Tampere University

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CAN BLOCKCHAIN TECHNOLOGY FACILITATE UNBUNDLING OF HIGHER EDUCATION

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ABSTRACT

Ira Sood: Can Blockchain Technology Facilitate Unbundling of Higher Education
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In spite of the technological advancements we are surrounded with on a daily basis, the current higher education ecosystem is still lagging behind in terms of innovation and continues to function in a tightly bundled operation. Educational experts have stressed upon the need for reforming the higher education system in order to better fulfil the needs of its main consumer: the student. Unbundling aspects of higher education has been recognized as one such idea that can possibly result in universities reinventing themselves for the benefit of all stakeholders involved. At the same time, researchers have singled out blockchain technology as an emerging technology that has the potential of reforming current social systems. The launch of the EU Blockchain Observatory in February 2018 is one of the major indications that reflect the nature of interest in the potential of blockchain. Due to its capability to break the existing barriers of a trust less society and to provide a decentralized, transparent and secure method of handling any kind of transactions, blockchain technology could be used to unbundle aspects of higher education. There is a noticeable lack of empirical research when it comes to the use of blockchain technology in the higher education sector, specifically related to unbundling.

The main goal of this research is to understand if blockchain has the capability of facilitating unbundling of the higher education sector. In order to get a holistic view of the current ecosystem, a literature review was conducted regarding the problems surrounding the current higher education system along with the possibility of an unbundled education system in solving those problems. The literature review further included an analysis of blockchain as a technology and the current practical applications in the higher education already in motion in different parts of the world. Subsequently, semi-structured interviews were conducted with experts in the field of higher education as well as blockchain technology. The literature review and the results of the data analysis shed light on how unbundling should be brought about in the higher education sector. Adoption barriers with reference to blockchain technology in the context of unbundling higher education were revealed and discussed. As a result of this study, it was concluded that unbundling could possibly be instrumental in solving the numerous problems plaguing the higher educator sector today however, there has to be a balance between the traditional mode of education and the new modular amendments that are made in the process of unbundling. The capability of blockchain technology was identified as being just right to facilitate the unbundling of higher education. However, a number of technological, cultural and political and regulatory barriers were identified that could pre-vent the adoption of a blockchain based solution for higher education.

Keywords: Higher Education, Unbundling, Blockchain Technology

PREFACE

This thesis is a culmination of my interest in novel technologies that have the potential to alter the landscape of the world, as we know it. The topic of education reform has always been close to my heart and even ended up in my travelling halfway across the world to Finland to experience it in an entirely new way. Although this thesis is written to fulfil the graduation requirements of my master's degree programme, in a way, this research process provided an excellent opportunity for me to understand and discover issues that I am passionate about. The last three years in Finland have been a mixed bag but my experience studying and working at Tampere University of Technology has been one of the bright spots.

I would like to thank Professor Petri Nokelainen for guiding me and Assistant Professor Henri Pirkkalainen for having faith in me and helping me navigate my way across work and life. In addition, I am very thankful to all the people who agreed to participate in this research process as well as my colleagues for the many interesting and useful conversations we have had over the course of the research project and cheers to many more in the future.

This has been a tough year and I could not have made it through without my support system. I want to express my gratitude to my friends and family for always being patient with me and supporting me throughout. I am grateful to my friends Alisa, Misha and May for their support during the darkest of times, to my brother for always being around and to my parents for being my anchors to life.

Tampere, 29.01.2019

Ira Sood

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LIST OF SYMBOLS AND ABBREVIATIONS

CEO	Chief Executive Officer
COO	Chief Operations Officer
CPU	Central Processing Unit
DVD	Digital Versatile Disc
ECTS	European Credit Transfer System
EMBA	Executive Master of Business Administration
EU	European Union
HEI	Higher Education Institutions
HE	Higher Education
MOOC	Massive Open Online Course
P2P	Peer to Peer
R&D	Research and Development
TTY	Tampere University of Technology

1. INTRODUCTION

"A well-educated mind will always have more questions than answers", Helen Keller

In the golden age of technology, the way we interact with both man and machine is evolving at an exponential rate. Most of the crucial industries of the world are in a race trying to keep up with that rate, but education is one area that has historically been slow to evolve and continues to be the same (Matthew, 1964; Wang, 1975; Wildavsky et al., 2012). If history has taught us anything, it is that for the survival and evolution of an individual and human kind in general, innovation and adaptation with the changing surroundings is vital (Hoffman & Holzhuter, 2012). According to Crichton (2015), not much has changed in the way education is imparted in the last two decades. As such, it is critical that the acute need for transformation in the education sector is paid some attention on a global scale (Vieluf et al., 2012). Innovation in education has been described as a change in pedagogical theories, instruction tools, institutional structures or teaching and learning methods which eventually have positive outcomes for student learning (Serdyukov, 2017). The basic model of higher education has largely remained in the same crystalized structure as it was when it was first created for the masses during the Ford era of industrialization and mass production (Xing & Marwala, 2017; Rose, 2012; Jacobs, 2014). The purpose of such a model was to mass produce workers for factories. While the need for such labour has diminished to the extent of disappearance, the university structure has essentially remained the same.

When the concept of open universities and distance education was first introduced in the late 1960s and the 1980s respectively, it was simply categorized as a fad by most universities. However, we have witnessed the rapid growth of both those sectors in the last few decades (Pant, 2014; Tait, 2018). The New York Times called 2012 the year of the MOOCs (Massive Open Online Courses) and it was prophesized by MOOC proponents that it will change education forever, but that did not materialize to the same extent (Pappano, 2012; Yousef et al., 2014). However, MOOCs were able to get the ball rolling on the conversation about education for all which is personalized, flexible and secure both for the learner and the universities. In the employment industry, big players such as Google, Facebook, Apple, E&Y and many others have already made it abundantly clear that they do not consider degree certificates as proof of a skill or competence and are more than willing to hire people based on a demonstrable competence, even when it is accompanied by simply a digital certificate (Glassdoor, 2018). Universities have finally taken notice of the fact that they need to improve their value proposition in order to remain relevant in the long run. In order to innovate the traditional education models, many universities have considered various scenarios such as offering an extended curricula by

themselves or in collaboration with private MOOC providers which in a way unbundles their offering while complying with their internal quality assurance policies (Davis et al., 2014; Israel, 2015; EADTU, 2018). This has been one of the most common ways to unbundle an aspect of the traditional higher education model. Unbundled education has been a debatable subject among researchers and thought leaders in the field of higher education. Apart from unbundling curricula, there have also been discussions regarding unbundling other aspects of higher education such as separation of course implementation and course assessment or more ambitious attempts like the concept of a 'Multiversity' (McCowan, 2017; Kerr, 1963). Even though it has both supporter and opponents, the potential unbundling offers in reinventing higher education is worth exploring.

