credited with innovating blockchain technology (Forbes, 2020a). Interestingly, three of their papers have been cited by Satoshi Nakamoto, the pseudonym for the creator of Bitcoin, in the Bitcoin whitepaper (Nakamoto, 2009). Haber and Stornetta (1991) worked on creating a trusted and immutable linked timestamp of a series of digital documents using cryptographic hash functions, which are mathematical functions

[2] See Annex 2 for a discipline-wise breakdown of how blockchain technology is being incorporated in courses by universities around the world. Only 3% of course offerings from universities in CoinDesk's (2022b) Blockchain University Rankings were specifically associated with the 'Accounting & Information Systems' discipline with other disciplines doing a much better job in offering courses related to blockchain.

that converted the content of the documents to a fixed-length hash. However, they had not resolved the ‘trustlessness’ part of the blockchain technology puzzle at the time, and thus, they published their cryptographic hash in the Sunday edition of the New York Times as an advertisement, which acted as a fingerprint for all the prior transactions.

In Section 2, using the diffusion of innovation theory, I discuss how accounting has lagged as a discipline in embracing blockchain technology in comparison to other disciplines. I then explain how accounting academics and professionals should be made to find and discuss information on blockchain with the objective of evaluating it as any other technology innovation by debating the following characteristics, namely, its complexity, its relative advantage over existing technologies, its compatibility with legacy systems, trialability of its applications, and observability of its benefits. This first case study would give one a fantastic understanding of how blockchain is placed vis-à-vis other digital accounting technologies. A follow-up case study at this stage could be to place blockchain and its use cases in Gourville’s ‘*Capturing Value from Innovations*’ Matrix (Gourville, 2006). These two case studies would give students and practitioners an excellent understanding and a holistic view of blockchain, and its technology use cases.

In Section 3, using Bloom’s Taxonomy, I present a multi-layered cake approach to including different aspects of blockchain technology in accounting curricula and practice. I discuss the specific design features of blockchain (e.g., blocks, hash functions, and digital signatures) that pertain to data integrity and data governance that accountants need to know about. I also distinguish the less relevant design features of blockchain (e.g., nodes and networks and consensus mechanisms) that are better left to other disciplines and professionals to take care of as they are better suited to cover them. Thus, in the third case study, I discuss the basics of what the ‘blocks’ are in a blockchain and explain their two key features, namely, append-only, and timestamping. The fourth case study is about introducing the fundamental concept of asymmetric cryptography through a simulation of a hash function, and the role it plays as a feature of blockchain technology. The fifth case study is about extending the concepts of cryptography to public-key cryptography (PKC) and digital signatures and explaining the process of transaction authentication through a sender-receiver role-playing game.

After the first five case studies, we can expect accounting students and practitioners to have an excellent foundational knowledge of blockchain technology and its use cases. In the sixth case study, I level up on blockchain technology by covering cryptocurrency transactions from a ‘ledger’ perspective. This case study is about explaining how different cryptocurrencies are structured as different types of distributed ledgers. For example, bitcoin is a transaction ledger, while Ethereum is an accounts-based ledger or a balance ledger.

In Section 4, I discuss two case studies that cover the taxation aspects of cryptocurrencies and audit considerations in a blockchain environment, respectively. As mentioned before, each of these eight case studies were successfully trialled by me with several working and aspiring CPAs at the CPA organization/association conferences where I was invited to speak on blockchain. Finally, in Section 5, I conclude by discussing the steps that accounting academics (practitioners) need to take in coming to a decision on whether to incorporate blockchain technology and its use cases in their courses (specific practice) or integrate it across the accounting curriculum (function).

This is the first study to research the proliferation of blockchain technology in the accounting profession using the diffusion of innovation theory. Prior studies have studied the impact of blockchain on accounting without any theoretical foundation. Thus, blockchain has never been truly compared with existing legacy systems holistically in terms of its relative advantage, compatibility, complexity, trialability, and observability. This is also the first study to provide specific case studies to help accounting students and practitioners level up on blockchain technology without incorporating a lot of the technical jargon. Prior research on this topic has only provided vague guidance to academics and practitioners on developing blockchain skills. I believe my paper will be useful to university academics and accounting institutes around the world that are looking at setting up more relevant digital accounting technology courses and CPE courses respectively for students and members. It will also be helpful to blockchain professionals that are interesting in understanding the benefits and complexities of blockchain vis-à-vis legacy systems.

2. THEORETICAL BACKGROUND

2.1. Diffusion of the 'Blockchain' Innovation

Rogers (1962) suggested that the social system through which an innovation gets adopted has the following adopter categories: *innovators* (venturesome people willing to take risks), *early adopters* (opinion leaders embracing change opportunities), *early majority* (decision-makers based on evidence of utility and benefits), *late majority* (sceptical), and *laggards* (traditional and conservative). Figure 1 graphically represents the diffusion of the blockchain innovation through these members of the social system. The coloured oval shapes represent the members of different disciplines adopting a new technology and the curved yellow line represents the market share, which reaches a hundred percent following complete adoption. The vertical axis represents the market share in percent, while the horizontal axis represents the time of adoption. The horizontal axis is partitioned into five adopter categories (innovators, early adopters, early majority, late majority, and laggards) categories by laying off standard deviations from the average time of adoption.

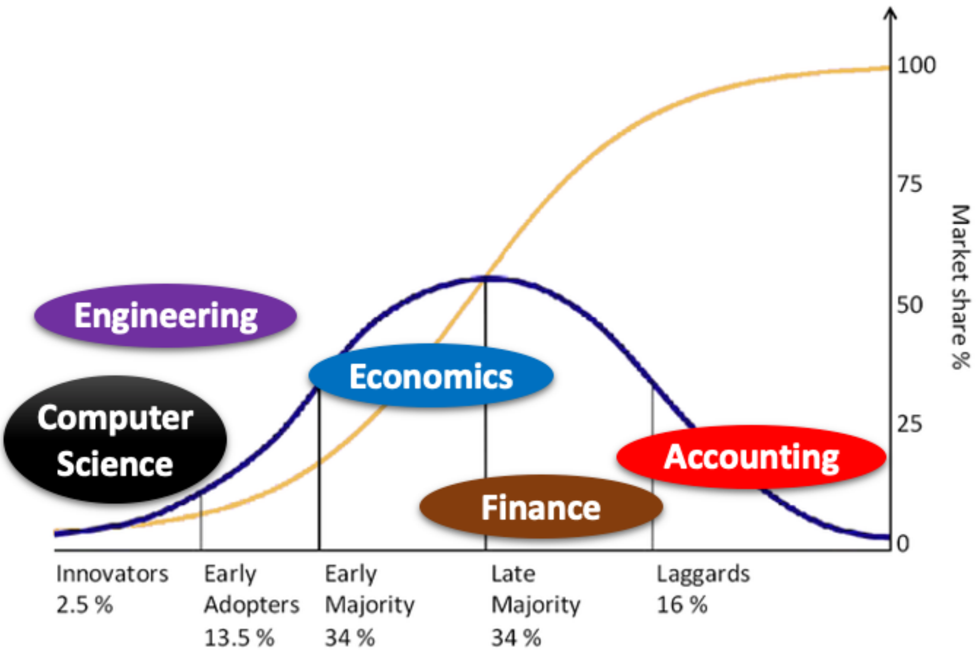

Figure 1. Diffusion of the blockchain innovation through the social system

If we think about blockchain, the broad consensus is that the computer science and the (software) engineering disciplines have been the innovators and early adopters due to cryptography and computer programming involved (Lewis, 2018; Elrom, 2019). Then, the economists caught up with the technology as the early majority since cryptocurrencies (such as Bitcoin) had an embedded economic system or hard-coded monetary policy (Tapscott & Tapscott, 2016). Finance professionals were a part of the late majority after the advent of token offerings and decentralized finance. Even the U.S. Securities and Exchange Commission (SEC) caught up with cryptocurrencies quite late – The Ethereum initial coin offering (ICO) in July-August 2014, which was a pre-sale of 72 million ETH, was not considered a security offering by the SEC (Campino, et al., 2022; Lambert, et al., 2021). It was only much later, in 2018, that the SEC suggested that Ethereum was sufficiently decentralized to be not considered a security (regardless of what it was in 2014). Interestingly, almost 60 percent of the crypto space (BTC & ETH) are not a security as per the SEC.

