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Blockchain and Smart Contracts: The Need for Better Education

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Blockchain and Smart Contracts: The Need for Better Education

by

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Abstract

The study aims at understanding the current scenario of blockchain education and whether it is meeting the increasing demand of blockchain professionals in the job market. In addition, it also provided a comparison between Ethereum and Hyperledger and analyzed the one best suited for better academic curriculum design. By drawing from various sources of data, including journals, articles, reports, the study provided critical insights into the various aspects of a blockchain education. It assesses the existing curriculum on the blockchain that includes courses and programs from various renowned universities and business schools. The study reveals that although the courses are comprehensive in developing theoretical knowledge of the learner, it does not provide the scope for practical skill development. This gap reflects the skill-shortage of blockchain professionals in the job market. To address this, the research also provides some guidelines for developing a comprehensive pedagogical structure using Hyperledger technology. The discussion also highlights the benefits associated with Hyperledger and the way it can foster active learning among the learners. Finally, the researcher also provided the practical and theoretical implications of the study and assessed its limitations directing on the future course of research.

Acknowledgement

The research on blockchain provided me with valuable insight into the blockchain, blockchain education and the existing curriculum. It helped me identify the gap and provide probable solutions to fill in the job market requirements. The study enriched my knowledge and enhanced my critical analytical ability. I feel greatly indebted to my mentor and guide Dr. Ali Raza for his continuous support and constructive feedback that helped address the research gaps and yield the desired outcome. The expert direction and guidance that is provided by my professor throughout the course of research have been immensely helpful in building the thesis. I would also like to express my gratitude to my colleagues and friends who always provided me with their suggestions and inputs. Finally, my sincere thanks go to my dear family members who stood by my side and supported me in all my efforts.

Statement of Originality

I, Ali Alkhajeh, hereby confirm that this study is an original piece of work and does not contain any plagiarized content. The project (entirely or in part) has not been submitted earlier to any university or organization. The sources used for completing this dissertation have been cited in the form of a bibliography at the end of the document in the IEEE format. I also confirm that I have read and understood the university protocols and rules related to plagiarism and agree to abide by them.

Students Signature : _____

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Chapter 1: Introduction

1.1 Background of the study

Blockchain and Smart Contracts is the buzzword in the current global business scenario, and every organization, irrespective of their industrial sector are making a significant investment in blockchain research and development. As per the PwC Global Blockchain Survey (2018) of 600 executives across 15 different territories, 84% of companies are involved in the application of this technology in some form or the other [1].

Blockchain is a "peer-to-peer" decentralized ledger technology, which provides a technique to record and distribute data about transactions on a distributed "peer-to-peer" systems with the aid of cryptography. The technology is tamperproof and cuts down the costs incurred by the third-party involvement while increasing the overall speed and reach. Blockchain technology provides better transparency and the ability to track. According to a forecast provided by Gartner, blockchain will generate a business of over $175 billion by 2025. [2]

As per the statistics provided by International Data Corp, the total spending by government and corporate houses on the blockchain will hit $2.9 billion this year that shows an 89% increase from the last year. Further, in 2022, the figure will reach $12.4 billion. Forbes identified 100 companies that have integrated blockchain solutions in their business operations through industry syndicates and other proprietary projects. These companies include Google, Microsoft, Amazon, Facebook, IBM, Intel, Samsung, Walmart, and many others. [7]

Along with blockchain, there is the concept of **Smart Contracts**. A smart contract is a contract that is run by specific codes underlying the blockchain system. The parties who are in the contract agree to the set codes that are electronically programmed and respond to certain encoded conditions. The data that is required for the execution of the contract lies outside the system. This sort of mechanism that involves the deposit of digital assets by any or all of the involved parties gets redistributed automatically amongst them. The smart contract code facilitates, authenticates, and enforces the agreement of a transaction. [3]

Considering the popularity and amount of benefits, the companies are adopting blockchain technology in their business. This has led to a high demand for these talents and professionals in the job market. In August 2018, there were nearly 1,775 job openings in the United States that depict an almost 300 percent increase from the last year. [4]

According to a TechCrunch report, “blockchain-related jobs are the second-fastest growing in today’s labor market; there are now 14 job openings for every one blockchain developer.” The blockchain engineers are in high demand. According to Toptal (a marketplace for technology professionals), their demand has grown by 700 percent since January 2017. Given the shortage of skilled professionals in this area, Toptal has focused on training its engineers and developing the talent force in order to meet the rising demand. [6]

Given the growing need in the job market, blockchain and cryptocurrency have become an academic spotlight. In the U.S., Coindesk listed out the top ten universities who are providing blockchain courses that include: Harvard University, Massachusetts Institute of Technology, Stanford University and Princeton University. These are, however, mostly classroom programs, and very few universities offer online courses [5].

In addition to these curriculums, there are several top-ranking universities in the U.S. that have formed associations with many entities. Thus, in addition to classroom teachings, students are also participating in conferences and seminars that have led to cooperation between the school and the business. IBM Center for Blockchain and Data Transparency and Columbia University formed a collaboration and initiated two new projects that targeted the students and the entrepreneurs. This will help the students and the entrepreneurs to access business networks, attend workshops, and receive mentoring and guidance. Through such initiatives blockchain industry is looking forward to building sustainable companies [5].

1.2 Rationale of the research

Given the above scenario of blockchain trends, adoption of the technology in big businesses, and rising need in the job market, the present research seems feasible. The purpose of this research is to assess the industries and businesses that are adopting blockchain technology and identify the benefits that they are reaping from its application. The study outlined the significant advantages of blockchain technology and smart contract in terms of data security, encryption, and validation. The security of the integrated network also lies in the decentralized mode of operation and its ability to prevent corruption, tampering, and hacking. Along with these various advantages, the research highlighted the security risks and threats that pose a substantial business risk and creates apprehension in its adoption.

The focus of the study is the current job market trends and demand of blockchain professionals. By presenting several important facts, figures, and statistics, the study showed the growing need

for these talents in the job market. It also identified a lack of these talent pools in the market. Drawing from this analysis, the study uncovered the willingness of the academic institutions and the universities in terms of promoting blockchain education. While marketplaces like Toptal, are focusing on developing the skills, it is also important that the academicians design curriculum that suits the need of the job market and support the growing need for these professionals. Along with formal classroom teaching, the study emphasized the importance of developing skills for practical application and identified the lack or gaps in the existing curriculum. The significance of this study finally lies in its attempt to develop a new curriculum that will address the gap in the existing academic courses and fulfill the needs of this talent pool. In this context, the research evaluated Ethereum and Hyperledger and identified the one that is best suited for building the foundation for blockchain & smart contracts education. The critical analysis and scrutiny of the blockchain curriculum remain as one of the focal points of this research.

1.3 Research Aim

The purpose and aim of the present study is to assess the growing interest from businesses for blockchain and smart contracts technology that will inevitably trigger the industries to adopt and implement these advanced technologies. The research also highlights the inadequacy of the blockchain curriculum in universities and academic institutions. Finally, the study aims to develop a curriculum that includes both theoretical knowledge and application-based technical skills that prepare the students for filling in the gap in the job market.

1.4 Research Objectives

- To understand the interest and demand for blockchain or smart contracts from the business.
- To analyze the growth of blockchain and smart contracts adoption in the industry.
- To assess the increasing demand for blockchain and smart contracts in the job market.
- To understand the availability of blockchain curriculum in universities and to examine the lack of adequacy of the courses provided.
- To evaluate Ethereum and Hyperledger technologies best suited for building the foundation for blockchain & smart contracts education.
- To develop a curriculum that provides theoretical education and practical knowledge of blockchain and smart contracts using python or java.

1.5 Research Questions

- Are companies adopting blockchain technologies and smart contracts in their businesses?
- Which industries are adopting blockchain technologies and smart contracts?
- What is the job market scenario of blockchain technology and smart contracts?
- Are the universities promoting blockchain education?
- Are the existing curriculums on blockchain adequate to meet the demand of these professionals in the job market?
- Which one of these two, Ethereum or Hyperledger technologies, is best suited to build the foundation for smart contracts education?
- What kind of curriculum can best provide for both theoretical knowledge and practical application of blockchain and smart contracts using python or java?

1.6 Dissertation Structure

Chapter 2: Trends in Blockchain or Smart Contracts

This chapter will shed light on the current course and trends of blockchain technology and smart contract. It will assess the extent to which the businesses are willing to adopt the technology considering both its advantages as well as the disadvantages. In light of this, the chapter will also assess the industry initiatives with respect to the adoption of these advanced technologies. Finally, the job market scenario will be discussed in terms of demands of the blockchain professionals.

Chapter 3: Blockchain education in universities and academic institutions

Concerning the analysis of blockchain trends and job market situation, this chapter will shed light on the existing courses on blockchain. Along with this, it will attempt to assess whether these curriculums are adequate to prepare the talent pool both in terms of theoretical understanding and practical application. Finally, the chapter will assess whether these existing courses suffice to cater to the need of the job market.

Chapter 4: Evaluation of Ethereum or Hyperledger technologies

This chapter will evaluate Ethereum or Hyperledger technologies and identify which of these two is best suited to build the foundation for smart contracts education. Based on this analysis, a curriculum plan will be indicated that will address the current gaps and promote blockchain education.

Chapter 5: Summary and Recommendations

Finally, this chapter will address the gaps in the existing academic courses and curriculum and focus on the development of a new model curriculum that will be best suited for promoting blockchain education and cater to the need for the broader job market.

Chapter 2: Trends in Blockchain or Smart Contracts

2.1 Introduction

This chapter provides a detailed overview of the current developments and trends in blockchain technology and smart contract. It will identify the industries and businesses that are adopting blockchain and highlight the significant advantages as well as disadvantages. In light of this, the chapter will also assess the industry initiatives concerning the adoption of these advanced technologies. Finally, the discussion portrays the job market scenario in terms of the demands of the blockchain professionals.

2.2 Background of Blockchain and Smart Contract

In recent times blockchain and smart technology have received immense attention from the industries because of its distributed unassailable ledger system that allows seamless transactions between the parties. The primary application of blockchain-based technologies can be seen in the financial sectors. However, it has witnessed a surge of application also in the Pharma sector, Internet of Things (IoT), public services, reputation system, and smart contracts. Blockchain can also be considered as a public ledger, and all the transaction that takes place within the blockchain are stored in the block or the list of records. This chain of record subsequently grows as the new block is introduced.

Anonymity, persistency, and decentralization are the key characteristics of the blockchain system. Also, it facilitates conducting audits and increases efficiency. [1]. The technology of blockchain has revolutionized the IT system and advanced integrated technologies like cloud computing, Artificial Intelligence (AI), and big data. This model is a novel application of innovative computing technologies and makes possible bilateral multiparty transactions [2]. Figure 1 illustrates a typical system of blockchain.