Meanwhile, higher education has also been undergoing a huge wave of digitalization just like most other industries, with the advent of revolutionary, disruptive as well as foundational technologies. One such incumbent technology is blockchain. The hype surrounding blockchain, the underlying technology behind all major cryptocurrencies is one of the most extreme hype cycles our generation has witnessed, however blockchain technology has also been tapped as a foundation that can bring about social change (Galen et al., 2018). As pointed out by technology pundits, theoretically, blockchain can be applied to any field which involves transactions between two parties. The decentralized and immutable nature of blockchain have been predicted to be the unique selling point for it when it comes to the education sector (Camilleri & Grech, 2017).

However, there has been a relevant lack of empirical research when it comes to using blockchain for education. Apart from that, there are also very few use cases that might help researchers to understand the extent and consequences of using blockchain technology in the field of education. To the best of my knowledge, there is no research yet available that specifically links the use of blockchain technology to unbundling aspects of higher education. This thesis is an attempt to cover up this research gap. In this Thesis, I will try to explore the implications of blockchain technology in the field of higher education, specifically related to the idea of unbundling higher education. The main research question is as follows

Can blockchain technology facilitate the unbundling of higher education?

The rest of the thesis is an attempt to answer the above question. It has been divided into seven chapters. Chapters 2, and 3 are based on a literature review that was undertaken in order to understand unbundling of higher education and blockchain technology independently. Chapter 2 introduces the elementary background of the concept of unbundling in the context of higher education where the change drivers responsible for its forethought and the apparent barriers in its implementation have been studied based on the existing literature available. In chapter 3, the theoretical background related to blockchain technology including its intrinsic elements and characteristics have been explained. In chapter

4, a link has been drawn between unbundling of higher education and the use of blockchain technology to achieve that based on the analysis of the results of chapter 2 and 3 and including the current use cases available. Chapter 5 explains the research methodology used in this research process. Chapter 6 analyses the results obtained from the data collected via semi structured qualitative interviews. Chapter 7 summarizes the results of the research process and identifies the barriers in the adoption of blockchain technology if it was to be used in the field of higher education. Finally, chapter 8 concludes the research process with some final statements.

2. UNBUNDLING OF HIGHER EDUCATION

Whenever a new technology arrives, it is initially bundled into a package of product and service(s) but as the technology undergoes innovation, new versions become available which are customizable and in turn modular and present buyers with the option to pick and choose (McCowan, 2017; Horn, 2017). We have witnessed multiple examples of this phenomenon across industries such as cable television versus Netflix, personal computers and software, travelling and many others. Today one does not need to buy an entire album for a single song, flights can be cheaper if luggage and flight experience are separated and furniture can be bought in parts and assembled via IKEA. These are just a few of the infinite examples of an unbundled or modular world surrounding us. Unbundling can be simply defined as the process of breaking something into smaller and modular fragments but the essence of unbundling lies in the benefits it usually brings to its benefactors and consumers. Historically, whenever an industry has undergone a wave of modularization, the outcome has always been beneficial for the consumers as it brings down costs massively, increases flexibility by allowing for customization and gives consumers some leverage over service providers (Horn, 2017; Ferreira, 2014).

In higher education, the incoming of modularization has been much slower as compared to other industries and has been mostly driven by the growth of the for-profit sector (Robertson & Komljenovic, 2016a, 2016b; McCowan, 2017). Universities have more or less continued to exist within the traditional time tested models which seemed to have kept a demand for their services alive so far. In practical terms it is hard to measure the economic impact of their services on society and industry in general (McCowan, 2017; Barber, Donnelly, & Rizvi, 2013; Bok, 2003). Even though gradually, the university as such has seen its share of being unbundled. The incoming of open universities, which removed the limitations of a fixed campus and time schedule from university level learning, was one major change that laid the foundation for transition.

When talking about unbundling of higher education, it is vital to firstly understand what is being unbundled. Literature points out some of the possible modular functions of a university as follows:

- In 1975, Wang listed four distinct functions of a university as Impartation of information (Dissemination of knowledge), Accreditation (Grading and awarding degrees), Coercion (Pressure to excel via exams and assignments) and Club membership (Social and intellectual aspects)
- Cummings (1998) has classified a university into Teaching, Research and Service (public service, professional service, and outreach)

- Staton (2012) has classified a university into four units, Content Loop (Content production, Content transfer, Content sequencing), Access to Opportunities (Credentials, Networks), Meta content and skills (Models of thinking and doing, Mentorship, coaching and apprenticeship) and Experience (Social elements and Personal Exploration)
- Norton (2013) has stated five units including Marketing and Admissions, Curriculum development, Curriculum delivery, Assessment and Credentialing

Drawing on the above classifications, some common factors have emerged in what could be unbundled in traditional higher education. Firstly, the content loop which includes creating, delivering and sequencing the learnings and learning pathways for students. The next part is assessment of the student performances followed by awarding the assessments in terms of credentialing. The remaining two parts are not directly related to studies but are nevertheless vital, firstly research and secondly, the social element that a university offers to students which is also an essential aspect fundamental to the intellectual growth of a learner. One of the earliest analysis on unbundling elements of a university was done by Wang (1975) who studied the possibility of applying anti-trust laws to the traditional package of a university in an American context as they were not often the best for students themselves. According to Norton (2013), when the services offered by the university are bundled into a package with hardly any room for personalization, students end up buying services they do not require in order to get access to something that they need. This leads to students getting access to 'local services' and missing out on the 'best services'. He goes on to explain the existence of a conflict of interest in the traditional university model where even though universities provide students with course advisers, that only insures that the recommendations learners will be receiving will most likely be limited to the options within that particular university. A modular education splits the different aspects of a traditional degree into separate modules so that it can best serve the interests of the consumer that they were designed for in the first place: students. Studies suggest that universities need to adjust themselves according to the changing global economic landscape (Gerhke & Kezar, 2015; McCowan, 2017). McCowan has elaborated on two distinct models of unbundling: *no-frills model*, where the consumer chooses to pick only certain parts of a bundle and get rid of the non-essential ones; *disaggregation*, where the consumer picks all the parts of a certain bundle but not from a single producer. Both these models would be in the interest of students. In his 1975 study, Wang went on to predict a certain future for universities quite precisely, which we have witnessed in the last decade manifesting at least to some extent. For example, he predicted that in future students would have access to a subindustry (profit based) that would handle information impartation via 'video cassettes' and programmed texts that could be available worldwide. The web based learning opportunities present today especially in the field of MOOCs (Massive Open Online Courses) are just a digitally improved version of the 1975 prediction. In order to understand what is bringing forth this trend of an unbundled education, it is important to go through the factors that are driving this change.