Accounting, unfortunately, has been a clear laggard in blockchain adoption despite it being nothing but a distributed ledger on a decentralized network. A primary reason for this is the lack of technological understanding, training, and expertise (Alles & Gray, 2023). Though blockchain is probably touted as the most significant invention since the double entry accounting system, our discipline hasn't been at the forefront of embracing it. John Culkin's quote is quite relevant here - "*We don't know who discovered water, but we're certain it wasn't a fish.*"

2.2. Characteristic of 'Blockchain' as an innovation

Due to the deluge of information and misinformation online on blockchain, students and practitioners in accounting seem to lack a fundamental understanding of how to evaluate a new technology. Accounting students and professionals need to be made to find and discuss information on blockchain with the objective of evaluating it as any other technology innovation. Rogers (1962) promulgated the 'Diffusion of Innovation' theory, and it is important to understand this theory as it relates to blockchain. He defined diffusion as 'a process by which innovations are communicated via certain channels over time among members of a social system.' He suggested that every innovation that comes about shares the following characteristics: relative advantage (over competing options), compatibility (seamless adoption), complexity (difficulty in learning for potential adopters), trialability (ease of test runs), and observability (of the benefits of adoption).

Case Study I: Comparing blockchain with other digital accounting technologies

To get an informed debate or discussion started on if and when we will see a widespread adoption of blockchain technology in the accounting field, accounting students (practitioners) should be made to think about which of the aforementioned characteristics of an innovation are shared by blockchain under the supervision of accounting academics (supervisors and consultants), who understand the technology well.

If we consider **relative advantage** of blockchain over competing options, it is known to boost transparency, improve security, increase the accuracy and accessibility of data, and improve the credibility of entire business processes by making them trustless (Nofer, et al. 2017). These advantages follow from the decentralized and immutable nature of blockchain, which requires multiple computers to validate every new transaction that is added to the chain and also makes it impossible to go back and change transactions in blocks already added to the chain.

Some sceptics may argue that a big concern with blockchain is its **compatibility** with legacy relational databases used in accounting and whether data from Enterprise Resource Planning (ERP) systems can seamlessly flow into blockchain (Yli-Huumo, et al., 2016). However, blockchain-based ERP systems are already gaining in popularity (101 Blockchains, 2021), and a typical business ERP system could possibly include one or more permissioned blockchains or private distributed ledger technology, in which the owner of the network decides who can or cannot join the network. Many blockchain technology platforms (for e.g., *Hyperledger Fabric*, *R3 Corda*, *Kaleido*, *Amazon Managed Blockchain*, *Microsoft Azure Blockchain Workbench*, *IBM Blockchain Platform*, etc.) already offer blockchain-ERP integration and customization services that are being used by businesses to port existing data and new information into the blockchain. It is a win-win for organizations to integrate a centralized ERP system with a decentralized distributed ledger and, thus, compensate for the lack of visibility and trust over the entire supply chain that is a consequence of just implementing traditional ERP systems.

Many organizations that report on sustainability in accordance with the Global Reporting Initiative (GRI) standards might also want to capture data at several points over their entire value chain starting from manufacturing to logistics to effectively report on their sustainability 'impact.' Another point to consider may be whether the current network of users of relational databases would agree with the governance rules or consensus mechanisms on the blockchain (Computerworld, 2019). Though blockchain is not a simplistic technology, there is a considerable interest from developers in learning blockchain skills despite the **complexity**. A first-time adoption of blockchain in an organization would require experts to review all the ingress and egress points in the blockchain, applications that interact with the blockchain, public key infrastructure, networks, and chain code (programs running on top of the blockchain). However, there is still a massive supply shortage of skilled blockchain developers, which is delaying its rapid adoption in several business processes (Yahoo Finance, 2021).

Moreover, blockchain developers cannot just be hired like other programmers given their niche. Many companies have to hire blockchain specialists from special portals, such as *Stack Overflow Talent*, *DevTeam.Space*, *X-Team*, *Toptal*, and *Arc* (Desai, 2023). Upon checking Big 4 blockchain-related job offerings on Indeed.com in the U.S. in August 2022, I found that Deloitte had 2,031 vacancies (top recruiter), PwC had 211 vacancies, Ernst & Young had 72 vacancies, and KPMG had 270 vacancies. These statistics provide a perspective on the high demand for blockchain-related skills in accounting.

Trialability of blockchain has become much easier recently due to the rise of permissioned blockchains. This is in contrast to blockchains like *Bitcoin* and *Ethereum*, which are permissionless and are powered by native currencies (e.g., BTC, ETH). *Hyperledger Fabric* and *R3Corda* are popular blockchain platforms that are being used for business-to-business (B2B) operations and have made the trialability of blockchain applications much easier.[3] For example, *Hyperledger Fabric* has a test network that developers can use to test their smart contracts (code deployed on the blockchain that runs as programmed without requiring a user to control it) and blockchain applications. It is not required for students and

[3] They are less decentralized, but more scalable (in terms of supporting a higher number of transactions) and more secure.

practitioners to delve too deep into the workings of permissioned versus permissionless blockchains, and a very high-level overview is adequate.

With respect to the **observability** of the benefits of blockchain adoption, Dobrovnik, et al. (2018) suggested that when blockchain was relatively immature as a technology, tangible benefits from its adoption were hard to determine, resulting in several blockchain projects stalling. The Hype Cycle by Gartner (2022) graphically represents the stages any innovation passes on its path to productivity. The Hype Cycle has five stages, namely, *technology trigger* (initial interest in the innovation), *peak of inflated expectations* (formation of bubbles and general build-up of buzz), *trough of disillusionment* (impatience resulting in performance problems and failure to deliver returns), *slope of enlightenment* (recommitment of efforts to overcome initial hurdles), and finally, *the plateau of productivity* (sharp rise in adoption due to lower risk and demonstrated benefits).

Figure 2 is a graphical depiction of Gartner's Hype Cycle. This figure depicts Gartner's Hype cycle for an innovation and its five stages, namely, technology trigger, peak of inflated expectations, trough of disillusionment, slope of enlightenment, and plateau of productivity. The horizontal axis represents time, and the vertical axis represents expectations (i.e., the five stages). The chained blocks are a depiction of blockchain technology on the Hype cycle in 2018 and in 2022. Gartner (2018) put blockchain technology somewhere on the path from the 'peak of inflated expectations' to the 'trough of disillusionment' in the year 2018.

However, blockchain has definitely matured as a technology over the past couple of years. As per Deloitte's (2021) global blockchain survey, 81 percent of respondents (84 percent of respondents in financial services industry or FSI) indicated that the technology was broadly scalable and had achieved mainstream adoption. Moreover, 78 percent of respondents (83 percent of FSI respondents) indicated their organization's executives believed there was a compelling business case for the use of this technology within their organization. Further, 80 percent of respondents (83 percent of FSI respondents) indicated their business partners, i.e., suppliers, customers, and competitors, were discussing or working on blockchain solutions or strategies. Interestingly, 73 percent of respondents (77 percent of FSI respondents) indicated their organization would lose an opportunity for competitive advantage if they didn't adopt blockchain and digital assets. Lastly, 80 percent of respondents (80 percent of FSI respondents) accepted that their industry would see new revenue streams from blockchain solutions. The results from this survey very clearly indicate that blockchain as a technology is somewhere on the path from the 'slope of enlightenment' to the 'plateau of productivity' in Gartner's Hype Cycle.