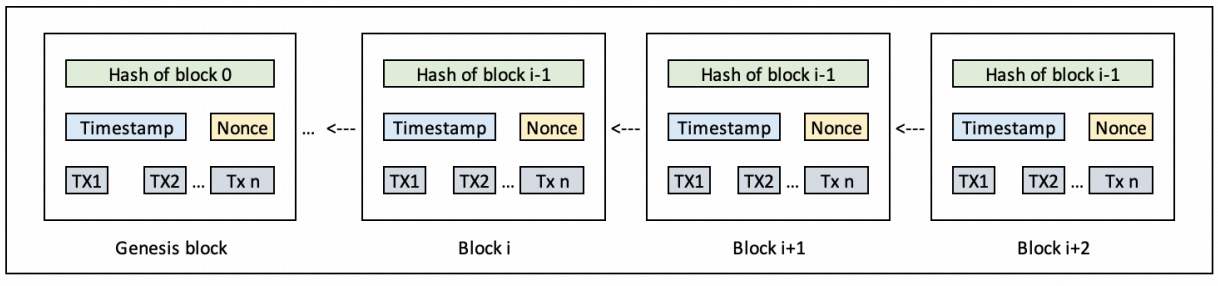


Figure 1: Blockchain technology

Source: Adapted from [3]

Bitcoin and cryptocurrency have become the catchphrase in today's economy, and in 2016 the capital market reached 10 billion dollars [4]. In 2019, bitcoin and Ethereum respectively hold the first ($105.3 billion) and second ($18.8 billion) largest market capitalization [5]. The prime advantage of blockchain is its robust design of data storage system, tamperproof structure as well as a decentralized method of transaction. The bitcoin network thus can take place without any third-party intervention that is based on the core technology of blockchain. The concept first introduced in the year 2008 and came into being in the year 2009 [6]. Another technology that makes uses of blockchain is smart contracts. This is a contract that operates by the input of some codes that underlies the principle of blockchain technology. These codes are electronically programmed, and the parties who agree to the contract also are bound to follow these codes. These parties respond to the encoded conditions that facilitate the fulfillment of the agreement or the transaction [7].

However, blockchain technology is not devoid of any threats or risks. Since the mechanism operates by a complex amalgamation of multiple technologies, there occurs a lack of consensus between them. This leads to an enormous consumption of the computing power and resources, which in turn engenders a low level of system throughput and long latency [8]. In addition to this, blockchain scalability and capacity are questioned, given the growing mass of information storage. The system requires all the nodes to process data backup that seems unrealistic [2]. In addition to this, the technology also poses an information security risk, operational and IT risk, regulatory risk, contractual risks, data confidentiality risk, liquidity risk, and consensus protocol risk [9].

Blockchain security threats can be categorized into double-pending security risks, smart contract threats, mining pool security risks, wallet security threats, and network security threats. Double-spending security risks engender when the user uses the same cryptocurrency multiple times for a particular transaction. Mining pool security threats occur when the miners work together to achieve 51% attack on the network. DDoS (Distributed Denial of Service) attacks, routing attacks, partition attack, delay attack, Sybil attack are some of the network security threats of blockchain. The vulnerability of signatures, lack of control in the creation of address re the most common form of private key security risks, or wallet risks. Lastly, the smart contract-based blockchains face vulnerabilities in solidity and Ethereum Virtual Machine (EVM) [10].

2.3 Trends in blockchain technology and smart contract

n the era of rapid technological advancements, financial institutions and other global companies are increasingly disposed to regulatory risks and counterfeiting. This creates the need for cryptocurrency and blockchain that provides greater security and anonymity in transaction systems. However, blockchain technology poses some serious operational risks fraud and money laundering. The following are the few highlights on the economic trends with respect to crypto-currency and blockchain usages [11].

Asset transfer

The blockchain platform contains technologies that facilitates the tokenization of assets. The users can issue these tokens and use for trading that complies with the regulatory requirements. The platform also contains protocols related to asset exchange that ensure the smooth peer-to-peer transfer of the assets without friction [12].

Blockchain fundraising

An ICO (Initial Coin Offering) constitutes a form of fundraising that exploits the power of the blockchain-based trading system and cryptographic assets. ICO assigns tokens to the investors that extend access to a platform that facilitates trading through cryptocurrency. Firms or entities who use ICO to raise funds use SAFT (‘Simple Agreement for Future Tokens) to attract investors and interested parties [13]

Cryptocurrency in banks and money transfer

The world’s largest banks like UBS, Credit Suisse Group, Barclays, Banco Santander, are making a considerable investment to create a system of digital money transfer by using blockchain technology. The purpose is to make financial settlements and clearance more efficient [14].

Digitalization of Assets

By using decentralized ledger technologies, the new trend is marked by the digitalization of existing assets. Also, there has evolved a robust infrastructure supporting this form of digitalization. From the beginning of 2019, there is an upsurge in digital asset trading in a regulated framework [15].

Bitcoin trading

Bitcoin serves as the medium of exchange and is accepted for trading goods, services, or other forms of assets. A change in the ratio of trading to transaction volume brings about a change in

the bitcoin amount that is used for transactional reason and exchanges. An increase in the mentioned ratio denotes the popularity of bitcoin and medium of exchange [16].

Crypto-currency usage

A recent development is witnessed in the use of cryptocurrencies, considering the security offerings [17]. Coinbase is the United States' leading the cryptocurrency exchange, and its users have increased from 0.4 million to 5.6 million during the period between January 2017 to June 2018 [18]. The other payment solutions, however, also depict somewhat similar records. Nowadays, blockchain applications are not using virtual currencies and instead focus on what is known as CIS (Collective Investment Schemes). The European Securities and Markets Authority (ESMA) estimated approximately €246 million from 13 CIS using virtual currency [11].

Increasing rate of crime

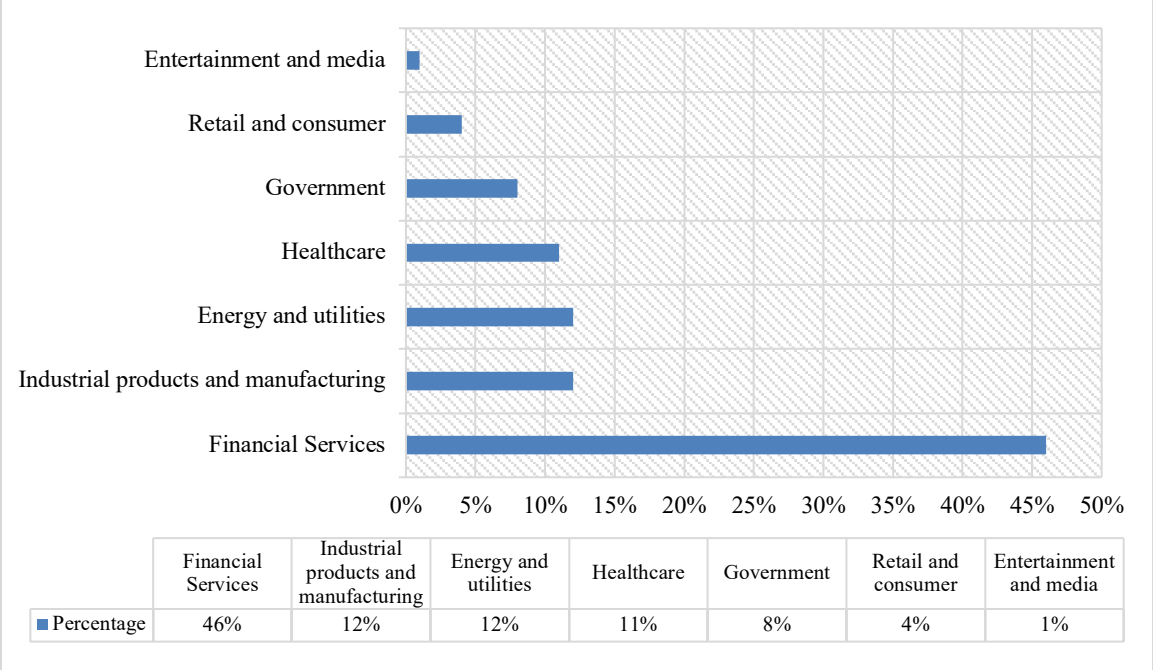
Finally, bitcoin and cryptocurrency are associated with an increasing rate of crime. Bitcoin is used as a money-laundering tool [19]. National Crime Agency in the UK saw that the majority of the transactions that are done through the system are illegal. The anonymity that has once been considered as one of the prime advantages has facilitated criminal activities in reality[11]. However, the application of blockchain is diverse, especially in areas that require third-party interventions. The public sector in the future will adopt blockchain to bring in decentralization and improve its public administration process. Wealth and assets can be protected in a secured manner by using blockchain. Primarily bitcoin will be used for speculative assets. The significant primary contribution of blockchain is a reduction in transactional costs. [20] However, as the Deloitte 2018 survey reveals that blockchain cannot perform effectively until it is paired with a use case where it can serve as TaaS (Trust-as-a-Service) for the involved participants. Therefore the technology is in a developmental stage and still has far more to go to solve some of its inherent issues [21].

The new era of blockchain 2.0 has arrived, and it is marked by programmable transactions that indicate a considerable improvement from its earlier version of Blockchain 1.0, whereby the transactions took place in the form of currency. Blockchain-related technologies will affect human ideology, and the AI system will produce more strong decentralized applications, and autonomous organizations will be built on a decentralized system. It will also be a powerful tool for Industry 4.0 that will facilitate interoperation between different architectures, devices, and

technological instruments. When these are integrated into the business operations, it will yield better productivity.

2.4 Industries adopting blockchain technology

PwC Global Blockchain survey has published interesting statistics regarding the industries that are adopting blockchain technologies (the below figure shows the leading industries that are adopting blockchain). The audit firm notes that blockchain technology has facilitated tokenization, and these digital tokens of real or the virtual assets will usher in a new era of doing business. Also, the ICOs or the Initial Coin Offerings are paving ways for alternative capital funding. The financial institutions are reaping huge benefits out of blockchain by integrating improved ERP software to streamline their business operations [22].



	Financial Services	Industrial products and manufacturing	Energy and utilities	Healthcare	Government	Retail and consumer	Entertainment and media
Percentage	46%	12%	12%	11%	8%	4%	1%

Figure 2: Industries adopting blockchain

Source: Adapted from [22]

Financial sector

The increase in cross-border financial transactions and cash flow has become one of the pressing concerns for the financial regulators and impacted the traditional system of banking [23]. Given the integrated system of blockchain and its robust security solution, the financial sector has shown widespread adoption of the same to bring in integrity and authenticity. Blockchain has particular uses in financial institutions and has the potential to solve some of the burning issues [2].