2.1 Change Drivers for Unbundling

Change drivers that have most contributed towards creating a massive amount of interest regarding a modular education among practitioners and learners alike have been identified through a review of the existing literature. While some drivers are technological in nature, others can be linked to the changes occurring in the socio-political and cultural environment and the opportunities arising from that. Firstly, the extent to which students have access to non-traditional learning resources and technology has affected how learning occurs which inadvertently sheds light on the possibility of an unbundled curriculum. Meanwhile, the advancement in information and communication technologies now offers the possibilities that were not apparent before. The student demographics and faculty roles have also rapidly evolved over the years with increased emphasis on lifelong learning. The burgeoning cost of education in most parts of the world has been a matter of concern, hence, the opportunities to cut costs offered by unbundling the traditional university is another driving factor towards this trend. The snowballing importance of competence based learning in the labour market as well as the need for enhanced student and faculty mobility in the global knowledge economy are other major factors that contribute towards the need to unbundle. These factors are explained in detail in the following sections.

2.1.1 Improved Offer of Educational Content

According to Bass & Eynon (2017), today, students need a different kind of skill set that helps them to become more adaptable. The need to develop skills such as critical thinking, problem solving, communication and integrative learning is vital. In the recent years, due to the rise of internet the digital content space has been revolutionized, hence, the number of non-traditional knowledge providers has increased enormously (Horn, 2014). As a result, both traditional and non-traditional students are now exposed to a much wider offer of courses as well as degree programmes from sources such as Udacity, Coursera, Udemy and others. This not only gives students an option to choose a much more individualized study pathway which is personalized to their needs but also gives them a way out of the rigid curriculum requirements which previously did not exist. Although digital content providers are still treated with skepticism (both in literature and in practice), their net effect on the higher education sector cannot be totally discounted. In recent years, they have penetrated the threshold of adoption, even collaborating with some of the most prestigious universities in the world to further enhance their offer (Chafkin, 2013). Many universities now offer study content via these third party digital content providers, which is already a good indication towards an unbundled curricula. A review by Class Central (2017), one of the websites that does not produce content but hosts it, states that by 2017 there were 81 million registered users studying online courses with at least 800 universities participating.

2.1.2 Advanced Information and Communication Technology

Laurillard (2007) and Selwyn (2007) have argued that academics have not been employing technology as a part of curriculum as well as they could and the overall IC&T usage in universities is still very limited. Presently only 2% of the global $4.9 trillion education market is digital (Citi, 2017). Learners are exposed to a multitude of technological tools on a daily basis, beginning from their personalized fitness trackers to their social media and so on. However, this technological advancement has not yet been translated to the field of higher education (Ernst & Young, 2012; Tozman, 2012). New and innovative technological advancements such as those in the field of big data analytics, machine learning and blockchain could have a major impact on how educational institutes are structured today (Acheampong, 2018; Camilleri & Grech, 2017; Leliopoulos & Drigas, 2014). Additionally, Craig & Williams (2015) have pointed out that the unbundling in the education sector may not be caused by a courseware based software but instead an online marketplace, similar to what has happened in other industries, for instance Airbnb in the hotel industry and Uber in taxi hiring.

2.1.3 Changing Demographics and New Opportunities

The demographical composition of students today is much different and as such the 'one size fits all' model fails to provide for every sub section of learners (Mintz, 2015). The National Center for Education Statistics (America) has described a new kind of student demographic, which includes another sub category of students known as the non-traditional student who usually have the following characteristics (Pelletier, 2010).

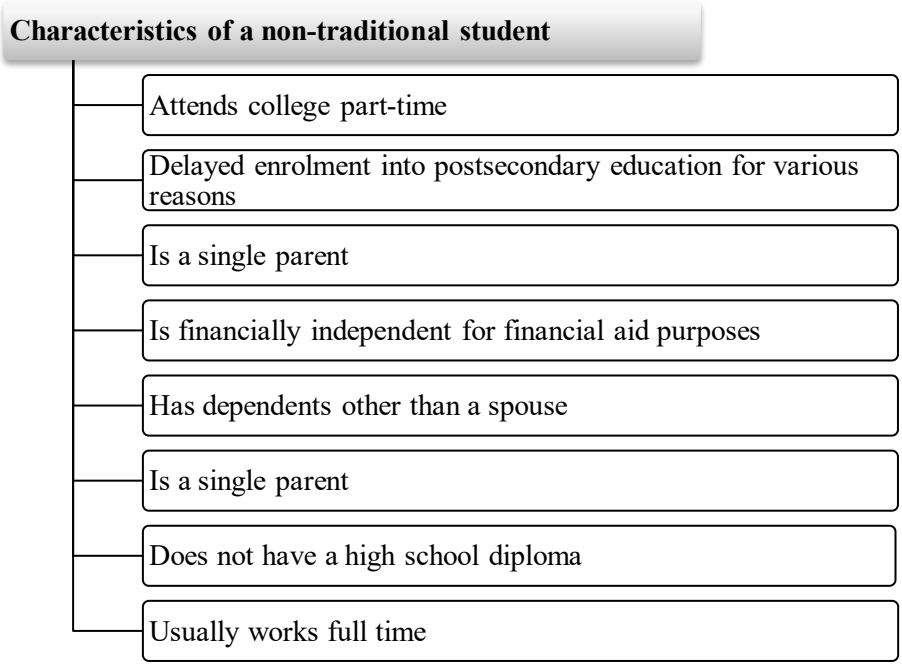

***Figure 1**. Characteristics of a non-traditional student (Pelletier, 2010).*

The kind of learner defined in the figure above is gradually becoming mainstream. Life-long leaning has increasingly become an important area of focus not just from a learner's point of view but also from a university standpoint. University of Windsor clarified that in order to create a better society for the future, they believe in total commitment towards lifelong learning (University of Windsor, 2016). Macfarlane (2011) argues that the change is not just limited to students but also to faculty roles. He goes on to say that disaggregation is already underway in most universities as a new element called 'the para academic' has emerged as seen in the figure below.

Figure 2. *Origin of 'para academic' (Macfarlane, 2011).*

Another area of opportunity to unbundle is to outsource credentialing. For instance, Pearson VUE Business has offered Certiport, which can offer services such as administering tests, grading results and verifying identity of learners. Certiport delivers its solutions in about 148 countries and in 27 languages through its 12000 authorized centers (Martinez & Perry, 2015).