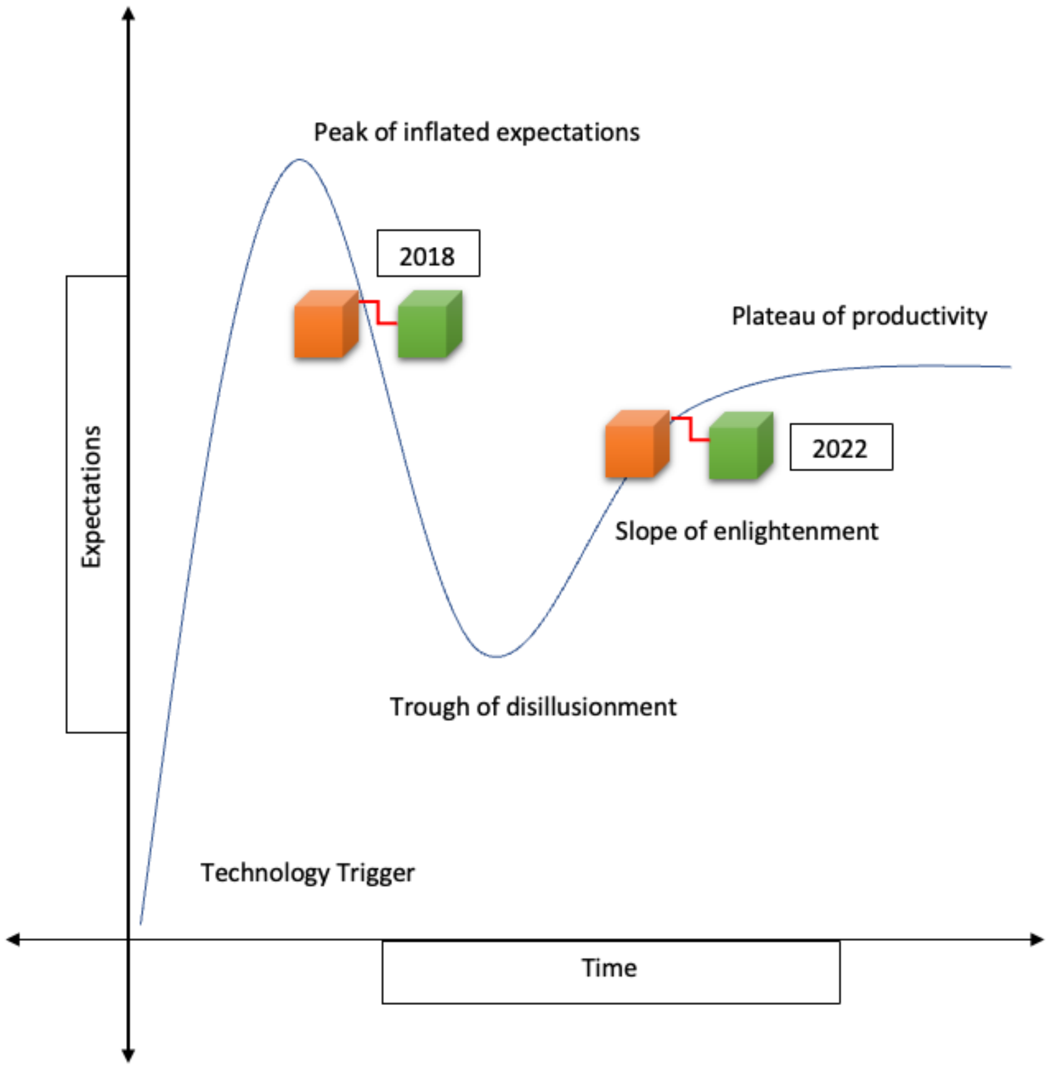

Figure 2. Gartner's Hype Cycle

Recent initiatives from Big 4 accounting firms also corroborate my argument that blockchain technology is on the path to productivity. In February 2017, Deloitte announced that blockchain technology had passed professional audit and assurance standards after a successful audit of a permissioned blockchain (CCN, 2017). A Wall Street Journal (2018) article indicated that PwC was "validating the validators" by applying control and testing criteria to blockchain transactions. In

July 2018, all the Big 4 accounting firms came together with a consortium of twenty Taiwanese banks to pilot a blockchain-based system for auditing financial reports in Taiwan (Cointelegraph, 2018). In its 2019 Global Fintech Report, PwC suggested that more than seventy-five percent of global financial services firms planned to adopt blockchain. In 2021, Ernst & Young (EY) announced it was integrating its blockchain offerings with the Polygon protocol, which is an Ethereum-based scaling solution to increase transaction volumes while lowering costs, and was focussed on developing private, sophisticated, and regulatory-compliant use cases of blockchain technology (EY, 2021).

Recently, KPMG purchased Bitcoin and Ethereum for its corporate treasury consistent with their belief that “institutional adoption of cryptoassets and blockchain technology will continue to grow” (Investopedia, 2022). More recently, Deloitte partnered with TaxBit, which is a cryptocurrency tax and accounting software, for crypto tax reporting for its clients (Accounting Today, 2022).

To sum it up, accounting students and practitioners need to understand that we are at a stage in the evolution and adoption of blockchain technology, where its relative advantages over existing technologies and databases are recognized, its compatibility with legacy systems is no longer an issue due to blockchain-ERP integration, its applications can be test run or trialled without difficulty due to the development of several test frameworks, and its benefits have been observable resulting in more initiatives to adopt it. The only hiccup is that of its complexity and a severe talent shortage of blockchain developers, issues that are expected to be addressed over time with more training and course offerings from academia and the industry.

2.3. Mapping out blockchain and its use cases as innovations

Following from the Diffusion of Innovation theory, Rogers (1962) proposed a five-stage innovation-decision process: Knowledge/Awareness, Persuasion, Decision, Implementation, and Confirmation/Continuation. I suggest the application of this decision process for incorporating blockchain and its use cases in accounting curricula and practice. The first step ‘Knowledge/Awareness’ in this setting would be about how we as accounting academics need to focus on knowledge or skills to adopt in this topic area. To figure out these skills, we need to start by determining what user ‘behavior’ blockchain technology is changing and what new ‘products’ (use cases) are being introduced via new applications of blockchain technology.

Gourville (2006) introduced a powerful matrix to map out innovations by comparing product change and behavior change. Figure 3 provides a graphical depiction of the matrix with the '*degree of behavior change required*' on the vertical axis and '*the degree of product change involved*' on the horizontal axis. This figure also depicts the four quadrants in which an innovation can be classified into, namely, Easy Sells, Smash Hits, Sure Failures, and Long Hauls. The chained blocks are a depiction of blockchain technology use cases in the upper right and lower right quadrants.