- It is a useful tool to reduce the reconciliation costs between the financial organizations and simplifies the processes.
- Blockchain technology can also make the transaction process in the securities market quicker and reduces the high cost that is involved in the process.
- It deduces the involvement of the intermediaries or the third parties in asset management activities that pose the risk of counterfeiting.
- The technology faceplates interaction between the institutions by implementing user identification of data that is being used.
- The robustness of the blockchain technology establishes precision and greater security in cross-border business that solves the problem of lack of trust on intermediaries [2].

The interbank payment system is now making use of the distributed ledger of blockchain because of its efficiency, reliability, and stability. The closed system of consensus ensures the authenticity of each transaction that is made on the blockchain. It provides security and standardization that lacks an open type. Financial institutions, especially banks and other global companies, are now making use of consortium that provides a standard platform for forming business partnerships. It is based on blockchain technology that simplifies the complex inter-bank interactions [24].

Healthcare and Pharma Sector

According to a PwC Report, blockchain-based technologies have provided considerable opportunities to the healthcare companies and transformed the process of data collection, distribution, monitoring, leveraging, auditing, and storing. Healthcare organizations primarily have faced challenges because of the traditional, slow-moving manual processes that are in place and have made the data-intensive processes cumbersome and more complicated. As per the report, these organizations can employ blockchain in their business operations to make it more effective. It can be employed in the pharma supply chain and inventory management, whereby companies can keep a check on the transaction history. Also, it can be used for provider data management, whereby the enrollment criteria and other relevant and useful information can be stored in the blockchain. The data exchange and management process can also happen through blockchain technology whereby the patients can use their health records and share them with doctors and physicians as and when needed. The security system of blockchain can help the

companies track compliance information, and the smart contract system can help in reporting any violation from the set regulatory guidelines. Finally, it can also assist in making payments to the investigator for R&D purposes [25].

Chemical Industry

In the chemical industry blockchain has facilitated machine-to-machine (M2M) interactions and established the M2M electricity market. Application of the advanced technology has augmented the trading system whereby two electricity producers engage in a transaction with one consumer. The industry makes use of several software packages like MultiChain and Aspen Plus. The former helps the creation of private blockchain, and the latter is used in polymer and biochemical industries for manufacturing purposes [26].

Energy sector

The energy sector has transitioned from the traditional method of energy production and formulated new principles that are built on a market of distributed energy that is primarily developed by blockchain technology. The exchange of energy now takes place through an interconnected system of hardware that supports the sharing of pertinent information. The hierarchical, centralized ICT system has now been given away and is replaced with a decentralized system of energy. This new infrastructural arrangement now integrates the small renewable energy resource producers. These new forms of the energy market are now more energy-efficient and record a lower rate of carbon emission. The technology also witnesses high applicability in the energy sector because it reduces the inflexibility of the regulatory structure that poses the biggest challenge to the industry. It is also employed to integrate electric vehicles. In the long run, blockchain will also innovate new models of business in the energy sector and facilitate peer-to-peer micro-grids [27].

2.5 Companies adopting blockchain

Forbes has published the list of billion-dollar companies that are actively using blockchain technology in their business. Apart from the big banks, the list also includes retail giants, supply-chain management firms, pharma, and food companies. Some of the names are pretty common, like Microsoft, Facebook, Amazon, Walmart, Nestle, and ING MasterCard [28]. Oracle is has joined Hyperledger Fabric in the year 2017, and now it is planning to launch its blockchain platform. Below are the few highlights from the list [29].

- The entertainment giant Walt Disney (US) has installed an internal blockchain solution

- Daimler AG (Germany) has issued a corporate bond of €100 million using Ethereum and has started testing cryptocurrency.
- Amazon (US) partnered with ConsenSys and offered cloud integration in the blockchain.
- The pharmaceutical conglomerate Pfizer Inc. (US) has partnered with a start-up named Chronicled to implement blockchain in their supply chain
- Samsung Electronics (South Korea) has introduced the Nextledger platform for managing its global supply chain [29].

Twenty-two global banks like Barclays and RBC are now making use of the consortium system and have developed standard platforms using blockchain technology to form a business alliance with FinTech corporations. Financial organizations have built 'R3CEV' consortium that refers to Cryptography, Exchanges, and Venture practices to develop a trading platform based on the integrated system of blockchain [24].

Table 1: Examples of Projects using 'R3CEV'

Project Name	**Contents**
Project Zero	Based on Ethereum blockchain platform, 11 banks have completed real-time processing to encrypted currencies called ether coins as Ethereum's Bitcoin.
Project On	42 banks completed smart contract test based on Ethereum blockchain platform
Project Genesis	40 banks completed the test that three procedures of issuing, trading and closing the corporate bills in the form of smart contract using a blockchain technology from Ethereum,Chain,Eris,Intel and IBM.

Source: Adapted from [24]

Another example of a hyper ledger project is the one announced by IBM led Linux Foundation. IBM is focusing on bringing standardization in the global blockchain technology and thus is participating in these sorts of projects. Companies like Intel, Wells Fargo, and other 48 renowned financial institutions have also participated in these projects. IBM has stabled blockchain labs and made substantial investments in the markets of Europe, the US, and Asia. Microsoft has formed a partnership with a start-up named ConsenSys that specializes in Ethereum to commercialize the functional applicability of smart contracts. A US-based FinTech company like

Ripple has implemented a globalized system of payment network by employing blockchain technology. Even start-up companies like ABRA are actively involved in institutionalizing blockchain technology in their remittance services [24].

The exchange market has also witnessed a noticeable shift in the post-application phase of blockchain-based technologies. TenX is a Singapore-based financial transaction settlement company is working closely with MasterCard and Visa to plan for a novel service whereby customers can use virtual currencies to make a payment on the conventional credit card system. For instance, an individual who holds a TenXcheck card pays $10 at a store, and immediately, the same amount of virtual money will be deducted to match the account price. Finally, the securities transactions have also reaped considerable benefits out of blockchain. In the US, The NASDAQ OMX group plans to build an off-exchange stock market by using blockchain technology. The company has also applied blockchain technology in Nasdaq Private Market and reduced the trading time to 10 minutes since the year 2015. The Toronto and London Stock Exchange market have implemented blockchain while the Japan Stock Exchange Group partnered with IBM and The Nomura Research Institute for R&D initiatives on blockchain [24].

2.6 Blockchain job market scenario

As per the World Economic Forum report, the emerging trend shows significant growth for the Blockchain specialists, and 45% of the companies are likely to adopt distributed ledger technology by 2022. In addition to this, the report also highlighted the widespread adoption by several industries [30].

As per Google Trends, Blockchain-related jobs have significant growth in the last five years. General interest has grown on this new technology, and companies are looking for these talents. Indeed.com that is one of the most famous job sites in the world, has published interesting data on blockchain-related jobs. From December 2016 to 2017 December the blockchain jobs have witnessed a steep rise of 207%. Therefore, it is evident that companies are looking for high-quality talents in this field. The study also notes significant growth in the blockchain job search as well as in the job posting [31].

In addition to this, the ACS Report also highlights the growing advertisement in various parts of the Globe and particularly in Australia. The below figure depicts the blockchain-related jobs in Australia from 2015 to 2018. The report notes that there has been a substantial increase in jobs in the last three years. This indicates the growing need for blockchain workers in the workforce of

Australia. New South Wales and Victoria show the maximum number that constitutes 44.1% of the total blockchain related jobs, followed by Queensland at 9.6% and Western and Southern Australia at 2.9% and 1% accordingly. The report also devotes a significant increase in the blockchain related jobs in the United States. In 2014, 500 jobs increased to 3,958 in the year 2017. [32].

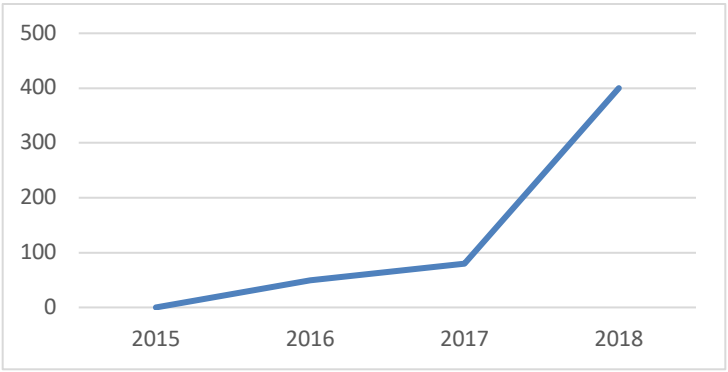


Figure 3s: Blockchain related job advertisement in Australia

Source: Adapted from [33]

The ACS report also highlights the technical skill required for blockchain-related jobs that are primarily based on JavaScript Programming, software engineering, Artificial Intelligence (AI), Internet of Things (IoT), and Mathematics. In addition to this, the blockchain specialists are also required to demonstrate research skills, problem-solving ability as well as enterprise skills. In Australia, blockchain-related jobs are quite highly paid. Annual compensation of AUD 100,000 is paid in 60% of the blockchain jobs that compare to 45% of other jobs. The higher the qualification, the higher is the pay. Therefore the report concludes that blockchain has a higher potential in creating new jobs and drive the economy of the country [32].

2.7 Summary

Blockchain and its related applications like smart contracts have transformed the customary and conventional ways of business operations and transformed the industries. It has fostered a decentralized system, maintained anonymity, provided traceability, and therefore increased the overall efficiencies of the companies. Blockchain technology has received widespread attention also because of its integrated storage system and distributed ledger system that keep information tamper-proof and secure. It is because of these reasons the industries and businesses are incorporating blockchain solutions to their day to day operations. Owing to the growing need in the business, the job market is also showing an increase in the demands of these talent pools. As

depicted in the above discussion, there is an increasing demand in the last few years for blockchain specialists. Therefore, it can be stated that the academic curriculums and courses must be designed in a way that caters to the growing job market need. The universities and academic institutions must concentrate on developing academic programs and incorporate blockchain education in their courses. In light of the discussion, the next chapter will analyze the existing courses on blockchain and assess whether they can meet the growing need for these special categories of talent.

Chapter 3: Blockchain education in universities and academic institutions

3.1 Introduction

As has been discussed in the earlier chapter, there has been a significant amount of attention on blockchain technology and smart contracts and the way they can offer useful solutions to industries and businesses. Given this increase in the application of this technology, the job market is also booming with several jobs and career opportunities in this line. Therefore, the rise in the demand of blockchain professionals is evident. However, in contrast to this, there has been very little response from academic institutions and universities in terms of designing a curriculum that will develop these skills and meet the requirement of the job market. The present chapter highlights this issue and assesses the existing academic courses and evaluates whether they suffice the growing need of these talents in the market. It will discuss some of the significant courses as provided by the renowned universities in the US and attempts to understand the gaps in these curricula.