2.1.4 Unbundling of Costs through Social and Economic Opportunity

According to a 2014 Sallie Mae report, in view of the burgeoning cost of education students usually use one or a combination of the following strategies:

- Students have cut personal spending (66 percent)
- Students are choosing a college closer to their parents' home (61 percent)
- Students try to get extra part-time work (48 percent)
- Students accelerate the coursework to graduate earlier
- Students apply for change to a more marketable major

For obvious reasons, the above factors could adversely affect the performance, development and well-being of an average student. In a regular university bundle, apart from learning and credentialing which are the primary outputs, there are various elements such as research, learning support, facilities, housing, healthcare and so on. These elements often add to the cost of a university bundle while having only a minor effect on the total

return on investment for students (Craig & Williams, 2015). Universities constantly struggle between trying to control costs while maintaining high quality among all of its different elements, which is not a sustainable business model (Christensen et al., 2011). Unbundling different elements of a university could lead to more cost efficient models while creating a healthy competition in the market (McCowan, 2017). Bringing the costs down could in turn improve the access to education for those most in need, henceforth, cultivating social equality. For instance, digital content provider Udacity collaborated with Georgia Institute of Technology and technology giants AT&T and Accenture in 2014 to create an online Master of Science degree programme in Computer Science, bringing down the cost of the online programme to about $6600 which is only one-sixth the cost of what the same programme would cost on campus (Mckenzie, 2018). Moreover, efforts in the space of digital content creation can save costs through economies of scale.

2.1.5 Industrial Recognition of Competence Based Education

In 2015, Ernst & Young announced that they have removed the requirement of a university degree from their hiring policy since there was no evidence of a proportional relationship between a college degree and good performance on the job (Sherrif, 2015). In 2018, job search portal Glassdoor compiled a list of 15 major companies, which included business giants such as Apple, Google, IBM, and Bank of America that no longer considered a lack of college degree as a barrier to the hiring process (Glassdoor, 2018). Recognition of moves like these are just an indication of how the labor market has in recent times repeatedly stressed on the importance of competence and skill with minimal credential rather than a credential accompanied by zero competence (Craig & Williams, 2015). Moreover, transcripts and diplomas fail to provide a clear picture (Hope, 2017).

Many private entities are also increasingly involved in planning curriculum alongside universities and/or digital content providers in order to create offerings that focus on general cognitive ability and soft skills instead of grades and seat time (Friedman, 2014; Bryant, 2013). For instance, Microsoft and Linux have collaborated with EdX to offer short courses that are more in touch with the rapidly innovating world of technology and Eastern Washington University now offers a bachelor's degree programme designed by Microsoft in the field of data analytics. Microsoft, Accenture and Boeing have also jointly created a non-profit called the 'Internet of Learning Consortium' to facilitate the creation of current and up to date skills among students to make them job ready (Marcus, 2017). This suggests that the move towards an unbundled education is imminent.

2.1.6 Demand for Increased Student Mobility

The world today has become increasingly porous, with national boundaries almost blurring. More and more students go abroad not just to study but also to work and educators as well, are keen to explore universities located in foreign countries (Corak, 2013). The

Bologna convention created in 1999 is signed by learning stakeholders from over 29 countries in Europe. The coalition aims to promote the recognition of lifelong learning and enhance student mobility and has come to an agreement for creating a mutually beneficial recognition framework for higher education. The European Credit Transfer and Accumulation System (ECTS) is a tool that facilitates transfer of credits between universities, hence, technically creating an acceptable tool for student mobility across Europe (Reichert & Tauch, 2003). However, due to a clear lack of trust and consensus among most international institutions, recognition of prior learning even after ECTS is still a complex and difficult process (Chapman, 1997; Adams, 2001; Karran, 2004). Guy Haug (1997) has argued that grading systems and practices differ considerably from country to country and therefore, the recognition of grades of students going overseas or coming from overseas has some space for interpretation and bias. The demand for providing ways to facilitate increased student mobility which is in keeping with the trend of a global knowledge economy will play a massive role in making way for an unbundled future in higher education.

2.2 Barriers to Unbundling

Although there are many supporting factors that highlight the importance of modularity in higher education there are some very realistic roadblocks in its way. When it comes to the opportunities to unbundle curricula by making use of digital content providers, it becomes essential to understand their current weaknesses as well. Universities resist unbundling due to the probable disruption it would bring about and due to the concerns regarding the degraded quality of the 'university package' that unbundling aspects of the traditional universities would cause. Lastly, there is a risk of education being turned into a commodity more than it already is. Some of these are identified as following:

2.2.1 Limitations of Digital Content Providers

Despite the fact that digital content providers have opened up a new space for high quality content, there are some areas which have validated some scope for criticism. Firstly, too much information and options can be overwhelming for learners and at a certain point it might become hard to differentiate between different quality levels; secondly, their Achilles heel is their recorded low rates of completion; thirdly, even though technology is constantly advancing, online courses are not fully interactive yet as opposed to a regular classroom; fourth, there are currently more recorded cases of online and digital education serving as a complimentary source of knowledge rather than a primary one with very few exceptions; fifth, it has also been suggested by experts that more mature learners are better suited for such kind of learning; lastly, though digital learning avenues boast about creating opportunity to learn for all irrespective of socio-political status, experts have found out that only those who have access to a high bandwidth internet (indication geographical

prosperity) have been able to benefit from them so far (Vardi, 2012; Zheng et al., 2018; Allen & Seaman, 2014; Czerniewicz et al., 2014; Hansen & Reich, 2015).

2.2.2 Resistance from Universities

Universities are rigid structures and by nature, resistant to change due to the robust nature of demand in their favour. The power lies mostly in their antiquated ability to accredit, in other words 'an official seal of approval', which serves as a quality guarantee of a degree programme. Despite many promising innovations, accreditation remains to be one of the biggest obstacle in the path of unbundling. Accreditation process is expensive and complex and needs reform on a regulatory and governmental level in order to reform the traditional bundled offer of higher education (Burke & Butler, 2012).

There are proponents who insist on making universities more integrative by turning them into distinct learning environments while maintaining the existing structure and hierarchy but adapting it to a digital environment (Bass & Eynon, 2017). The inter relation between education which is the core element of a university and the student experience which is a complementary but essential element as well, can only be fulfilled in an integrated campus environment (Garvin, 1993).

The creation of new para-academic roles although tends to fill in the void that is created so that academics can be multifaceted, but it also has its disadvantages. Macfarlane (2011) has suggested that it creates additional work pressure on the academics, sometimes unwillingly, to adapt to being an all-rounder and thus, might inhibit their own development.