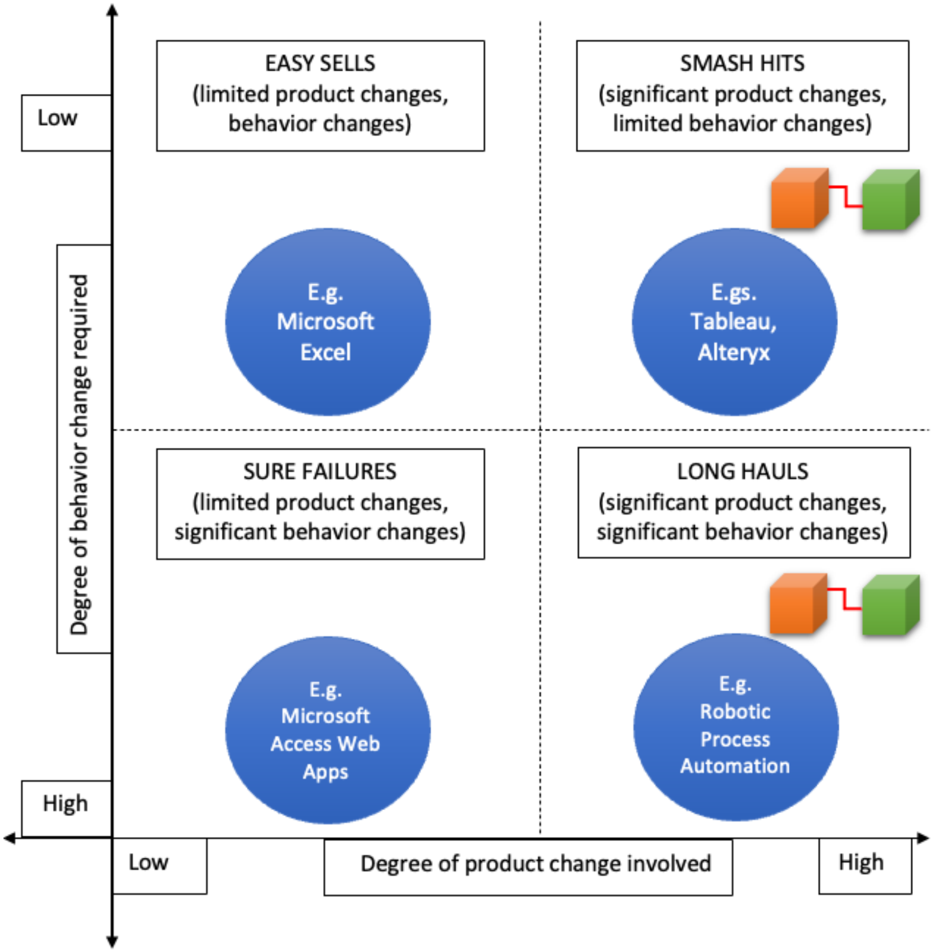

Figure 3. The 'Capturing Value from Innovations' Matrix

Case Study II: Placing Blockchain in the 'Capturing Value from Innovations' Matrix

Students and practitioners should be asked to debate in which of the four quadrants of the matrix would they place blockchain and its different use cases. I believe this case study is extremely practical, and if one has worked or interned in accounting or management roles before, they should be able to come up with interesting justifications in this exercise and gain a better understanding of the technology and its use cases.

With respect to the upper left quadrant of the matrix, Gourville argued that the products 'easily sold' were those that entailed limited changes and limited behavioral adjustments. From an accounting technologies perspective, an example of an 'easy sell' would be the Microsoft Excel spreadsheet application, which came about in 1985 and has had minor product changes over the years with limited behavioral adjustments for its users. For example, the interface and the format of the spreadsheet has remained more or less the same.

The lower left quadrant comprises innovations that are 'sure failures,' since they involve limited changes to the product but require significant behavior changes from users. From an accounting technologies perspective, an example of a 'sure failure' would be Microsoft's cloud-based database system, Access Web Apps (AWA), which was retired by the company in April 2018 and was a failed attempt at making an online Access database (Microsoft, n.d.). One of the big reasons the innovation failed was that it had functional limitations (unlike the desktop version of Access) and required significant behavior changes from developers while not bringing much to the table in terms of product performance.

The upper right quadrant comprises innovations that offer significant benefits through changes or updates to the product but require minimal behavior change. From an accounting technologies perspective, the data visualization tool, *Tableau*, and the data analytics tool, *Alteryx*, are examples of 'smash hits.' Tableau is drag-and-drop, while Alteryx has a low- to no-code drag-and-drop interface.

The lower right quadrant comprises innovations that offer significant benefits through product changes or updates but also require significant behavior change. From an accounting technologies perspective, Robotic Process Automation (RPA) is an example of a technology that is there for the 'long haul.' RPA, which involves automating manual tasks through the deployment of bots, works successfully with well-defined data formats and steps; RPA is known to struggle with small variations in the data or steps (CMSWire, 2019; Forbes, 2020b). Thus, it requires significant changes to organization processes and behavior modifications to make a process well-defined in terms of data and steps.

With respect to blockchain technology, a reasonable argument could be that some blockchain use cases (e.g., cryptocurrencies, smart contracts, and tokens) can be considered smash hits, while other use cases (e.g., decentralized autonomous organizations or DAOs, decentralized finance or DeFi) could be considered 'long hauls' (Crypto.News, 2022). In academia, I believe introductory-level accounting technology courses would be the right place to discuss these various use cases of blockchain. In practice, depending on the service domain, practitioners could discuss blockchain use cases relevant to them.

2.3.1. Blockchain Use Cases – Smash Hits versus Long Hauls

It is common knowledge that cryptocurrencies are the first use cases of blockchain technology. Bitcoin was the first successful cryptocurrency that was invented in January 2009 by Satoshi Nakamoto (which is a pseudonym for the mysterious inventor) and is touted as an alternative to fiat currencies that are unstable. El Salvador and the Central African Republic have already made it legal tender (CNBC, 2022). The Bitcoin Pizza Day, which is celebrated to remember when a father in Florida bought 2 pizzas for 10,000 BTC (worth $41 back then but worth hundreds of millions of dollars now) for him and his kids, was first time bitcoin was used as a medium of exchange.

Ethereum, invented by Vitalik Buterin, is the second most dominant and successful cryptocurrency since its genesis in July 2015, and aims to be a 'World Computer.' It is more 'socially' centralized than Bitcoin due to its founder being a public figure and having a large following in the blockchain community. The Ethereum Virtual Machine (EVM) code has the flexibility to perform any task unlike the Bitcoin Scripting Code, which does not. Thus, the Ethereum blockchain is much more accommodating in terms of use blockchain cases, for e.g., smart contracts and tokens (Buterin, 2014; Nofer, et al., 2017).

Szabo (1996) defines smart contracts as "*A set of promises, specified in digital form, including protocols within which the parties perform on these promises.*" These smart contracts are programs (similar to if-then-else statements) that are deployed on the blockchain and run as programmed (not controlled by users) – they are immutable once deployed. Users interact with smart contracts by submitting transactions that execute functions defined in these contracts (Chou, et al., 2021). Smart contracts involve significant product change as they are coded in programming languages like Solidity and are unlike traditional legal contracts. They involve little change in behavior from users, who interact with them through interfaces such as Web apps (termed 'decentralized apps or DApps') – a vending machine is typically given as a simplistic example of a smart contract since it has the logic programmed into it for purchase, restocking, and product balances.

Tokens, which represent what a holder owns, are built on an existing blockchain using smart contracts (Srinivasan, 2017). For example, equity tokens represent shares of a company, while asset-backed tokens represent real world assets. Ethereum Request for Comment-20, or ERC-20 for short, is a standard used for creating and issuing smart contracts on the Ethereum blockchain that is then used to create fungible tokens (i.e., each token is exactly the same as another token). Similarly, the ERC-721 standard is used for creating non-fungible tokens (i.e., unit of data stored on the blockchain that represent a unique item). Tokens are separate from cryptocurrencies (coins) that are native assets of a blockchain (e.g., BTC, ETH) and have 'utility.' For example, issued by a company named Tether, USDT, an asset-backed stable coin, is a token, and its utility comes from its ability to combat volatility due to its U.S. dollar peg and provide price stability to its holders (Kristoufek, 2021). Alternatively, the Bored Ape Yacht Club (BAYC) came up with a collection of 10,000 unique bored ape NFTs that live on the Ethereum blockchain. The NFT doubles as a yacht club membership card and its sales surpassed $2.04 billion in May 2022 (Cryptocurrency.News, 2022). Famous owners of the BAYC NFTs include Adidas, Eminem, and Stephen Curry. NFTs, which are not mutually interchangeable, encode the provenance (origins) about an asset on the blockchain and help in the identification and authentication of digital assets, of which a finite number of replicas are created and tracked.

Thus, there has been a significant interest and adoption of the blockchain use cases, namely, cryptocurrencies, smart contracts, and tokens. In Figure 3, these blockchain use cases would be in the upper right quadrant. However, DAOs and DeFi are blockchain use cases that have had slower acceptance due to several external factors stunting their growth. DAOs are more 'democratic' blockchain-based organizational forms that use smart contracts in place of traditional organizational structures (Ethereum.org, 2022). In DAOs, you do not have a central authority (e.g., a CEO) making decisions, but crypto token-holders vote on all the important issues such as, funding capex for a certain project. The term 'DeFi' involves all financial services activities (borrow, lend, earn interest, buy insurance, trade assets and derivatives) done peer-to-peer on blockchains without conventional financial institutions (Coinbase, 2022).