3.2 Importance of academic discourses on blockchain and few initiatives

Blockchain has enormous potentials and industries, companies, and governments are increasingly realizing the importance of such advanced technologies. It has a significant contribution in building customer trust, prevention of counterfeiting, reducing transactional costs, and targeting new markets [34]. Also, as discussed in the previous chapter, the job market is booming with blockchain technology-related jobs. There has been a significant demand for these skill sets. However, when viewed in terms of initiatives from the educational sector or academia, the courses and academic learning opportunity of the technology is relatively low. Learning such skills becomes essential to target the lucrative jobs that are available in a market. As noted by Upwork, a global freelancing website, in the quarterly skill index, blockchain was ranked as the most demanding technology, and the demand for such skills grew by nearly 6,000% in the first quarter of 2018 [34].

Owing to these, we can see responses from the universities like Stanford that launched a blockchain research center in 2018. Through a press release, the university announced that this center would be focused on solving the various social and legal challenges of the technology and develop an academic curriculum to augment the use of blockchain technology in various fields. The professors of the university understood the importance of blockchain education and stated that blockchain would pave the new way for doing business globally, and therefore, the

university will be at the forefront of putting in efforts to improve the drawbacks of this technology. The university endeavored to bring the scientists and the industry leaders for research and will also focus on creating new courses on blockchain to help the students and professionals to use blockchain technology and apply them in protecting IP rights, developing new financial instruments and techniques and manage company confidential information and records. Stanford University will delve deep into scientific research in this area and conduct Ph.D. theses [35].

In addition to this, IBM and Columbia University collaborated and established a center for Blockchain and Data Transparency. The center, while fostering in-depth research on blockchain technology, also aims to originate business models, new services and increase the application of these advanced technologies. Also, the training and education of the blockchain professionals is also an area of focus of this center. The below diagram depicts the framework of research, education, as well as innovation endeavors of the research center [36].

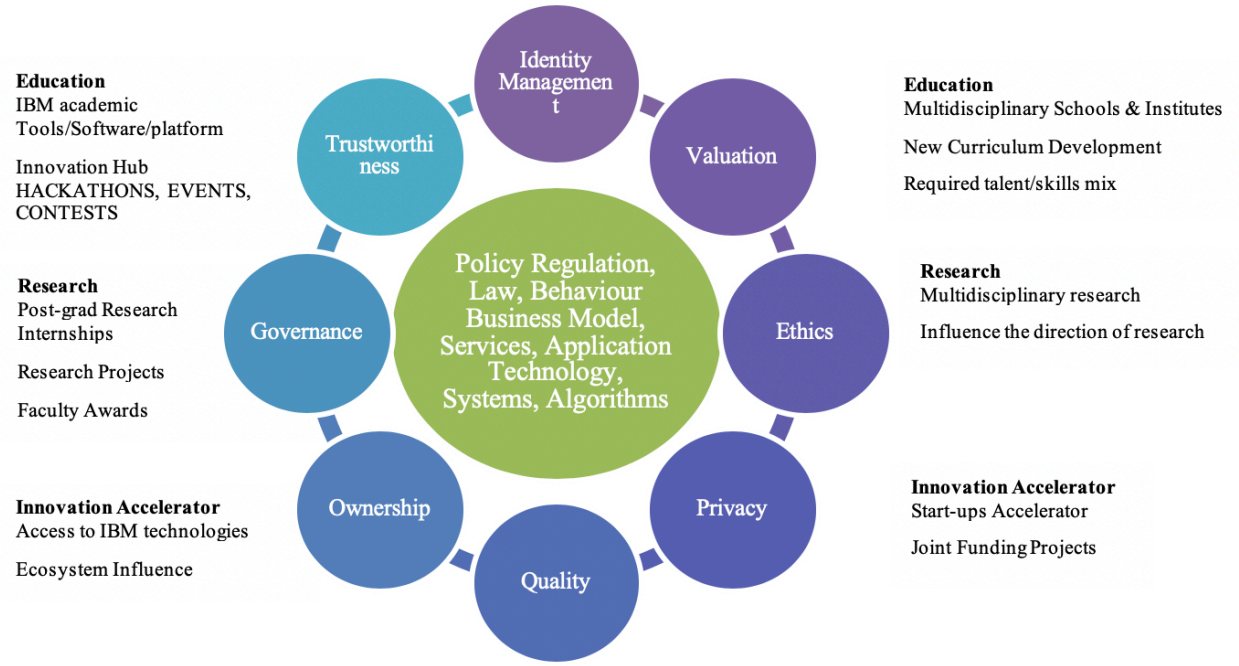


Figure 1: Framework for Columbia-IBM Center for Blockchain and Data Transparency

Source: Adapted from [36]

However, the center is primarily focused on research on blockchain technology, fraud detection, and encryption by leveraging the academic strength of the university. The purpose of this collaboration essentially is helping the industries in fostering data transparency and promote trust [37] and is not solely focused on the development of academic curricula. Viewed from this light,

the following section will entail a more in-depth discussion of the curriculum and academic courses offered by renowned universities and arrive at a precise evaluation of the same.

3.3 Academic Courses and Evaluation

3.3.1 Massachusetts Institute of Technology - Sloan School of Management: Blockchain Technologies: Business Innovation and Application

MIT offers a six-week online course that helps the learners understand the various business applications of blockchain technology as well as developing their problem-solving ability and ability to innovate. The program is headed by leading faculty members of the institute as well as experts of crypto-economics and provides an economic perspective on blockchain technology. The foundational course will offer the necessary technical know-how of blockchain, the way it operates and helps the learners to gain a better grasp of the advantages and limitations of the technology. Over the six weeks, the learners will arrive at a deeper understanding of the technology beyond the fundamental knowledge to appreciate the application technology within the context of different organizations [38].

The program covers a comparison between general technologies and blockchain technology and highlights the enormous capacity that such advanced technologies have. The trainees will be able to examine how blockchain technology can provide for verification and authentication of transactions at a low cost and operate without intermediaries. The program makes uses of a mix of various kinds of resources and helps the learner to understand the potential benefits of blockchain in digital platforms and foster privacy. Also, the program also explores future technologies based on blockchain and how they can be applied in current business practices and be combined with other technologies like Artificial Intelligence (AI) and the Internet of Things (IoT) [38].

This program is primarily designed for working professionals who seek to gain a better understanding of the technology along with its applicability in the economic environment. The program is also good for the entrepreneurs who are willing to implement blockchain technologies in the business, be it finance, retail, or any other sector. For the managers, the program can be useful in terms of understanding how blockchain technology can bring greater efficiency and innovation within the organization [38].

The program makes use of interactive media like infographics, video, and other e-learning activities, as well as the traditional method of learning like case books and study materials. It

also provides opportunities accessing discussion forums that foster collaborative learning. The program is divided into six modules. The first module provides a general introduction to blockchain technology, highlighting the common misconceptions. The second module entails a discussion on Bitcoin and cryptocurrency as specific applications under blockchain technology and the way they can offer useful solutions to problems. The third and fourth module is centered on the cost-effectiveness of blockchain technology and the way it can reduce the cost of shared networking and its implication in removing intermediary involvement. The next one is on tokenization and the way it helps in raising funds. The last module encompasses a discussion of the future technologies of blockchain along with AI and IoT and how they can improve digital privacy.

The program also takes help from GetSmarter, a digital education company that partners with MIT to design short but practical online academic courses. Since this is an online course, the learner would require PDF Reader, Adobe Flash Player, Chrome Browser, and access to the internet. The learners are offered one-to-one support from GetSamrter subject matter experts who can help in solving any technical challenges that they may face. Such collaboration provides the learner with a better learning experience. After the successful completion of the course, the learners are offered with certificates from the leading business school [38].

3.3.2 Columbia Business School – Blockchain courses

An Introduction to Blockchain and Cryptocurrencies

Columbia Business School has several programs of blockchain. Recently, the business school has launched an online course on blockchain and cryptocurrencies. The course will provide a basic idea or the concepts related to computer science like cryptography, data structures, and a distributed ledger system. The course is primarily divided into six modules, and the learners will be able to gain more in-depth insight into the emergence of blockchain technology and the new consensus models, smart contracts, and ICOs. As can be understood from the syllabus, the program entails a more in-depth discussion on the blockchain design as pioneered by bitcoin and also smart contracts as introduced by Ethereum. It also sheds light on the application of blockchain in finance, real estate, and supply chain. The most important part of this program is the IOTA case study that is a relatively new case that has received much popularity, success as well as considerable challenges. The understanding of this case helps the learner to identify the decision point that requires to be addressed by the project leaders. During the final week of the

program, the learners will be asked to give a 15-minute presentation on their chosen cryptography project, which will determine the course grade. A group of 4 will be required to work on the project and will highlight the underlying technology used and the problem it seeks to resolve [39].

Blockchain, Cryptocurrencies, and Digital Tokens Demystified

The above MBA course that the business school offers is interdisciplinary and comprehensively covers several important aspects like economic theories, economic growth trends, monetary policies, fiscal and monetary policies, the role of central banks, financial products, increasing rate of cybersecurity as well as national sovereignty. This is a classroom teaching program that comprises of a total six modules and requires no prior technical background of the learner. The course is particularly suitable for MBA students or the ones from the field of engineering, medical, law, and have the interest to seek a career in technology and finance. It will also be useful business development managers, strategists, and future organizational managers. While covering the fundamentals of the technology, the course will also encompass complex topics like the challenges in the current financial framework and shed light on some useful solutions to overcome such problems. The students will gain deep insight into the technology of blockchain, cryptocurrency, and digital token systems and be well-poised to interact meaningfully with the industry participants in terms of developing new corporate strategies and formulate ideas. The course has a strict grading system and demands active participation from the students, including the timely completion of the reading materials and project assignments. 40% of the course grade depends on the final presentation, and the rest 60% is equally divided into class participation, and company debriefs [40].

3.3.3 New York University - Blockchain courses

Digital Currency, Blockchains, and the Future of the Financial Services Industry

Similar to Columbia University, NYU also has come up with several courses on blockchain. The above course, as provided by NYU Stern School and NYU Law School, covers essential aspects of the FinTech area, including blockchain, digital currency, and tokens. The primary learning objective of this course is to equip the learners with an in-depth understanding of the law and businesses of the technology. While it covers its initial application in the form of bitcoin, it also focuses on the recent developments in the financial services sector and beyond. The course, in a way, facilitates more exceptional communication between the law students and the business students. The students are provided with course material from the university. The evaluation is based on the projects or the papers that the students are required to submit. The course covers the emergence of blockchain, the way it works, bitcoin as payment systems, cryptocurrency custody, regulatory approaches, digital currency, smart contracts, Ethereum, tokens, and ICOs, taxation of digital assets, and application of blockchain [41].