2.2.3 Commoditization of Education

There is a perception that a completely unbundled future in the context of higher education will lead to knowledge becoming a commodity. Market led approaches might lead to heavy monetization of different aspects of education if not properly regulated. Some experts also predict that it might turn institutions into 'businesses specializing in preparing people to work in businesses' (Czerniewicz, 2018). Watermeyer & Olssen (2016) have argued that the neoliberal pursuit of excellence by universities in a knowledge economy in the higher education market has diminished the personal welfare of academics.

3. BLOCKCHAIN TECHNOLOGY

In 1980, Ralph Merkle first presented the concept of a 'Merkle Tree' which in 1992, was used by Haber, Bayer and Stornetta to propose a computational methodology to timestamp documents cryptographically in a way that made them tamper-proof (Merkle, 1979; Bayer et al., 1992). They also introduced the concept of cryptographic hash functions and mentioned the chaining together of hash functions in a linear list. In 1998, the first ever 'cryptocurrency' called B-money was proposed by Wei Dai which employed some of the same protocols which were used in 2008 by Satoshi Nakamoto (possibly a pseudonym) when he published a paper titled 'Bitcoin: A Peer-to-Peer Electronic Cash System' introducing the concept of Bitcoin. This immensely popular paper still did not mention the word blockchain as we know it today, however, it introduced the elaborate concept to explain Bitcoin, a cryptocurrency invented by him. In his paper, Nakamoto referred to Merkle Trees and cryptographic hash functions as the foundation behind his invention. In the following year Nakamoto made the Bitcoin network available as the first open source program that was founded on the principles of complete peer to peer electronic cash system that would eliminate the use of an intermediary and use cryptographic proofs to generate trust.

Blockchain is a shared, decentralized and distributed ledger that can be used to record any kind of transactions across several computers (also called a peer to peer network). The information related to transactions on a blockchain is stored in blocks in the form of a unique hash where each proceeding block contains a reference to the hash of the previous block, thus connecting them in a chain. In other words, blockchain is a type of database which is stored on many computers (called nodes) at the same time with each node containing the same information (Iansiti & Lakhani, 2017; Kastelein, 2017; Gupta, 2017). What distinguishes a blockchain from other distributed databases (such as those by Oracle) is that it allows all its multiple nodes to share and modify this database by achieving a consensus among all its participants, thus, eliminating the need of an intermediary or an administrator (Hileman & Rauchs, 2017). Therefore, no single user has control over the entire database, making the system very transparent. Each entry made on a blockchain is permanent, transparent and searchable and can be anything including contracts, assets, identities or any other information that can be represented digitally (Camilleri & Grech, 2017).

3.1 Elements of Blockchain

Blockchain technology is under constant development on an international level both from a practical and theoretical standpoint. However, there are certain elements of the technology that have been identified in existing literature, that attempt to describe it to a certain extent.

3.1.1 Cryptography

Cryptography is used by almost everyone on a daily basis without even realizing it, for example on a smartphone, many apps use encryption. Cryptography is a technique used to secure communication by encrypting it in a certain code to protect it from third parties (Boucher et al., 2017; Kosba et al., 2015). In the context of blockchain, cryptography is used in two ways. Firstly, a public/private key mechanism is employed to secure the identity of the sender of the transactions which means that a combination of a public key and its mathematically linked private key is needed to access any information. A simple analogy to explain it is someone's e-mail address. Email addresses are usually shared information and hence, individual A can have individual B's email address but to access B's emails, A needs B's password or key. Hence, private key plays a crucial role in ensuring privacy and must be kept safe as it is the only proof that can link an individual to the blockchain. Secondly, hashing functions are used to make sure that the existing information cannot be tampered with. Hashing is a process by which any digital document can be converted into a unique code which can then be used as a digital identifier for that particular information. Hashing is a one way process which means that a hash generator can create a hash from a document but it is impossible to generate a document from its hash (Camilleri & Grech, 2017; Boucher et al., 2017). Each block in a blockchain is identified by a unique hash. Every block also contains a reference of the hash of the previous block in the chain thus, keeping all the transactions in an order. This makes the information on a blockchain very secure because if bad elements attempt to modify certain information on a certain block, its hash would change, which in turn would require recalculating and changing the hash of all the subsequent blocks (at least over 50% of the blocks on the chain). This would require considerable amount of computing power thus, ensuring the security of the information on a blockchain (Buterin, 2013; Delloite, 2017).

3.1.2 Peer to Peer Network

A peer to peer network can be defined as any network with a distributed architecture which simply means that all the peers on the network are equal partners in the equation. One of the foremost and well-known examples of a P2P network was music streaming service Napster which allowed its users to freely share MP3 files with each other (Oram, 2001). Figure below compares a traditional network to a P2P network.

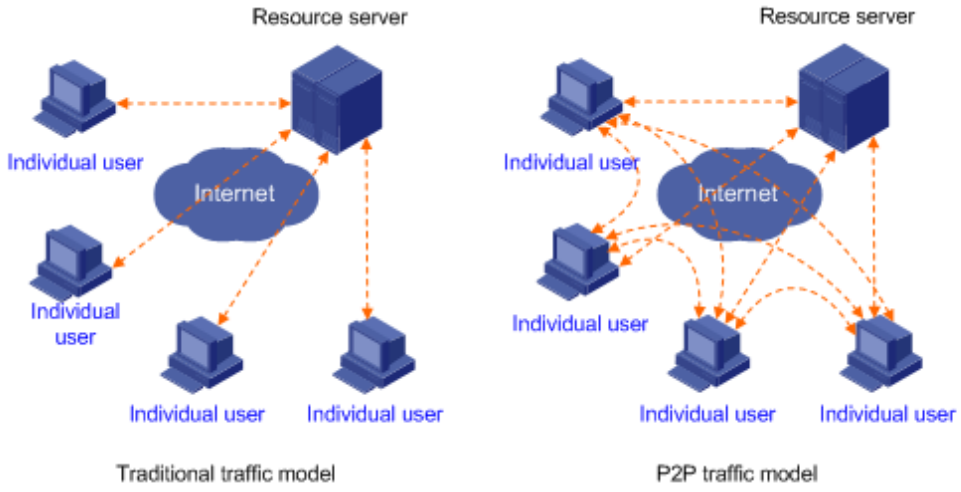

Figure 3. *Comparison between a traditional and P2P network model.*

The peer to peer networking approach employed in blockchain enables direct exchange of information between the network participants without going through an intermediary or a central point of control thus, creating a decentralized network (Nakamoto, 2008; Gupta, 2017; Wright, 2017). Each peer is called a node and the entire ledger is replicated on every single node. Nodes act as participants as well as resources for the blockchain that they are a part of. The true strength of a blockchain is demonstrated via its nodes as they preserve the integrity of the blockchain itself. While in a centralized network all malicious elements need to do is attack the centrally located server, on a P2P blockchain, they need to essentially attack every single node and modify every block on that blockchain, which though possible, is highly resource consuming and unlikely (Iansiti & Lakhani, 2017; Bharadwaj, 2016; Seebacher & Schüritz, 2017).