The growth of DAOs, relative to smart contracts, slowed down due to an infamous incident that took place in 2016 when the first decentralized autonomous organization called 'The DAO' was created that allowed investors to receive tokens in proportion to the amount of Ethereum they invested in the project and to vote on funding projects. Unfortunately, a bug in the program code resulted in a hacker stealing the DAO's funds worth almost $50 million (Deloitte, 2016). Though Ethereum's lead programmers reversed the transaction history to retrieve the lost funds, others did not agree to it. This resulted in a hard fork of the Ethereum blockchain, which is a permanent split of the blockchain into two networks by a software update that is not backward compatible with the existing blockchain protocol. The blockchain operating under the old network rules came to be called '*Ethereum Classic*' while the one operating under the new, updated network rules continued to be called '*Ethereum.*'

DeFi growth has also been slow due to several regulatory hurdles caused by lack of required Know-Your-Customer (KYC) and Anti-Money-Laundering (AML) information, overcollateralization (pledging more cryptoassets as collateral than the borrowed amount), and sceptics questioning the efficiency of DeFi protocols over the existing system (CoinDesk, 2022a; Bloomberg, 2021). In Figure 3, DAOs and DeFi would be in the lower right quadrant.

Depending on the information that students and practitioners find to support their answer, they may place blockchain and its different use cases in different quadrants rather than the ones I have mentioned above. However, the justifications that they come up with when they do so can be further debated to ensure they understand the different aspects of how blockchain is changing behavior as it relates to organizational functions and process. To sum it up, discussing this case study would be a good first step in the decision process to incorporate blockchain in accounting curricula and practice since it gets accountants thinking about some relevant questions such as: *What is blockchain? What are its use cases? What is the value of blockchain and its use cases to us?*

3. EXPECTATIONS, CHALLENGES, AND STRATEGIES OF INCORPORATING BLOCKCHAIN TECHNOLOGY AND ITS USE CASES IN ACCOUNTING CURRICULA AND PRACTICE

The next step 'Persuasion' in the innovation-decision process is about forming opinions about the innovation and discussing with other professionals. In this setting, this step would be about how accountants form opinions about blockchain and its use cases and engage in a discussion with others on this topic before deciding on incorporating it in accounting curricula and practice. To prevent accountants from shying away from blockchain due to the technical complexity and scientific jargon, the aim should not be for accounting students or practitioners to master every aspect of blockchain technology, which is quite impossible and unrealistic. My approach indicates what parts of blockchain and its use cases are relevant to accounting curricula and practice – the rest we leave for other disciplines to take care of. For example, the fintech-related enterprise applications of blockchain or token offerings (initial coin offerings/ICOs or security token offerings/STOs) would be more relevant for finance professionals than accountants. Accountants also need not concern themselves with mining hardware, mining rewards and difficulty, and other technical proof-of-work concepts since those aspects of blockchain would come under the expertise of computer science and engineering professionals. Moreover, the economics of mining cryptocurrencies and mining pools would be better left to professionals from the economics discipline.

I prescribe adopting a multi-layered cake approach to including blockchain in accounting curricula (based on Bloom's Taxonomy) and practice. Figure 4 graphically depicts this approach. At the lowest 'introductory' level, we have some of the 'accounting-relevant' fundamentals of blockchain technology and its use cases for coverage in introductory accounting courses. At the middle 'intermediate' level, we have slightly advanced blockchain concepts (e.g., blocks and ledgers) being covered along with a discussion of the tax implications of transacting blockchain use cases. Lastly, at the topmost 'advanced' level, we would have coverage of the audit- and assurance-related aspects of blockchain and its use cases.

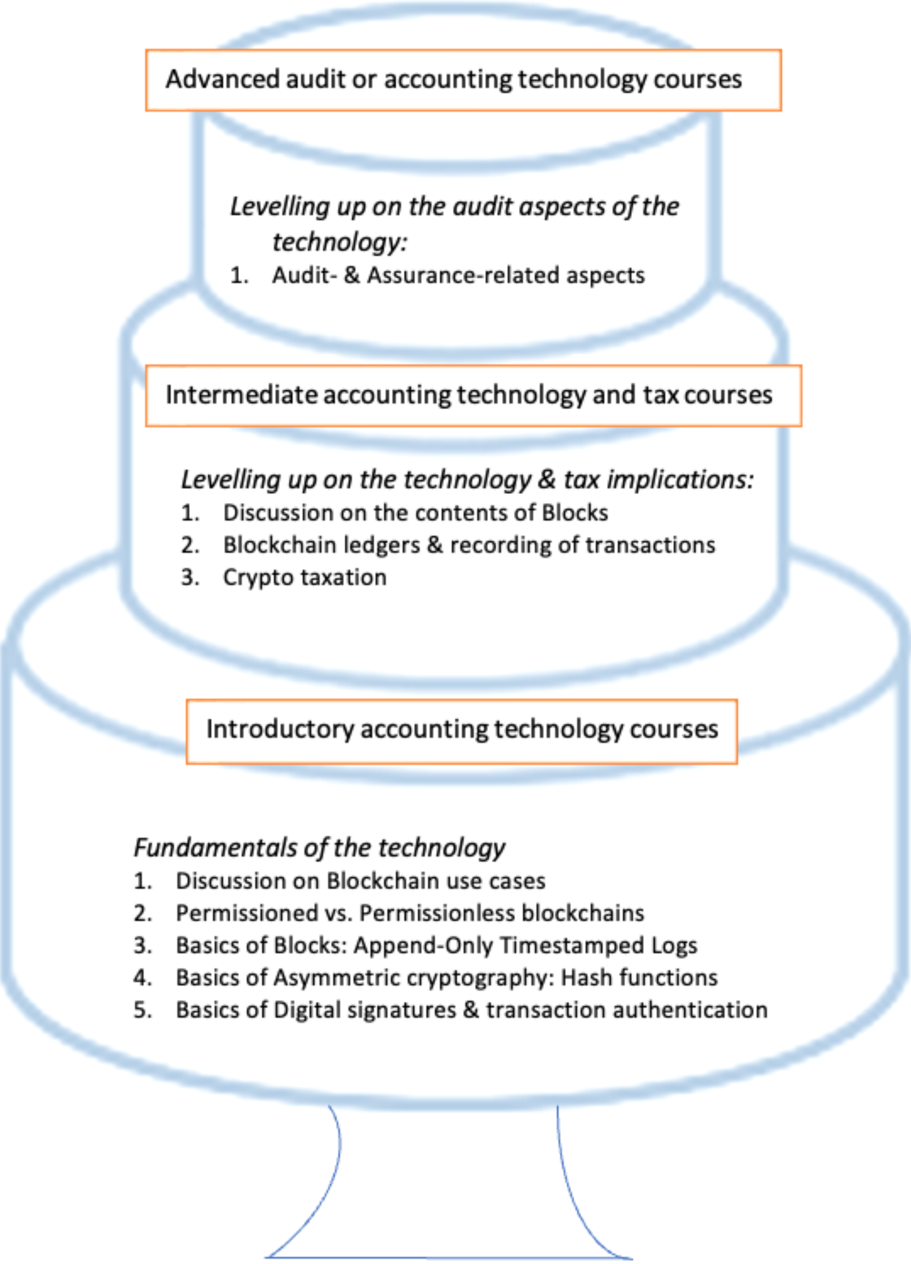

Figure 4. A multi-layered cake approach to learning blockchain

3.1. Fundamentals of the technology

Accountants do not need to go too much in detail on the technical side of blockchain. However, accounting students and accountants in all areas of practice need to understand the inner workings of the technology to be able to comprehend the tax- and audit-related aspects of the technology later. To put things into perspective, this stage is more like we, as accountants with a non-technical background that don't know how the mouse of a computer works but wanting to know what the mouse does – that should suffice!

At a big picture level, introductory accounting technology courses for accounting students and continuing professional education for accounting practitioners need to explain that all blockchain does is move data, which could be value (money) or computer code (smart contracts) on a decentralized network, i.e., without relying upon a central authority. Accounting students and practitioners also need to be familiarized with the basics that feature into the design of blockchain technology: a*ppend-only timestamped logs (blocks)*, *asymmetric cryptography (hash functions)*, and *digital signatures*. It is important to note that these features of blockchain have to do with ensuring the integrity of data and also data governance on the blockchain.