Cryptocurrencies and digital ledger

The program covers essential technical concepts related to blockchain, distributed ledger system, and its potential application in banking and financial sector, law, corporate governance, and online gaming. In contrast to the other programs, this course by NYU Computer Science provides opportunities for the students to do practical assignments and gain familiarity with the actual operation on bitcoin and Ethereum. This also entails a survey of the potential future application of the technology in the future. Another important aspect of this course is that it assigns computer programming projects to the students that must be completed in Java and Solidity. The students must, therefore, be familiar with computer programming, and also a little exposure in cryptography is preferred.

Along with four programming projects, written assignments are also assigned to students for the final examination. 80% of the score is divided between the programming projects and final examinations. The written assignments entail the rest 20% of the total grading system. The syllabus entails introduction to cryptocurrencies, bitcoin applications, mining mechanics, mining attacks, privacy and anonymity, smart contracts, and its programming in Ethereum and many more [42].

3.3.4 Stanford University - Cryptocurrencies, blockchains, and smart contracts

Stanford University offers a comprehensive course on cryptocurrency, including distributed ledger system, consensus, blockchain, smart contracts, and their potential applications. The course comprises of 20 lectures that are accompanied by further readings. On the website, the university provides links to useful references that can be used by the students. For instance, in order to understand the consensus protocols, one can take a look at the white paper written by Satoshi Nakamoto. The course entails mining strategies, mining attacks, the methods of protecting crypto assets, a detailed discussion on Ethereum, how it can be used in blockchain and EVM (Ethereum Virtual Machine). It also helps the students to understand the privacy of blockchain network, distributed exchanges, the economics of the token system, legislative regulations, and future of blockchain technology [43]. The course is mainly designed for graduate and undergraduate students. At the end of the course, the students will be required to sit for exams. [44]

According to Coindesk, Stanford is at the top of the university list that provides courses on blockchain. It has attracted experts, economists, and industry leaders from the field. The university has also received considerable investment from the blockchain technology industry. For instance, The Ethereum Foundation has contributed to Stanford Center for Blockchain Research that addressed several technical challenges of the technology. However, retaining these talented professors is one of the significant challenges that the university is facing because they are increasingly involved with the developments in the industries [45].

Table 2: Existing academic courses on blockchain in the universities

University / Course	**Duration**	**Mode**	**Theoretical / Practical**	**Subjects**
Massachusetts Institute of Technology - Sloan School of Management				
Blockchain Technologies: Business Innovation and Application	6 Weeks	Online	Theoretical	Blockchain business & economics
Columbia Business School – Blockchain courses				
An Introduction to Blockchain and Cryptocurrencies	6 Weeks	Online	Theoretical	Blockchain Smart contracts ICOs
Blockchain, Cryptocurrencies, and Digital Tokens Demystified	6 Weeks	Online	Theoretical	Blockchain business & economics
New York University - Blockchain courses				

Digital Currency, Blockchains, and the Future of the Financial Services Industry	13 Weeks	Classroom	Theoretical	Blockchain law & business
Cryptocurrencies and digital ledger	13 Weeks	Classroom	Theoretical	Blockchain, distributed ledge system, potential application in banking and financial sector
Stanford University				
Cryptocurrencies, blockchains, and smart contracts	20 Lectures	Classroom	Theoretical	Cryptocurrency, distributed ledger system, consensus, blockchain, smart contracts and their potential applications

Source: Author's Own

The Table 2 provides a snapshot of the existing courses on blockchain in different universities. Following this the next section attempts at a thorough evaluation of the curriculum, identify the gaps, and thereby develop a new curriculum on blockchain that meet both the theoretical knowledge as well as practical experience.

3.4 Evaluation of the curriculum

Blockchain technology has received widespread attention within FinTech as it is able two address two most significant aspects of the business trust and transparency. Owing to this, there has been a significant rise in career opportunities, and thus the universities have endeavored to prepare its students to support FinTech technologies and innovations. The universities are, therefore, nowadays developing courses, programs, and curriculum that will teach students the blockchain technology in FinTech. However, the approach of the universities towards FinTech and Blockchain is different. While some programs are focused more on the technical aspects of blockchain and bitcoin, the others are concentrated on data analytics and its benefit in FinTech [46]. Also, as noted by Kursh and Gold [46], most of these programs are lecture-based that have one instructor along with several guest lecturers.

Following the above Table 2, it can be stated that majority of the courses offered by various renowned universities have failed to address the practical skill development scope to the students. For instance, the Stanford University although offers a comprehensive course on distributed ledger, blockchain and smart contract, it must be kept in mind that the teaching is strictly based on classroom teaching that offers little room to the students to explore practical application. Similarly, the Massachusetts University's online course does not fulfill the practical application knowledge requirement of the students. Moreover, NYU although offers

opportunities to the students do do practical assignments on bitcoin and Ethereum, it provides limited knowledge of its operation. As a part of the 'Cryptocurrencies and digital ledger' course at NYU the students gain some knowledge of application of the technology, however, it has largely remained classroom-oriented. A systematic laboratory-based testing and learning opportunity is not provided in these academic courses.

Therefore it can be stated that most of these universities provide a course that is primarily pedagogical and lacks exposure to the actual applicability of the technology. Although the courses provide the students with a deep understanding of the technology and help them to understand the technical know-how, they do not provide them with opportunities to explore its practical implications and applicability. The courses are excellent in terms of its comprehensiveness and the way they cover essential aspects of cryptocurrency, blockchain, smart contracts, and digital assets. However, the significant lack remains in its provision in offering students with the practical application of such knowledge. Also, most of the courses are short-term and are merely professional development courses. Exceptionally few universities like NYU and Stanford provide full-time degree courses to equip students with a comprehensive knowledge of the technology.

Moreover, the online courses, although it can help students gain an understanding of the technical concepts, the videos, and online materials, cannot solve the impending questions that the students might have during the course. Therefore, the knowledge that they obtain remains partial that fail to equip them with the detailed nuances and aspects of such technologies. Academic knowledge, therefore, has to be accompanied by a practical application of the technology and thereby developing new technologies applying blockchain.

As noted by IBM, through the application of blockchain, the educational courses and systems can be revolutionized. People nowadays are primarily learning from MOOCs (Massive Open Online Courses) and are receiving recognized certifications from the universities. By application of these technologies, collaborative learning can be fostered where students will receive greater freedom to engage in teamwork and learn more effectively [47].

Universities, therefore, must invest more in blockchain training and course development to position future generations in this growing industry. The students must be continuously updated with the new inventions and developments of this technology and tailor their knowledge so that they can focus more on developing improved technologies to solve business issues. It is only in

this way the academia-industry collaboration can be reinforced, and there will be a growing pool of these talents in the market who can seek unique career advancement opportunities in these lines. Also, the students also should be able to understand specific industry needs and the challenges it faces in order to develop suitable solutions to address them. Only if the professional and academic courses emphasize actionable agendas and incorporate practical knowledge development opportunities, these can be beneficial for the real world [48].

Therefore, it can be stated that universities must develop an in-house system of learning whereby the students will be able to identify the specific business issues related to industries and be encouraged to apply their knowledge to develop new tools and techniques. In this way, the academic institutions will be able to produce talents and skills and meet the requirement in the job market.

3.5 Summary

The chapter provides a detailed discussion on the various courses provided by the renowned academic institutions and universities and identifies several drawbacks in terms of practical knowledge exposure of the students. By applying the technology itself, we can improve the educational system and foster more exceptional teamwork in this area. Addressing these existing gaps in the curriculum can help to build comprehensiveness of the academic courses and assist in filling the skill shortage in the job market.

Chapter 4: Ethereum or Hyperledger technologies in Smart Contract Education

4.1 Introduction

Based on the discussion in the previous chapters, the present one seeks to develop a curriculum by adopting Ethereum or Hyperledger technologies. The chapter entails a detailed discussion of these technologies, undertakes proper evaluation, and identifies the one that the educational institutions should focus on for skill development. It begins with a comparison between the two technologies in the educational setting and identifies the one best suited for better curriculum design. It then probes deep into analyzing the need for blockchain skill development, particularly related to Hyperledger technologies.

4.2 Comparison between Hyperledger and Ethereum in the educational context

Giammusso [49] provided a summary of the Hyperledger Fabric and Ethereum platform. According to the author, the former provides an extendable architecture that can be applied to any industry. On the other hand, the latter is an independent permissionless platform; however, the components of the same are not pluggable [50].

Peer participation: As has been identified in the earlier discussion, there are two forms of blockchain, permissioned and permissionless. For the permissionless blockchains like Ethereum, anybody can take part in the network and validate the network [51]. In contrast to this, the Hyperledger Fabric access is restricted and is provided only to the selected participants. Ethereum, for instance, can establish a learning contract and foster collaboration among the teachers and the students. As identified by Kuvshinov et al. [51] the platform allows students to choose their mentor and enroll themselves in their preferred courses. Smart contract learning based on Ethereum is associated with better learning outcomes for the students and make their progress noticeable [52]. However, the platform is not devoid of security threats and privacy risks. With Hyperledger technology such issues are solved as noted from the Sony Global Education study, it can provide for validation of smart contract protocols [53] and help in the analysis of the academic tests [54].

Consensus: As noted by Giamusso [49] the consensus protocol in Ethereum is weaker than Hyperledger. The mechanism is based on a proof-of-work (PoW) scheme whereby all the participants have access to all the blocks ever created. This kind of process affects the transaction process and does not cater to the setting that requires greater security and privacy [49], and as noted by Weng [55] it does not support deep learning. In addition to this, Alexander and

Anthony [56] stated that with the use of blockchain Hyperledger technology and its certifications, institutions could avoid any fraud and cyber-security issues. In comparison to Ethereum, the Hyperledger Fabric implements robust consensus protocols from the initial start of the transaction proposal until the network's commitment to the same [49]. The author also notes that the algorithms in Hyperledger is pluggable and serves the application specifications.
From this, it can be stated that with Certificate Authorities (CAs) of Hyperledger Fabric [53], the educational institutions, as an example, can build a more secure infrastructure and share the learning achievements [57]. Since certificates constitute one of the major aspects in any courses or curriculum, the educational institutions can make use of these digital certificates that can help the learners recognize the complete learning that they achieved from the course and bears evidence of their skills, competence and credits or awards [56]. In this regard, Schmidt [58] noted that MIT Media Lab issued digital certificates to recognize its valued contributors. The authors noted that these digital certificates are significant, as these credentials represent their experiences. The students can now share their digital certificates, and the digital degree to their prospective employers, and the employers can reliably count on those as proof of evidence [58]. employers and the employers can reliably count on those as a proof of evidence [58].
Smart Contracts: Grech and Camilleri [56] stated that Hyperledger Fabric entails programming languages like Java, and therefore, the smart contract prepared with Hyperledger will be more fool-proof. However, developers are required to learn Solidity in the case of Ethereum. Although smart contract learning [52] can be conducted on the Ethereum platform, the usage of advanced programming language can make it more robust and validate the protocols of the contracts**.**

Table 3: Comparison between Hyperledger Fabric and Ethereum

Characteristic	Ethereum	Hyperledger Fabric
Description of platform	Generic blockchain platform	Modular blockchain platform
Governance	Ethereum developers	Linux foundation
Mode of Operation	Permissionless, public or private	Permissioned, private
Consensus	Mining based on proof-of-work(PoW) Ledger level	Broad understanding of consensus that allow multiple approaches Transaction level
Smart contracts	Smart contract code (e.g., Solidity)	Smart contract code (e.g., Go ,Java)
Currency	Ether Tokens via contract	None Currency and tokens via chaincode

Source: Adapted from [50]

From the above analysis, therefore, it can be stated that although both the platform offers flexibility and applicability, taking educational systems as an example (same can be applied to any business operations), the Hyperledger Fabric seems more suitable. As a permissionless blockchain, Ethereum suffers from security risks and privacy, as well as performance scalability [49]. As noted by Giamusso [49] both of these can be solved by the Hyperledger Fabric with its permissioned system of operation, and its modular architecture provides for customization across multiple applications. As noted by Tapscott and Tapscott [59] by using blockchain technology, teaching styles can be customized for each specific student, and new models of learning can be created. In addition to this, the authors also noted that in the US, most of the students do not attend full-time campus courses and are inclining more towards part-time learning courses. The courses such as Learning Is Earning 2026 [60] can help these professionals get accredited for their learning.