3.1.3 Consensus Mechanism

Consensus mechanisms or protocols form the backbone of any blockchain. Protocols are a set of rules that ensure the synchronization of all the nodes within a network by providing a commonly agreed upon method to bring all nodes into agreement about the correct version of information on the chain (Mattila, 2016; Swanson, 2015). In order to add a new transaction occurring between two parties or any other piece of information on the blockchain, all the nodes must confirm the validity or in blockchain terms, provide consensus that the parties involved in the transaction have the ability to do so (Camilleri & Grech, 2017). Consensus protocols ensure that all the information on the blockchain is valid and prevent information corruption by a single entity meanwhile, providing incentives or rewards in terms of tokens for the participants (Mattila, 2016; Brenig et al., 2016).

There is a wide range of consensus protocols that can be used on a blockchain which mostly depends upon the type of blockchain used and on the participants involved. They

are designed in a way that makes it hugely expensive and practically impossible to imitate. There is a constant discussion among blockchain experts as to what protocol is the most effective. The conceptual solidity of consensus protocols lies in their ability to solve something called 'Byzantine Generals Problem'. The problem refers to the issue of reaching a unanimous agreement among of group of army generals in the Byzantine (Ancient Eastern Roman Empire) army about whether to attack or retreat. Due to the conflicted approaches offered by different generals and the lack of trust among each other, the decision is in limbo (Lamport et al., 1982). The consensus protocol introduced in Nakamoto's 2008 Bitcoin paper is commonly known as 'Proof of work' and was one of several protocols to solve this problem. The table below summarizes some of the commonly used consensus protocols.

Table 1. *Examples of Consensus Protocols (Adapted from Mattila, 2015).*

Consensus Protocol	**Ruling Mechanism decided by**
Proof-of-work	Computing power
Proof-of-stake	Ownership of scarce tokens
Delegated proof-of- stake	Ownership of scarce tokens + peer reputation (elections for delegates)
Proof-of-activity(PoW/PoS-hybrid)	CPU power + ownership of scarce tokens
Proof-of-burn	Destruction of scarce tokens within
Practical Byzantine Fault Tolerance (PBFT)	Consensus decision reached based on the total decisions submitted by all the generals
Proof-of-capacity/Proof-of-storage	Free storage capacity/ Stored random data
Proof-of-importance	Participation in the economy (scarce tokens + transactional activity + peer reputation)
Proof-of-elapsed time	Briefest hold up time
Proof-of-validity	Security deposit of scarce tokens subject to burn if voting dishonestly

Although there are several consensus protocols available, the final choice depends upon several influencing factors taking into consideration the context and scale of application.

3.1.4 Ledger

Ledgers have historically been used in society since the 13th century to conduct business. The main purpose of a ledger is to record every transaction whether credited or debited making sure that for every debit there is a corresponding credit and vice versa. By design, a blockchain network acts as a distributed ledger, which may or may not be public in nature. In this context, a ledger is basically a list of transactions which have been bundled together and recorded in the order of occurrence and bound together in blocks which are cryptographically linked together (Hileman & Rauchs, 2017). This ledger is shared and updated after every transaction wherein every node has access to the same copy of the entire ledger, thus, serving as the single source of truth (Gupta, 2017). Blockchains have often been compared to the way banks maintain a ledger of financial transactions. Although conceptually valid, this assumption precludes the advanced functionality that blockchain offers as a distributed ledger since in a blockchain the transactions are not just limited to financial exchange but can be any kind of data (Graham, 2013; Wood, 2014)

3.1.5 Permissions

Permissions in a blockchain have two roles, firstly they end up defining the kind of blockchain used and secondly, permissions can also be used to define roles within a blockchain (Gupta, 2017). On a micro level, blockchains can be permissioned or permission-less defined by three major types of permissions: read (who can see the transactions), write (who can generate transactions) and commit (who can update the ledger) whereas on a macro level these are defined as open or closed (Hileman & Rauchs, 2017). However, blockchains are also defined as public and private, which often creates misleading contexts. The table below is adapted from the work done by Ethereum founder Gavin Woods (2014), Carson et al. (2018) and Hileman & Rauchs (2017).

Table 2. *Types of blockchains and their features.*

	Type of Blockchain	**Characteristics**	**Security/Anonymity**	**Scalability**
Closed	Private Permissioned	Only authorized nodes can join and read	High level of security and low level of anonymity	Very high
Closed	Private Permission-less	Only authorized nodes can join, read and write	High security and low level anonymity	High

Open	Public Permissioned	Anyone can join and read	Moderate level of security and high level of anonymity	Medium
Open	Public Permission-less	Anyone can join, read, write and commit	Low level of security and high level of anonymity	Low

3.2 Characteristics of Blockchain

The characteristics of blockchain overlap with each other to a certain extent. Each characteristic is in some way related to or complements the other one.

3.2.1 Decentralization

Decentralization as a process has traditionally been used to redefine structures, procedures and practices by moving them from being controlled by a single entity to being handled by masses. The French Revolution was one of the first instance of a major movement that was aimed at decentralization, in that case the goal was more civic than technological (Leroux, 2012). In the context of blockchain, decentralization means shifting the control of data from centralized machines to decentralized networks (Camilleri & Grech, 2017). In conventional databases, all the information is kept and controlled by a centralized system that is usually owned by powerful conglomerates (e.g. Facebook, Google, NASDAQ, Universities). Users allow their personal data to be handled by these third parties to gain comfort and convenience but at the cost of their personal privacy and individual freedom due to the single point of failure protocol employed (De Filippi, 2013; Schneier, 2009). Conversely, a blockchain enables the creation of a decentralized arrangement where data and information is not held by a single entity third party but in a public ledger which is managed by a consensus mechanism and distributed techniques in a peer to peer network containing multiple nodes (Hence, multiple points of failure) (Turkanovic et al., 2017; Chen et al., 2018). The decentralized mechanism works on the basis of trust between different nodes which is built via cryptographical and mathematical methods. Every node maintains its own copy of the data, thus, upholding data integrity.