Blockchain also has other key design features, such as *nodes and networks* and *consensus mechanisms*; however, they are not as relevant from an accounting standpoint and need technical knowledge along with an understanding of game theory to fully process. The information systems or the engineering professions are better equipped to get into the specifics of *nodes and networks*, while economists are better equipped to manage *consensus mechanisms* such as Proof of Work, etc. since it involves mastering the Byzantine Generals Problem, which is a game theoretic puzzle. It is adequate for accounting students and practitioners to know that the blockchain exists on nodes, which are participants in the blockchain network and function in a peer-to-peer (P2P) manner (Tapscott & Tapscott, 2016). It is also adequate for accountants to know that consensus protocols in blockchain are about who gets to add the next block (i.e., the next bit of information) on the blockchain. It is helpful to explain to them that this is the reason why blockchain is said to be 'decentralized.' This discussion will also help them to understand how information about transactions and new blocks is transferred.

Case study III: Basics of Blocks

The objective of this third case study is to explain to students and practitioners how blocks in a blockchain are just time-stamped, append-only logs. Each of these blocks contain transactions. Since they are timestamped, we know that something came before something else. Also, since they are append-only, we know that we can only make the blockchain larger by adding to the existing blocks and cannot remove any formerly added blocks (Champagne, 2014; Lewis, 2018). At this point, I typically draw a bunch of rectangular blocks on a whiteboard vertically, one after the other, and point out to the audience at conferences that these blocks that form a chain are nothing but a decentralized 'database.' While teaching what a 'database' is in introductory accounting technology courses for students or in CPE data analytics courses for practitioners, I believe it might be a good time to introduce this concept of what blocks are in a blockchain.

In intermediate-level accounting technology courses or more advanced CPE courses, we can go one step further and discuss the make-up of a block. For example, it would suffice to explain what information is in a block and how that information is organized at the *head* of the block as opposed to the *body* of the block. It would be adequate for accounting students and practitioners to know that the '*block header*' has key pieces of information on all the blocks that came before it, a timestamp of its creation time, and a mapped and compressed ciphertext of all the data inside the block, amongst other additional information. The actual data is kept below the header in the '*block body*,' i.e., at the bottom of each block. It would help to simply draw the picture of a rectangular block with two rectangles inside it – the one at the top would be the block header, while the one at the bottom would be the block body.

The next step would be to discuss how this chain of blocks can be secured with the help of cryptographic hash functions and digital signatures. Before delving into cryptographic hash functions, I first explain the concept of asymmetric cryptography at a very elementary level. For example, in my conference presentations, using the example of the Enigma machine from the movie '*The Imitation Game*' (which is an extremely popular movie known to most people), I explained that cryptography is about secure communication when there are adversaries around. I further explained to conference attendees the shortcomings of symmetric cryptography by linking it to the failure of the Enigma machine that used a single key to encrypt and decrypt information, which could be stolen or cracked. Then, I explained how blockchain technology is secured using 'asymmetric' cryptography, which involves two keys (public and private) that link together in a mathematical relationship, for integrity and immutability (Lewis, 2018).

Only after introducing these basic cryptography concepts, I delve into cryptographic hash functions, which compress data of an arbitrary length and create a fixed-length output, called a 'hash' (Champagne, 2014).

Case study IV: Basics of asymmetric cryptography

To illustrate this case, I use Bitcoin's Secure Hashing Algorithm, also known as the SHA-256 hash function. There are several free online tools that allow for a demonstration of the SHA-256 hash function. Using some of these free online tools (see footnote), I demonstrate how the SHA-26 maps whatever data we provide to 256 bits (0s and 1s for 256 registries) and outputs a hash of fixed length in 64 hexadecimal digits, which is a numbering system that uses the base 16 (instead of base 10 that is used in our decimal numbering system) and represents the cryptographic hash using numbers from 0 to 9 and capital alphabets from A to F.[4]

Specifically, I open one of the free online SHA-256 hash generator tools and type in the following single line (students and practitioners concurrently follow along my steps on their computer systems):

Data: "Accounting is the best discipline to study."

Hash:
be1e22720455088d56639f44a04102fbe84c06cb2c4c02d5c3a47786364172b3

Then, I have them type out an entire para on accounting as a career (example below) and pass this para through the SHA-256 hash function to demonstrate how the output was a significantly changed hash but of a fixed length (in 64 hexadecimal digits).

Data: "Accounting is the best discipline to study. Everyone should study accounting since it opens doors to a promising career. An accounting job also provides stable income and flexibility. Accounting is also moving towards the integration of all the latest technologies to keep students up-to-date."

Hash:
3da8e47eba7093e2a87d30a30d96b540093b356fcfbad33858ec5f3d76ca656a

At this point, I like to point out how the hash was similar to a digital fingerprint for data (i.e., tamper resistant) and how if you changed even a tiny bit of underlying

[4] Examples of free online SHA-256 generator tools: https://emn178.github.io/online-tools/sha256.html, https://codebeautify.org/sha256-hash-generator

information, the hash changed significantly – For example, I had my conference attendees try changing a letter or word in the data string and note what happened to the hash. I explained to them that in 'blockchain' parlance, this property of hash functions was called the *avalanche effect*. I also used this opportunity to have them play around with the SHA-256 algorithm and explained the other properties of hash functions, namely, *preimage resistance* (how it is infeasible to work out the original data from its hash), *puzzle friendliness* (how it is infeasible to work out the original data even if its hash and a part of the data were known), and *collision resistance* (how it's infeasible to find two pieces of data that would have the same hash). I also explained to them why I am using the words 'infeasible' and not 'impossible' since the former indicates it is possible, but the process would be so computationally expensive that no one would think of doing it. Lastly, I told them that one of the key purposes of the hash was also to tie the blocks in the blockchain together by pointing to previous information (i.e., the previous block).

Case study V: Basics of Digital signatures and transaction authentication

After doing the earlier case study, students and practitioners should have a superior understanding of how data on the blockchain is secured using cryptographic hash functions. I typically follow up the earlier case with another case study that involves a discussion on how public-key cryptography (PKC) as it relates to digital signatures is used to secure the data. I start with the concept of public and private keys and explain that the private key is almost a random number, and the public key is generated along with it (Warburg, et al. 2019). Moreover, the private key is kept secret, while the public key is shared with everyone. The analogy I use to explain public versus private keys is that of a public key being a bank account and a private key being the bank account password. It is adequate to explain that these keys are linked through a mathematical relationship without going into the technical details.

For this case study, I pick two random members in the audience and then engage in a discussion on how they would securely send 'data' to each other using hash functions and public-private key encryption. I assign them the following two roles - one is the 'sender' (the person sending the data securely) and the other is the 'receiver' (the person receiving and verifying the authenticity of the data sent). The case involves the sender using a cryptographic hash function to encrypt the data (money or computer code) and converting it into a fixed-length hash and then signing it using their private key based on some signature algorithm to authenticate the transaction. As discussed earlier, any change to the data would result in a significant change to the hash. The hashed data and signature are then sent to the receiver.

The receiver would verify the sender's sign using the sender's public key and get the decrypted hash, which would then be compared with a second computed hash by running the same hash function on the received data. If the two hashes matched, I explain that it indicates the integrity of the data sent (Ramamurthy, 2020). If they didn't match, it would indicate data tampering. I believe hash functions and PKC are quite fundamental constructs to understanding blockchain technology and are fairly easy to teach through my case study-styled examples. Lastly, for informative purposes, I tell the audience that their crypto wallet addresses are nothing but hashed versions of the public key that get shared with everyone that wants to send them money. For ease of understanding, I use the analogy of a paper check here and explain that a crypto wallet or bitcoin address would be the beneficiary ('Pay to the order of') on a paper check.

When I trialled these three case studies (III – V) at CPA organization/association conferences at which most of the conference attendees were working CPAs or CPA aspirants, I also tested the participants on these concepts after having explained them in detail, and interestingly, almost seventy to eighty percent of the attendees (on average) got the concepts right or were able to decisively answer my test questions.