Further expanding on the education system example, by applying Hyperledger, therefore, one can have a complete record of their learning process. It provides the ability to track the learning progress of the student and assess their learning outcome. Compared to Ethereum, Hyperledger technology is better able to provide for the security of their data and record the unique teacher-

student interaction. It can also help the student to gain better insights from the course and track their progress and also share their digital certificates with their employer. Since Hyperledger is a permissioned blockchain, it also gives the teachers to have control over their confidential data and restrict access. Finally, Hyperledger can offer reliability, security, and privacy of the network and facilitate deep learning. Therefore a better curriculum can be designed by using Hyperledger technologies.

4.3 Analyzing the need for blockchain (Ethereum or Hyperledger Technology) education

4.3.1 Ethereum

Ethereum is a programming language and a decentralized platform that provides autonomous applications [61]. Ethereum is often termed as radical because the programming scripts that are popularly known as smart contracts are stored in the system of blockchain that is executed by the blocks or nodes. Any sort of computation, therefore, becomes distributed, decentralized, and transparent [62]. In recent times, much focus has been given on collaborative learning that is also known as distributed learning or federal learning [55]. In this form of learning, there is a parameter server that underlies the learning model, and it trains multiple parties who take part in such a distributed training process at the same time [55]. As noted by the authors, this sort of learning can be fostered by blockchain technology, and along with blockchain, Ethereum-based smart contracts facilitate turing-complete programmability. As defined by Swan [52], turing completeness refers to the "the ability to run any coin, protocol, or blockchain". Thus, as identified by the author Ethereum is a platform that has the advantage of turing completeness and, therefore, can be applied to any script, coin, or any cryptocurrency project. From this point of view, the technology seems useful to teach and learn in the academic institutions as it can facilitate learning through the collaborative method. Moreover, solidity, the programming language of Ethereum, is easy to use and learn [63]. It is a programming language that is turing complete and is used by developers to develop Ethereum Virtual Machine (EVM). The language is easy to learn by the students as its syntaxes have a lot of similarity with C and Java Script [64]. Despite such advantages, academic institutions should focus more on educating students on Hyperledger technologies than Ethereum, as it has greater applicability in the organizations. Moreover, Ethereum also has certain limitations, as discussed below.

There are certain disadvantages of Ethereum as permissionless blockchain. As noted by Kuvshinov et al. [51] it leads to unethical practices whereby a student wrongfully creates an

educator and notes scores of the courses they did not even attained. This kinds of instances show that teaching Ethereum in the academic institutions is not desirable. Moreover, Luu et al. [65] stated that Ethereum-based smart contracts are increasingly faced with security issues. The author noted that in an automated analysis 8333 out of 19,336 smart contract based on public Ethereum suffered from critical security concerns. The study also notes that there are major threats in terms of cyber-security and the vulnerability of losing the digital assets like the cryptocurrencies. Such security concerns are decreasing the importance of public blockchain and adoption of Ethereum in the industries is going down. The storage issue, requirement of intense computation, security concerns are all preventing its adoption in the industries [51]. In such a scenario, it is important that the students learn those blockchain technologies that have a more widespread popularity and requirement in the job market.

Kuvshinov et al. [51] stated that in that the industries are now looking for more and more secure and private network that has permissive solutions that led to the development of private ledgers like Hyperledger. From the analysis, it can therefore be stated that Ethereum is a collaborative platform that fosters better teacher-student collaboration. Since it has the advantage of turing completeness it can be replicated in other blockchains and cryptocurrencies. However, the major drawback is its vulnerability to security threats. Such issues with public blockchain are increasingly posing security threats to organizations who are looking to build a private network of blockchain based on Hyperledger. In such a scenario, it can be stated that the educational institutions should look to develop curriculum that can help the students learn developing more robust solutions for the business and cater to the industry needs. Also Weng [55] stated that in the educational context deep learning requires preserving privacy. The deep learning model operates at what is known as parameter server and provides for security. Therefore, the educational sector itself is in need of more secured platforms that provide for greater security and data protection.

In light of the discussion in this section, the following section will analyze the Hyperledger technology and draw out its unique advantages and attempted to analyze why educational institutions should focus on educating Hyperledger technologies.

4.3.2 Hyperledger

Hyperledger is a permissioned blockchain that is able to address the security threats as faced in the Ethereum platform. As noted by Qui et al. [66] the advantages of Hyperledger blockchain are

many. The Hyperledger Fabric is a model of permissioned blockchain that is able to control and determine who can participate and validate the protocols [53]. The author also notes that the fabric provides security of the system through Certificate Authorities (CAs) like the certificates of transaction and enrollment and thus lays a robust infrastructure for authorization, encryption, and authentications.

4.3.2.1 Need for Hyperledger technology professional skill development

In recent times, we witness a variety of organizations are employing Hyperledger technologies in their businesses that provide them with the ability to carry on with transactions in a secured manner. IBM is one of the significant members of the Hyperledger community and is actively contributing to the Hyperledger Fabric open-source project. The project is aimed to achieve standardization of the private permissioned blockchain so that the businesses can use it successfully. This project includes various developers, start-up companies, and other contributors and is looking to provide businesses with effective solutions [67]. The company is now looking for professionals and application architects who will be able to design various technical solutions and blockchain fabric based on Hyperledger. The architects will be responsible for designing as well as the implementation of Hyperledger fabric, create effective solutions for business problems and also be able to develop solutions blueprint [68]. In 2017, IBM undertook 400 blockchain projects and employed more than 1600 employees from 150 job vacancies [69]. This indicates a growing need for professionals in this field, and therefore, it can be stated that educational institutions must focus more on developing skills on Hyperledger technologies. There is a need to develop an effective curriculum that will teach the students about Hyperledger and how it can be applied to develop solutions to overcome business challenges. As evident from various platforms like LinkedIn, Glassdoor, the opportunities in the job market related to Hyperledger blockchain is increasing [70]. To meet this growing need, it is important to teach these technologies to fill in the gap in the job market.

Researchers at Purdue University have recently developed X-Blockchain that is a ledger technology based on crypto power. This helps the users to carry out transactions with confidentiality by using shredded data. The platform also facilitates transactions across the blockchain and hides any sensitive data [71]. Such efforts from the universities and academic institutions should be increased to educate the students about Hyperledger technologies. These skills are now a requirement in today's business and industries. For instance, the Dubai

government sector has created the Dubai Blockchain Platform to integrate various digitized services running on IBM Blockchain [72]. The platform will provide storing data protection conforming to the Dubai Government information security protocols with low operational costs. Therefore it can be stated that in the Dubai government sector, there will be a growing need for such skills. Providing merely the online courses will not be sufficient. What is required, therefore, is to come up with comprehensive plans to increase education in Hyperledger technologies to serve the demand in the job market.

Not only in the public sector, can the application of Hyperledger technologies also be seen in the private sectors. For instance, Walmart, the retail conglomerate, has partnered with IBM and applied Hyperledger Fabric for record-keeping and tracking drugs [73]. As noted by Allison [73] the retail giants are now applying Hyperledger blockchain in their business functions and are doing multiple projects. In this regard, Castillo [74] stated that various other companies like Accenture, Cisco, Intel, JP Morgan Chase, Wells Fargo, State Street are applying Hyperledger technology in their business and are undertaking corporate blockchain projects. Therefore, it can be stated that the private sector will also have a considerable requirement of blockchain professionals in the coming days.

Another major application of Hyperledger Fabric is made by Sony Global Education, who attempted to integrate the scattered set of educational data and credentials into one platform [54]. The purpose was to help the educational institution to gain a more comprehensive background of the students and thereby to select them for program admission. In addition to this, the study noted that due to the application of such permissioned blockchain, the academic institutions were able to analyze and verify the educational background and training of the population and arrive at a better evaluation of the courses and educational programs [54]. Giammusso [49] stated that the platform is a “one-stop solution” for creating an educational profile. The credential platform that was created by Sony Global Education is able to generate global rankings, provide test analysis, and offer the learners valuable insights and improvement suggestions [54]. Therefore, the education sector also can gain potential benefits from Hyperledger technologies.

According to Hori et al. [75], the process of learning should encompass the whole spectrum of learning, including sports, technology, and arts, and entail a comprehensive approach that can help people to learn on a constant basis and practice the acquired knowledge at the same time. In order to overcome the boundaries of conventional teaching styles, the authors developed

Creative Higher Education with Learning Objects (CHiLO) based on Hyperledger Fabric. By employing Hyperledger technology, CHiLO can record articles and also prevent any unauthorized access [75]. In addition to this, the e-learning platform is able to create and purchase e-books. Tapscott and Tapscott [59] stated that for higher education, the blockchain-based platforms could have three stages. The first phase is the stage of content exchange, whereby the professors can share their ideas and teaching materials with others. The second stage is the phase of co-invitation, whereby different university professors and teachers collaborate across the academic disciplines and create more effective teaching materials. The third stage is of learning collaboration, whereby the institution becomes a node of the global network [59]. The CHiLO e-learning platform caters only to the first stage of content exchange [75].

Hyperledger. Teaching the application of Hyperledger technologies and creating business solutions will also help talented individuals get a suitable job and develop economies.