One of the key principles of a decentralized ledger technology is trust (Gencer et al., 2018). In a conventional centralized environment, we establish blind trust without any pre-conditions. For instance, we take it for granted that our finances and personal as well as financial information is safe with the banks and it is okay for these centralized authorities to charge its users for the use of resources that they personally own. Similarly, in a democracy, citizens trust the government issued currency and students trust their universities with their personal data. With Blockchain, trust is calculated mathematically, which

inherently shifts the 'for granted' nature of trust from a centralized system and spreads it over compounded decisions of an unbiased community (Zheng et al., 2017; Atzori, 2015). Swan & Filippi (2017) have discussed the decentralization in blockchain from two perspectives:

- Architectural decentralization: The peer to peer network with multiple nodes in it presents a decentralized architecture
- Operational decentralization: The practice of involving every single node in evaluating and confirming the new blocks also demonstrates a decentralized operation.

Decentralization is achieved by using different kind of consensus algorithms. Some of these approaches are: PoW (Proof of Work, e.g. Bitcoin), PoS (Proof of Stake, e.g. Peercoin), PoA (Proof of Activity, upcoming algorithm is a combination of PoW and PoS), PBFT (Practical Byzantine Fault Tolerance e.g. Antshares), DPOS (Delegated Proof of Stake e.g. Bitshare), Ripple and Tendermint (Zheng et al., 2017). Furthermore, decentralization is most easily achieved in a public blockchain, partially in a consortium blockchain and can be attained in a private blockchain to a limited extent depending upon the access control mechanism. Thus, it can be concluded that decentralized structures are conducive to individual freedom, privacy and autonomy and diminish the risk of losing the stored information by eliminating single point of failure (Ziccardi, 2012).

3.2.2 Immutability

In object-oriented programming languages, an immutable object is the one whose state cannot be modified once it has been created (Boyland et al., 2001). Immutable simply means the property of being unchanged over time. In blockchain, immutability is achieved in two ways (Chen et al., 2018; Tschorsch & Scheuermann, 2016; Bachmann et al., 2017). Firstly, by storing the information in a chain of blocks where each block is identified by a unique 32-bit alphanumeric time-stamped hash function which also contains a reference to the previous block in the chain. Secondly, as the ledger runs on a large number of nodes, which are programmed to sync in real time, in order to make changes at least 51% of those nodes, need to be changed. Immutability has two contexts: immutability of data and immutability of code; while immutability of data means that the data recorded on the blockchain cannot be modified due to the technical properties of the blockchain, immutability of code is related to the underlying software code that creates blockchain in the first place (Morabito, 2017).

The main principles defining immutability in a blockchain according to several studies (Boucher et al., 2017; Bachman et al., 2017; Chen et al., 2018; Morabito, 2017; Hoffman et al., 2017) are as listed below:

- The consensus mechanism employed in a blockchain requires the different nodes in the peer to peer network to agree on the validity of every transaction. In other words, a single actor cannot make any changes to the data recorded without collective agreement rendering tampering essentially unlikely.
- The ledgers are duplicated at every node as such creating multiple copies of the data blocks. In order to modify data, every single node has to be modified which is computationally impossible.
- If a transaction is recorded in error, it cannot be changed but a new transaction can be issued to reverse the recorded error. This in turn makes both these transactions visible on the blockchain.
- Each block identified by a hash key is unique i.e. no two hash keys can be same. Every block contains its unique hash as well as the hash of the previous block in the chain, linking the blocks together in a perfect sequence preventing any insertion of a new block between them.

Camilleri & Grech (2017) have tried to elucidate on the immutability concept with different kinds of blockchain. Public blockchains, which rely on public consensus to ascertain decisions and are open to everyone, may have millions of nodes, hence, they offer maximum immutability. Private blockchains are limited in a way that they may allow modifications by a pre-defined small number of users, hence, reduced immutability. Finally, consortium blockchains, which are an amalgam of the two former blockchains, consists of all pre-defined parties with equal consensus rights; hence, it provides an equitable immutability. In general, the immutability feature of blockchain offers increased transparency, data consistency and integrity meanwhile preventing data forgery and theft (Boucher et al., 2017; Bachmann et al., 2017).

3.2.3 Pseudonymity

Blockchain attempts to ensure anonymity by employing a public-private key mechanism in which a public key is issued to every user which is cryptographically linked to a private key known only to the owner. Thus, anonymity is maintained via a digital signature (Nakamoto, 2008). Mougayar & Buterin (2016) have compared the blockchain anonymity mechanism to obtaining an individual's house key; just like the public key on a blockchain, a person's house address is visible to everyone as public information, however, the content of the house (or a transaction) is only visible to the key holder. Most researchers have maintained that blockchain offers Pseudonymity instead of complete anonymity (Lansiti & Lakhani, 2017; Boucher et al., 2017; English et al., 2016, Reid & Harrigan, 2013). In other words, all transactions are visible but it is not easy to link the information to individual identities. Thus, anonymity is not absolute and even though the transactions occur between digital addresses, there is a possibility for malicious elements to make the connection between those addresses and individuals.

Reid & Harrigan (2013) suggest that blockchain was not created to achieve anonymity as a primary goal. However, the fact that there is no central authority storing all user data preserves the privacy to a certain extent. Experts from the field of education have suggested that the public-private key is efficient enough for blockchain to be used to manage student data and certifications (Camilleri & Grech, 2017; Chen et al., 2018).

3.2.4 Self-Sovereignty

Blockchain inherently promotes data owners' right to own their data without the need to go through an intermediary (Camilleri & Grech, 2017). A self-sovereign identity would allow an individual to essentially take ownership of their data and control how, when and who accesses their data (Lilic, 2015). This would in turn eliminate the need of 'identity providers' that traditionally own public and private data on their servers, usually for a cost. The public private key mechanism in which the private key is linked to the public key cryptographically will come into play in this case.

4. BLOCKCHAIN AND UNBUNDLING

As discussed previously, literature has pointed out that the realisation of modularization in education would be facilitated by advancement in modern technologies that provide unprecedented solutions for issues that were previously unheard of. Technologies like big data analytics, artificial intelligence, virtual/augmented reality and blockchain are some of the innovative technologies that technology pundits have recognized as having the potential of being instrumental in reforming higher education (Esposito, 2018; Luckin et al., 2016). All these technologies have enormous potential worth delving into, the focus of this thesis is on blockchain technology in particular.