3.2. Levelling up on the technology and understanding cryptocurrencies as ledgers

After discussing the aforementioned five case studies, students and practitioners should be ready to level up on blockchain technology. The next case study I covered in my conference presentations was explaining how different cryptocurrencies were organized as different types of ledgers. We all know that ledgers can be transaction records or balance records. Accountants need to know that not all cryptocurrencies are organized as balance ledgers, which is a common misconception. For example, Bitcoin operates as a transaction ledger, while Ethereum operates as a balance ledger. It is crucial that accountants understand and are able to distinguish between these different mechanisms to store transaction records.

Case study VI: Understanding cryptocurrency transactions from a 'ledger' perspective

In my conference presentations, I typically select three random people (let's call them X, Y, and Z) for simulating how transactions are recorded in Bitcoin. I first ask the audience how they would simply check if their bank balance had enough money if they planned to send a certain number of dollars to someone. Then, I explain how the bitcoin transaction ledger works – it consumes previous unspent transaction outputs (termed 'UTXOs') as *inputs* and creates new transaction *outputs*. I further explain that an *input* is an unspent output of a previous transaction and a digital signature (Lewis, 2018).

I pick one of the three random people (say, X) I have selected to simulate how a bitcoin transaction ledger works. I tell X that he or she has to send 4 BTC to Y and 4 BTC to Z for a total of 8 BTC (BTC is the native token of Bitcoin). I draw up a ledger for X and show that X has formerly received 9 BTC in total at his or her address that aren't spent. The transaction IDs (Tx ID) and the vector of output or vout (index) together uniquely identify these previous transactions as indicated in Figure 5.

Inputs (X)
Tx ID 11, Vout 1, Digital Signature1 2.0 BTC
Tx ID 12, Vout 2, Digital Signature2 3.0 BTC
Tx ID 15, Vout 0, Digital Signature3 4.0 BTC

Figure 5. Bitcoin inputs

I then go on to explain that the way a bitcoin transaction ledger works is that it finds previous unspent individual transaction outputs (UTXOs) that add up to at least 8 BTC. It consumes these UTXOs as inputs and creates new transaction outputs. Since bitcoin has fees that are market-based, if we assume a fee of 0.1 BTC for this transaction, the new transaction outputs created would be to send 4 BTC to Y, 4 BTC to Z at their respective addresses. Moreover, another transaction output would be generated to return 0.9 BTC (after deducting the fee) to X's address (Figure 6).

Outputs (X)
Bitcoin Address 1 4.0 BTC Y
Bitcoin Address 2 4.0 BTC Z
Bitcoin Address 3 0.9 BTC ('Change' returned)

Figure 6. Bitcoin outputs

This case study has seen a lot of success since the audience in my conferences is quickly able to grasp the fundamental concept of UTXOs and the bitcoin transaction ledger. I do not go further into the details of how the outputs are denominated (e.g., for bitcoin, they are denominated in a unit called ‘satoshis’). However, these details would be extraneous information from the point of view of accounting practitioners or students.

After explaining how bitcoin operates as a transaction ledger, I explain how Ethereum is accounts-based and operates as a balance ledger. This part of the case study is simpler because unlike Bitcoin, Ethereum doesn’t have transaction inputs or outputs (i.e., UTXOs). I explain the concept of a ‘State Transition System’ here, which is how it is termed in blockchain parlance. I give a very simple example to illustrate how when one moves from one set of balances to another set of balances (e.g., from \$100 to \$110), one would have what is called a ‘State transition’ (i.e., adding \$10). Bitcoin and Ethereum together form almost sixty percent of the cryptocurrency market capitalization. So, these two examples are adequate in my opinion to drive home the concept of blockchain ledgers.

At this point, it might also help to discuss and evaluate competing accounting treatments of cryptocurrencies that are currently being practiced in the industry. Following Procházka (2018), further discussions could also be initiated with accounting students and practitioners on the conceptual definitions of virtual assets in U.S. GAAP and IFRS along with recognition and measurement criteria proposed by standard setters. A brief introduction could also be made to the ‘triple-entry accounting’ method, which is once again being widely discussed in connection with blockchain technology (Silva, et al., 2022). This system requires parties to a transaction to write and validate the transaction on an immutable ‘third’ shared ledger. This accounting system is argued to be less prone to errors and fraud because the internal records of both parties are linked together and verifiable.

To sum it up, for accountants to be broadly ‘persuaded’ to infuse blockchain and its use cases in accounting practice and curricula, it is vital that the vast majority have a very solid understanding of the various technical concepts covered in the aforementioned case studies along with an overview of how cryptocurrencies (the most well-known use case) operate from a ledger perspective. A lack of understanding of these fundamentals by an economically significant group of accounting professionals would halt any further progress on the adoption of blockchain in accounting curricula and practice. For forming a complete opinion at the second stage of the decision process, practitioners would also need to research potential changes to their organizations functions and processes brought about by blockchain as well as consider guidance provided by regulatory bodies such as the AICPA or researchers.

4. UNDERSTANDING THE AUDIT AND TAX IMPLICATIONS OF BLOCKCHAIN AND ITS USE CASES

The third step 'Decision' is about how accounting academics and practitioners form the intention to adopt blockchain in accounting curricula and practice respectively. This step is about determining the practical, work-related aspects of blockchain in accounting service domains such as audit and tax, understanding the cognitive load on accounting students and professionals, and figuring out a timeframe for training.

After covering the previous six case studies, I believe students and practitioners would be familiar with the intricacies of blockchain technology and the types of transactions that are typically done with blockchain use cases. When introducing crypto taxation in academia, the right place to do so would be in an intermediate-level tax class for students (which would typically be the second tax class or a third tax research class that accounting students take). For tax practitioners, a simple day seminar or introducing crypto taxation in one of the online CPE courses should suffice. For accountants in the auditing field, the bar for blockchain training is higher since there is a certain expectation of 'adequate technical training and proficiency' created by Public Company Accounting Oversight Board's (PCAOB) Auditing Standard (AS) 1010, *Training and Proficiency of the Independent Auditor* (Desai, 2023).

In my conference presentations, I have covered crypto taxation by way of the following case study.

Case study VII: Understanding the nuances of crypto taxation

I first ask the audience members whether cryptocurrencies are considered property or currency. The answer to this question is interesting. The U.S. Department of Treasury considers cryptocurrencies as 'virtual currencies' because they wanted these currencies to come under the Bank Secrecy Act, 1970 so that Know-Your-Customer (KYC), Anti-Money-Laundering (AML), and Counter-Terrorism-Financing (CTF) laws would apply to them. However, the Internal Revenue Service

(IRS), which is under the Department of Treasury, considers them as ‘property’ for applying tax laws. It is important for students and practitioners to understand the intent behind the differential treatment of cryptocurrencies by these government agencies.

Then, I go on to discuss how different crypto transactions are taxed. For example, income from mining, capital gains from sale of crypto investments. I also talk about fair value measurement issues (Desai, 2022a, 2022b, 2023). I also ask the audience to consider how the tax complexity goes up when it’s a crypto-to-crypto transaction rather than a crypto-to-fiat transaction. I also ask audience members to consider how certain unique crypto transactions (e.g., hard forks, exchanges) can give rise to taxable events. I typically restrict the discussion to the taxation of cryptocurrencies; however, in advanced tax classes or tax research classes, academics can cover taxation of crypto air drops, DeFi transactions, or the tax implications of transacting other blockchain use cases such as NFTs.

Case study VIII: Audit- and Assurance-related aspects of blockchain

This is the last case study, which I recommend being discussed in an advanced audit or an advanced accounting technology course by academics. For audit professionals, this last case study needs to be conducted as part of on-the-job training since a purely theoretical CPE training would be futile. Before this case study, it is important to cover all the past seven case studies. One can think of the last seven case studies as destroying the seven Horcruxes of the villain, Lord Voldemort, in the Harry Potter series before confronting the Dark Lord himself! An accounting student or practitioner will understand the audit- and assurance-related aspects of blockchain only after developing a solid foundational understanding of all blockchain concepts that we’ve covered until now.