Summary

From the above analysis, it can be stated that Hyperledger has significant application in both the public and private sectors as well as in the education sector itself. However, there is little effort from academia to develop a curriculum that promotes effective learning of blockchain technology and in particular, Hyperledger. Hyperledger.org, hosted by Linux Foundation, provides for blockchain skill development and provides professional development training courses [76]. However, such efforts are not much observed from the educational institutions. As analyzed in Table 2 in the previous chapter, majority of the renowned institutes like Massachusetts Institute, Columbia Business School, and Stanford University have systematically ignored the need for students' practical school development. In comparison to these universities, NYU, however, do offer some practical expose to the students to learn the operations of bitcoin and Ethereum through practical assignments. However, such practical exposure is limited and the course does not provide the students with a detailed knowledge of its application. Moreover, the course is short (only for 13 weeks) and thus a detailed practical knowledge cannot be offered within a short span of time. Such gaps need to be addressed in order to actually meet the needs of the job market.

Hyperledger technology as a permissioned blockchain has widespread applicability in various segments of business as it can provide for robust security measures required in dealing with

confidential data. It can help the business maintain its confidentiality by providing a secured private network based on a private ledger. Hyperleger.org attests to the fact that educational institutions do need to play an active role in building skills that caters to the job market requirements and industry trends [77]. They also offer support to the educational institutions by providing materials and presentations that help them build the knowledge gap in blockchain. Therefore, it can be stated that with Hyperledger technology, a better curriculum can be developed that will not only be beneficial for the learners but will also foster collaboration among the universities. While providing security and privacy, it will connect the teachers at a global level on the Hyperledger based blockchain network and create effective study material that will enhance the learning process.

Chapter 5: Curriculum and recommendations

5.1 Curriculum Introduction

The project began with the aim to analyze the increasing interest related to blockchain and smart contracts and understand its utility that triggered widespread adoption of the technology in different industries across the world. It also analyzed the gap in the current curriculum and its lack in providing a comprehensive academic course that teaches the students both its theoretical background as well as practical applicability. Analyzing this aspect was important as it helped in understanding the inability of the current blockchain education system to meet the growing demand of the job market. Finally, the study also critically analyzed Ethereum and Hyperledger technology and its ability to build a strong, smart contract-based blockchain education to meet the increasing need for blockchain professionals in the job market. This chapter will summarize the findings of this research and indicate a curriculum design that includes both theoretical knowledge and application-based technical skills that prepare the students for filling in the gap in the job market.

The research revealed that the blockchain system provides for anonymity and persistency, and its decentralization feature helps the involved parties to make a seamless transaction. It is because of such benefits there is widespread adoption of the technology across the industries, including the financial sector, health, pharma, chemical, and energy sector. In addition to this, the PwC survey also reveals its adoption in the industrial products manufacturing sector, retail, and consumer industry as well as the entertainment and media sector [22]. The efficiency, reliability, robustness, and stability of the system is the primary driver for its large-scale adoption. In addition to this, the system is also effective in dealing with the threat of counterfeiting. Owing to these benefits, it has been observed that several big technology companies, including Microsoft, Facebook, Amazon, Walmart, Nestle, and ING MasterCard, are applying blockchain in their business [28]. In addition to these high-tech companies, significant effort has also been noticed from several start-up companies like ConsenSys and TenX that are partnering with the big companies and facilitating the implementation of blockchain in business.

The research project also successfully analyzed the job market scenario of blockchain. The study analyzed Indeed.com, one of the most popular job sites across the world, and revealed significant growth of blockchain-related jobs. These jobs are highly paid as it required specialized skills in JavaScript Programming, software engineering, Artificial Intelligence (AI), Internet of Things

(IoT), and Mathematics [32]. This indicates the growing need for blockchain professionals to fill in the increasing need of these professionals in the job market. However, the research reveals that there is a lack of attention from academia in developing these skills to meet the requirement of the job market. The academic learning opportunity for technology is relatively low in the education sector. One of the significant efforts is noted from the Stanford University that launched their own research center, facilitated greater collaboration between the scientists and industry leaders, and attempted to develop new curriculum that helps students and future professionals to apply blockchain technology IP rights protection, new financial instruments development, and managing confidential information [35]. In addition, Columbia University has partnered with IBM and has attempted to develop a new business model and services to increase the application of blockchain in the industries.

In terms of academic courses, the study identified four universities, including MIT, Columbia Business School, NYU, and Stanford, as having some courses on blockchain. However, most of these courses are for a short period and do not provide the students with complete knowledge of the technology and its application. For instance, the course offered by MIT is an online program that provides the learner with basic knowledge of blockchain technology and its applicability. Although the course helps in understanding the future blockchain technologies in combination with AI and IoT, it does not provide the student to develop practical skills. Moreover, since this is an online course, it does not provide room for the students to ask questions and gain clarification. Similar to MIT, the Columbia Business School has also come up with an online course. However, the course is basic and provides the learners with only an introductory lesson on the concepts related to computer science like cryptography, data structures, and a distributed ledger system. The program is predominantly theoretical and does not provide scope for practical skill development that is required for developing blockchain-based applications and functionalities. The other MBA program provided by the Columbia Business School, although it entails classroom teaching, is also theoretical and does not help the learner to develop practical technical skills. The course provides the learner with detailed knowledge of the theories, concepts and is useful for the organizational managers. However, in terms of developing application-based knowledge, the learners get a little scope in gaining technical know-how. However, the research revealed that the course provided by NYU on cryptocurrencies and digital ledger is useful in developing the learners' practical skills and knowledge. The course

emphasizes doing practical assignments, and 80% of the score is divided between these assignments and final exams. The students get the opportunity to learn the actual operation of bitcoin and Ethereum and leans the programming language of Java and Solidity [42]. Similarly, as highlighted earlier, the course offered by Stanford is also comprehensive and provides the students with both practical and theoretical knowledge. The learners receive comprehensive knowledge of distributed ledger system, consensus, blockchain, smart contracts, and their potential applications [43]. In addition to this, the course also provides a deep understanding of Ethereum and the way it can be applied in blockchain and EVM. Stanford University is at the top rank in providing courses on blockchain. The institution has received considerable investment from the blockchain technology industry like the Ethereum foundation and addressed several challenges related to blockchain.

However, it can be concluded that the courses provided by the universities are primarily theoretical. Programs, as provided by Stanford and NYU, should, therefore, be increased in order to bridge the gap between the theoretical understanding and practical knowledge of its applicability. The courses provided in most of the universities are merely professional development programs and lack in application-based knowledge development. What is required is the adoption of a comprehensive approach in developing a curriculum that incorporates both theoretical knowledge as well as practical skill development methods. More emphasis should be on addressing the practical knowledge gap that will ultimately help in meeting the growing skill-shortage of blockchain professionals in the market. A collaboration between industry and academia can help in developing the blockchain curriculum that prepares the student to take up a challenging role as professionals to solve critical business risks and issues.

Based on the above analysis, the researcher has developed a curriculum on the blockchain, focusing on Hyperledger technology to provide the learner with comprehensive knowledge about various concepts and frameworks. The course is divided into five modules and emphasizes on lab work focusing on application development using Hyperledger. This curriculum will provide the learner with both theoretical understandings as well as practical skills and bridge the gap in the existing curriculum n blockchain.

5.2 Curriculum design using Hyperledger

As identified in this study Hyperledger has several advantages over Ethereum. While the latter is a generic permissionless blockchain platform, the former is the modular permissioned blockchain

platform. Moreover, the consensus protocol is weaker in the case of Ethereum that is based on proof-of-work, and all the participants have access to all the nodes or blocks in the system [49]. This kind of system does not provide for the privacy and security requirement that is considered to be an essential aspect of business in today's environment. However, in contrast to Ethereum, Hyperledger and its digital certification system provides for better security and privacy.

In terms of curriculum design, using an open-source environment may be challenging due to its privacy risks and cost. Hyperledger can assist in better curriculum design by streamlining communication. As noted earlier, for designing a curriculum including both practical skills and theoretical knowledge, an industry-academia collaboration is required. The professionals working in the field can inform the specific skill required in the job market that the academicians can incorporate in their curriculum design and prepare a robust pedagogical structure that equips the learner with all the necessary technical skills and theoretical knowledge.

Hyperledger can also help the new course participants to learn quickly by gaining access to the required information. The collaborative effort can make the learning better and prove to be beneficial for both the teachers as well as the students. In addition to this, in a Hyperledger based curriculum, the participants can gain the benefit of specialization. In other words, participants can specialize in various technical areas of blockchain that make learning more effective. This can help to address the skill requirement in the job market and prepare the learners to become successful professionals who can provide specialized tailored solutions to address business needs and requirements.

Hyperledger can also reduce the chances of duplication. Since the industry of blockchain is relatively new and the number of application developers or seasoned professionals is low, the learners must focus on building differentiated skill sets that can cater to the vast array of business requirements. With greater collaboration using the Hyperledger platform, learners can develop new projects and standard solutions that can address the needs of the entire community. The stringent governing structure of Hyperledger can resolve interoperability issues that may emerge during such collaborations.

The governing structure of Hyperledger can also promote active learning because the learners engaged in technical solution building have the opportunity to receive inputs from the governing committee. This will also foster innovation and help maintain the quality of the technical solutions built by researchers, developers, and learners. Finally, Hyperledger fabric can also

provide for greater security and protection of intellectual property. Hence the solutions developed or brainstormed by the university will be protected from counterfeiting, thus, providing for IP rights.

From the above discussion, it can, therefore, be stated that Hyperledger can provide for better curriculum design. It can foster active learning through collaboration, enhance the specialized skill development of the learners, and provide for security and quality control. It can also protect the IP rights of the ideas and solutions developed over the course and prevent chances of duplicity.