In this case study, students and practitioners should be asked to discuss and debate how blockchain audits would require a higher bar for technical training and proficiency. In my conference presentations, I asked audience members to think about the learning curve for auditors and the skillset they thought was required to audit blockchains. I drew upon guidance from relevant AICPA and PCAOB auditing standards at this stage. From a practical standpoint, the three standard questions I typically ask in this case study are as follows: (i) *How can an auditor retrieve balances at specific block heights and dates?,* (ii) *How can an auditor verify ownership of addresses in bulk?, and (iii) How can an auditor retrieve and* *audit the code for smart contracts?*. In a classroom setting for students or as a simple trial before on-the-job training for working professionals, one can ask participants to go to Etherscan.io to discuss and debate their responses with respect to these questions in the context of the Ethereum blockchain.

For audit practitioners, it is important to go one step further and also discuss the following significant audit issues that they are likely to encounter while auditing the blockchain or blockchain-based applications: relying on the work of specialists (computer scientists and programmers), quality of audit evidence (relevance and reliability), level of technical detail in audit documentation, development of internal controls to address unique blockchain risks at points of ingress and egress, identifying and assessing risks and governance issues associated with distributed databases, and lastly evaluating judgments associated with valuing digital assets. I also typically ask conference participants if their analysis of program code on the blockchain might involve challenging, subjective, or complex judgments, making it a 'critical audit matter' (CAM) – it can be a topic of significant debate depending on the technical expertise of the audit team. In a classroom environment, it would only help to talk about these aforementioned issues if students had prior audit work experience through internships so that they can successfully think about these issues that they are likely to encounter in a blockchain audit environment.

Bonyuet (2020) also suggests some interesting points that are relevant to audit practitioners in a blockchain environment. With a more knowledgeable crowd of blockchain auditors in mind, CPE courses can also cover appropriate audit modules that need to be inserted as part of blockchain implementations. These courses can also discuss how auditors can leverage some of the latest artificial intelligence tools and other upcoming technologies with blockchain to make audit services more efficient. More advanced audit topics could also cover the measurement issues associated with the valuation of purchased versus self-created virtual assets (Smith, et al., 2019), the role of smart contracts in auditing (Andreś & Lorca, 2021) and corresponding improvements to audit data analytics brought about by newly developed smart audit procedures (Rozario & Vasarhelyi, 2018).

5. CONCLUSION AND AVENUES FOR DEVELOPMENT OF FUTURE CASE STUDIES

I explain how the coverage of digital accounting technologies in university curricula and as part of CPE learning products provided by accounting institutes is incomplete without a discussion on blockchain, which is nothing but a decentralized database. The eight case studies I have discussed in this paper will help accounting majors and practitioners level up their technology skills and compete with professionals from other disciplines in the blockchain space. In terms of the social system discussed in the Diffusion of Innovation theory, the goal is to move accountants from 'laggards' to the 'late majority' adopter category by converting the sceptics in the profession.

The case studies discussed in this paper cover the first three steps of the innovation-decision process in Rogers (1962), namely, Knowledge/Awareness, Persuasion, and Decision. Once a decision has been made to adopt blockchain, accountants do not require more training to get through the subsequent steps in the decision process. The fourth step 'Implementation' is about how we can adopt this technology and its use cases in our curricula and practice on a regular basis. Accounting academics would be getting into the specifics at this stage and thinking about '*How should I integrate blockchain into my classes?*'. Accounting practitioners would also be looking into the specifics of '*How should I integrate blockchain across all possible organizational functions and processes?*' The multi-layered cake approach that I proposed in the earlier section along with Bloom's Taxonomy (scaffolding blockchain concepts from lower-level thinking to higher-order thinking) can provide answers to these questions.

The last step in the decision process, 'Confirmation/Continuation,' is about recognizing whether the integration of blockchain in academia and practice has benefited students and practitioners. A follow-up question for academics at this stage is '*Should I continue to teach it and also promote it to others?*'. A relevant question for practitioners at this stage is '*Should I bring other stakeholders (e.g., suppliers) also on the organization's blockchain for greater transparency and efficiency?*' We can connect this step to how fast blockchain ends up being adopted by accounting firms, big and small, on a regular basis. For example, in an interview on Cointelegraph, Carl Evans, founder of Gresham International, said that "*One key thing to note is that many of the big four only got into blockchain when crypto* *projects began using them to show more transparency. The Big Four are known to only get involved with something when their client base is using it, blockchain was and is no exception …*". In another interview on Cointelegraph, Maurizio Raffone, CEO of Finetiq Ltd., said that "*My impression is that the Big Four are keen on blockchain as an additional area where they can provide consulting services rather than audit services. There has been a trend by audit firms to move into more lucrative consulting and blockchain offers them yet another opportunity for that strategy.*" (Cointelegraph, 2019).

To sum it up, there is a significant demand for blockchain professionals as the technology matures and its various use cases receive acceptance and widespread adoption. Accounting as a field needs to seize this opportunity and train its majors and practitioners to rise up to the occasion. The technical complexity associated with blockchain shouldn't be a disincentive for accountants from pursuing opportunities in this field. I strongly believe the eight case studies laid out in this paper are adequate to level up accounting students and practitioners on blockchain technology.

As the accounting profession levels up on blockchain, it presents a great avenue for future researchers to develop more case studies to train accounting students and practitioners on advanced concepts associated with blockchain. An initial attempt at this has been made by Moura de Carvalho, et al. (2022), who build a hypothetical case study to demonstrate the challenges in establishing accounting and audit procedures for novel blockchain transactions (e.g., stablecoin transactions conducted through DeFi). However, there is tremendous scope for more work on case studies on the following emerging topics: managing on-chain governance (involves developing a system for implementing changes to a blockchain), managing off-chain and on-chain data (involves determining what data to store within the blockchain and outside of it), and managing governance between a parent blockchain and sidechain extensions (that are now being used to scale pre-existing blockchains like Bitcoin).

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Annex 1

Blockchain education initiatives by leading accounting institutes around the world

Sr. No.	Accounting Institutes	Title of Certificate / Course / Program / Workshop
1.	American Institute of Certified Public Accountants (AICPA)	Blockchain fundamentals for accounting and finance professionals
2.	Institute of Management Accountants (IMA)	Blockchain 101
3.	Association of Chartered Certified Accountants (ACCA)	Bitcoin & blockchain technologies
4.	Chartered Professional Accountants of Canada (CPA Canada)	Blockchain fundamentals
5.	Institution of Chartered Accountants of England and Wales (ICAEW)	Blockchain for finance professionals
6.	Certified Practising Accountant (CPA Australia)	Blockchain technology and crypto assets for financial specialists
7.	Chartered Accountants Australia & New Zealand (CA ANZ)	Application of blockchain for accountants

This table provides details of the various certificates / courses / programs / workshops on blockchain by the leading accounting institutes around the world. For simplicity, only the title of the most comprehensive certificate / course / program / workshop covering blockchain-related content by an institute is included (the minor ones covering a subset of the content from the above courses are excluded).

Annex 2

Discipline-wise breakdown of blockchain-specific courses in universities

Sr. No.	Discipline	% of courses on blockchain
1.	Computer science	61%
2.	Engineering	8%
3.	Economics	6%
4.	Finance	5%
5.	Accounting & Information Systems	3%
6.	Multidisciplinary (Unclassified)	17%
	Total	100%

This table provides details of a discipline-wise breakdown of how blockchain technology is being incorporated in courses by universities around the world. The sample comprises blockchain-related undergraduate, graduate, executive education, and online courses from the top 50 colleges from CoinDesk's Blockchain University Rankings (CoinDesk, 2022b). The classification of course offerings by discipline has been done by following a five-step process: (a) check whether the course offering (brochure) specifically mentions that it is for students from a specific discipline, (b) if not, check whether the course offering is housed under a specific college in the university, (c) if not, check whether the course offering is taught by faculty belonging to a specific discipline, (d) if not, check whether the course offering mentions pre-requisites that students need to have met in order to take the course and the nature of those pre-requisites, and (e) if not, check whether the course syllabus involves coverage of topics from multiple disciplines or is taught by faculty from various disciplines (indicating that its multidisciplinary).