5.2.1 New Curriculum Development

Hyperledger Curriculum: 14 weeks

Modules	Topics	Timeframe
Module 1	Concepts of blockchain and smart contract	Week 1 - 3
Module 2	Importance of blockchain, its application, and various technologies available in the market (Bitcoin, Ethereum, Hyperledger, R3 Corda etc.)	Week 4 - 5
Module 3	Hyperledger Fabric and Architecture (this will include SDKs, chaincode, Ledger, and Security) ***Lab1 - Dev Machine Requirements & IDE Setup*** The objective of this lab is to walk the student through setting up there dev machine and IDE. *Key Activities:* • Discuss minimum requirements of dev machine • Discuss the need for the IDE • Download & install Visual Studio Code • Install VS Code extensions (Go & Yaml Support) • Install virtual box • Install Ubuntu ***Lab 2 – Installing Hyperledger Fabric & using playground*** The objective of this lab is to provide the students with knowledge of installing Hyperledger and using dev-	Week 6 - 8

	scripts. Upon completion of the Lab, the students will be able to run a full network in the plaground *Key Activities:* • Install Hyperledger components (CLI, playground, Fabric) • Familiarize with Hyperledger Composer Playground • Creating & connected to a new business network • Adding a transaction processor script file • Access control • Creating & adding participants • Creating & adding assets • Transferring assets between participants	
Module 4	Lab work (writing chaincode, develop application using Hyperledger on a smart contract) Lab 1 - Creating a Hyperledger Composer solution This lab will guide the student through building a Hyperledger Composer blockchain solution from scratch. *Key Activities:* • Creating & defining a business network • Modelling assets, participants, and transactions • Deploying the business network • Generating a REST server • Generating an application Lab 2 - Working with Hyperledger Explorer Tool The students will be introduced to various Hyperledger Explore Tool & connecting the Hyperledger network *Key Activities:* • Installing dependencies • Install Hyperledger Explorer • Setting up a database • Configuration of the explorer with fabric • Create web-based applications that can initiate and organize various artifacts	Week 9 – 12

	Lab 3 - Chaincode execution utility This lab will provide the students with an overview of chain code lifecycle, it interface with ledger, building blocks, and how to run chaincode in local docker. *Key Activities:* • Developing chaincode using GoLang • Hands on experience with chaincode package and various installation commands • Endorsement policy configuration • Upgrading chaincode for meeting application change requirements	
Module 5	Final Exam (written + lab work performance)	Week 13 - 14

Prerequisites Knowledge:

- Basic development skills (Java or Go is preferable)
- Understanding of Cryptography (Optional)

5.3 Case study of RIT Courses: CSEC & CIT

Rochester Institute of technology (RIT) offers courses on computer security and computer information technology. The institute provides the students with wide range of learning experience with opportunity to explore further to gain practical knowledge. In this section, an attempt is made to analyze the CSEC and CIT courses and assess how the developed course can enhance the curriculum of the institute.

5.3.1 CSEC Course

The department of Computing Security (CSEC) offers students with undergraduate and graduate level programs that help them to develop themselves as professionals in cybersecurity. They gain in-depth knowledge of protecting computer networks, system, information, and data security, prevent malware attacks, ensuring privacy, cyber analytics and explore career opportunities across various industries and sectors including electronic, computer hardware, internet and software, government, healthcare, telecommunication and various others. They can potentially develop themselves as computer security analyst, information security analyst, systems and network engineer, cyber security engineer etc.

The bachelor's course of cyber security at RIT is a four-year course that includes fundamental knowledge about computing security, calculus, mathematics for computing, programming for ensuring information security, fundamentals on reverse engineering, network services, and system administration. In the third year of the course it offers introduction to cryptography, security of web applications, data modeling, and finally, in the fourth year it offers computing security capstone along with some electives.

As can be observed from the above details, it can be stated that addition of a course on blockchain may be introduced. The above course as developed in this study can be a useful addition in this bachelors' program. For instance, Module 1 and 2 as mentioned above can be used in this course so that the students get the fundamental concepts of blockchain and smart contracts. This can be covered in the first and second year of the course. In the third year, when introducing cryptography, utility scripts may also be introduced. In particular, Lab 1 as proposed under module 3 can be useful. The students will be able to learn about Hyperledger, create content, and create various application. This can help in developing practical knowledge about scripts. While the entire course on blockchain as developed in this study may be overwhelming, the undergraduates can be given exposure to utility scripts and dev commands that may be useful for the students.

RIT also offers qualified students to pursue dual degree in computer security and advance the same to the masters' level. The entire module 3 and 4 can be introduced to the students that will offer the students detailed knowledge of scripts, Hyperledger, and chain code. This will help the potential cybersecurity professionals to expand their horizon and learn blockchain technology that has been widely used my industries across the world. It will also help them connect and combine their knowledge on cybersecurity and blockchain and enhance the security of the network to protect confidential information.

5.3.2 CIT course

Computing and Information Technology (CIT) is again a four-year bachelors' degree that offers student hands on experience with technology and become professionals in designs, technology implementation, and operations of computer networks. The program enables students to assess and analyze the existing systems and networks, offer recommendations for improvements, and monitor system faults. These professionals can gain ample of career options in defense, commercial banking, healthcare, manufacturing, and software and internet.

The four-years course include introduction to information security, technical communication, various concepts of computer system, computational problem solving, web and mobile, routing and switching, statistics, user experience design, modeling of information requirement and the like. The fourth year requires the student to be a part of project team and work towards defining the systems requirement. In addition to this, the program entails six advanced courses that include database, networking and communication, web development and administration, and enterprise administration. The students are required to choose any three of these courses. RIT Dubai has also encompassed virtualization, wireless networking, network design, network services, sensors, ad-hoc networks, and project management.

As described above the concentration courses covers various aspects of computer and information technology. As a part of these concentrations, the course on Hyperledger may be introduced. The students will get an additional option to learn blockchain, smart contracts, and learn cryptography through various practical labs. This will interests the students as it will offer exposure to various practical experiences and work on technology. Moreover, the students selecting database application may be more interested taking up the course on Hyperledger as it will help them gain better understanding of database operations, connectivity, and access. The introduction of the entire course as part of the bachelor's program also will provide the students to gain comprehensive understanding on blockchain and further pursue career in that arena.

5.4 Theoretical and practical implications of research

The study provided deep insight into various aspects of blockchain technology, including Ethereum and Hyperledger. By comparing the two types of a blockchain platform, the research provides a theoretical framework upon which further research can be carried out. The study can also help in understanding the level of blockchain application across the industries and the recent job market scenario.

Also, the research highlighted the gaps in the existing curriculum and indicated the need to develop a more robust curriculum that fosters both professional skill-building and theoretical understanding among the students. The thorough assessment of CIT and CSEC course also offers guidance on enhancement of the BS and MS courses offered by RIT. The research can be useful for academicians and industry professionals to design courses and programs that not only lead to professional development for the learners but also help them to acquire skills and expertise to fill in the requirements of the job market. Also, the curriculum that is developed by the researcher

can be adopted by the institutions to provide the students with a comprehensive understanding of Hyperledger technology. On the other hand, by using this study as a guideline, the universities and academic institutions can plan to develop a curriculum that uses Hyperledger technology to foster active learning, increase skill specialization, prevent duplication, and enhance quality control. Leaners can also learn better in a collaborative environment as there is a higher chance of mutual exchange of ideas, knowledge, and information.

Chapter 6: Conclusion

6.1 Conclusion

The study on blockchain and smart contract began with the aim to understand the interest and demand for these advanced technologies from the business, analyze their growth and adoption across the industry, and assess the increasing demand for these technologies in the job market. A secondary review has been produced gathering data from various sources including journals, articles, industry reports, and websites. It was found that there has been an increasing need for these technologies across industries and primarily in the financial service sector. These technologies are used as tools to reduce the reconciliation costs between the financial organizations and simplify the complex processes and facilitate the transaction processes. In addition, the healthcare and pharma sector was found to be making positive strive in terms of the adoption of these newly emerging technologies. Primarily the application is observed in the context of the pharma supply chain management and management process. The study outlined several trends in blockchain and smart contracts including Asset transfer, Blockchain fundraising, Cryptocurrency in banks and money transfer, Digitalization of Assets, Bitcoin trading, Crypto-currency usage, and Increasing rate of crime. The widespread adoption of blockchain and smart contracts has also been found from various big corporate houses and multinational corporations. Owing to all these transformations, the job market is witnessing significant growth in terms of the number of jobs. The growth of the job market is noted by Google trends, Indeed, as well as the World Economic Forum.

While there has been increasing adoption of technologies by the companies and the job market is booming with jobs, the significant finding of this study revealed that the blockchain education is lagging. This creates a significant supply-demand gap in the market as while there is a demand for blockchain professionals in the market, there is a severe shortage of such skills and knowledge among the individuals. The paper reviewed some of the major universities (including Massachusetts Institute of Technology, Columbia Business School, New York University, and Stanford University) and revealed that while courses are there they are primarily booking and theoretical in nature and thus do not provide for a holistic knowledge development opportunity to these professionals. NYU although requires doing practical assignments on bitcoin and Ethereum, limited operational knowledge is gained by the students. The university as a part of the 'Cryptocurrencies and digital ledger' provides some knowledge of technical application-

oriented exposure to the students, however, such knowledge has remained largely instructional and classroom-oriented. What is required now is to develop a curriculum that can provide the students with better exposure and learning opportunities to the students who can develop themselves as future professionals in these fields.

Following the above gap, the study made a critical comparison between Hyperledger Fabric and Ethereum. The findings revealed the suitability of Hyperledger for developing a curriculum based on blockchain. It was found that Ethereum has the drawback of security risks that can potentially harm the educational institutions. Hyperledger Fabric with its permissioned system of operation and modular architecture provides for customization across multiple applications that can be successfully used in meeting the learning requirements of the students. It can also record the learning of the individual students and track the progress that can help imparting deep learning among the students. Moreover, there is a need for Hyperledger technology skills in the market and companies are looking for skilled professionals who can design various technical solutions and blockchain fabric based on Hyperledger.

Based on this, the researchers also developed a curriculum based on Hyperledger owing to its benefits and governance structure. The purpose of the curriculum design was to reduce the gap in practical skills among the students. The course that is developed has been divided into five modules that offer the students a holistic and comprehensive knowledge of the technology. Starting from the theoretical learning of the concepts, the course offers detailed and in-depth knowledge Bitcoin, Ethereum, Hyperledger, R3 Corda, etc. along with Hyperledger Fabric and Architecture that includes SDKs, chaincode, Ledger, and Security. Module 3 and 4 of the course introduces several laboratory testing that can equip the students with practical skills and knowledge. These labs include the installation of Hyperledger Fabric, creation of Hyperledger Composer solution, working with Hyperledger Explorer Tool, and covers Chaincode execution utility. Each of these laboratory work highlights the key activities that it will involve.

Finally, the study also makes a critical evaluation CSEC & CIT RIT Courses and identifies how the proposed curriculum can be integrated within the existing courses and provide the students with better learning exposure. The analysis carried out in this study reveals some of the major gaps in the existing curriculum on blockchain and systematically addresses the same by introducing a new curriculum. The incorporation of the platform can provide better knowledge to the aspiring young professionals seeking a career in these new technology applications. Bridging

the knowledge gap in the curriculum requires the introduction of more practical skill development opportunities where the study makes its unique contribution by designing a comprehensive new curriculum.

6.2 Limitations of the study and future directions of research

Despite having several practical and theoretical implications, the study also has limitations. For instance, the analysis carried out in this study is based on a secondary source of information. Although these sources provided useful and reliable information, the findings may change if primary data is collected from the actual industry professionals. Also, the study offers analysis from a broader perspective. Therefore, the research results may also vary depending on the country-specific information. For instance, one country may show better results in blockchain education than the other.

Future studies can; therefore, attempt collecting primary data from the academic institutions and understand how they are addressing the job market needs. These studies can also explore whether Ethereum or Hyperledger is being used for curriculum design. Additionally, researchers may also undertake country-specific studies and report the awareness of the need for blockchain education in academic institutions. The present study may also be taken as a reference point to assess how the proposed curriculum can benefit the students to develop themselves as future professionals in this new emerging area.

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