Blockchain has been touted as the technology that could make way for reforming higher education in many ways, however, its particular relationship with modularization of education has not been the research focus so far. The different aspects of an unbundled world of education can be examined through the lens of various advantages (and limitations) that are offered by blockchain technology as a whole. For instance, immutability, which is one of the main selling points of blockchain technology, could facilitate unbundling by offering a way to create individualized and permanent lifelong learning records for learners, the consensus protocols built in on a blockchain could be used to create trust between universities and in turn simplifying student mobility. These are just a few examples of the many connections that can be drawn between these two phenomena. To begin this study the first step is to understand the extent of penetration of blockchain technology in the current higher education landscape. The following section describes some of the global blockchain initiatives and use cases in the field of higher education.

4.1 Use Cases

Blockcerts

The first major application of blockchain technology came in the form of a collaboration between Learning Machine and MIT Media Lab (Massachusetts Institute of Technology) which resulted in the launch of Blockcerts in 2015. According to their official description 'Blockcerts is an open standard for creating, issuing, viewing, and verifying blockchain-based certificates'. In 2017, MIT started issuing blockchain based diplomas to students at the MIT Media Lab (Media Arts and Sciences) and the Sloan School of Business. Since Blockcerts is an open standard, it provides an infrastructure to create applications on top of it in order to issue blockchain based credentials to anyone.

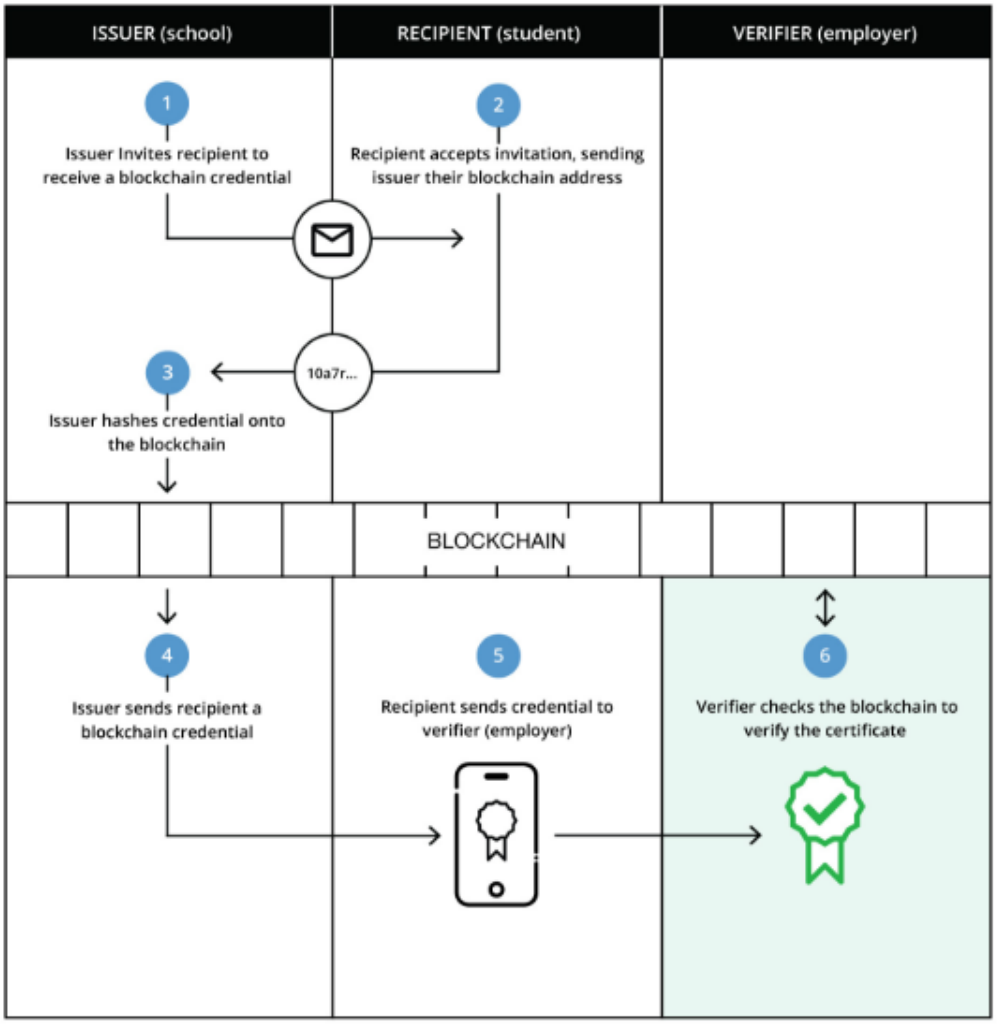

Figure 4. *Blockcerts How it Works (Blockcerts.org).*

Students are at the center of the Blockcerts project according to its founders, with the prime aspirations behind it being giving the control of their data back to students without the use of intermediaries (Camilleri & Grech, 2017). The figure above shows how Blockcerts actually works. There are four main components: Issuer (Institution that creates certificates/diplomas), Recipient (Student receiving the certificate/diploma), Verifier (Responsible for checking and verifying authenticity) and Wallet (A user friendly, sharable and learner owned repository of all their certificates/diplomas). In September 2017, the Republic of Malta signed an agreement to partner with Blockcerts and in December 2018, issued diplomas to 260 graduates from Malta's Institute of Tourism Studies for the second time. The Caribbean Examinations Council (CXC) (Member countries: Barbados, Jamaica, British Virgin Islands, Anguilla, Antigua & Barbuda, Trinidad & Tobago, Belize, Cayman Islands, Dominica, Grenada, Montserrat, Saint Kitts & Nevis, Saint Lucia, Saint Vincent & the Grenadines, Guyana, and Turks & Caicos Islands) have also started the process of issuing Blockcerts certifications to nearly 24000 students.

Knowledge Media Institute (Open University, UK)

The Knowledge Media Institute (KMI) is the R&D lab within the Open University of United Kingdom and is known for research in innovative areas including Semantic Technologies, Blockchain, Educational Media, Social Media Analysis, Big Data, Smart Cities, IoT and others. KMI launched the OpenBlockchain project in order to exploit the potential of blockchain technology in implementing micro-accreditation in the form of open badges. They have successfully converted the badges in the form of smart contracts and put them on the blockchain. Another experiment underway includes being able to put student work on the blockchain along with the corresponding feedback. There is also a plan to implement tokens that would be offered to corporate employees after achieving a specific amount of learning. KMI is also collaborating with University of Texas and startups such as Gradbase to create blockchain based accreditation which can be directly linked to learner CVs. According to their website,

'KMI has been working on a semantic blockchain platform, LinkChain, which supports the decentralization of personal data via a combination of blockchain and Linked Data technologies'. The figure below is a pictorial representation of what a blockchain based future of education would look like.

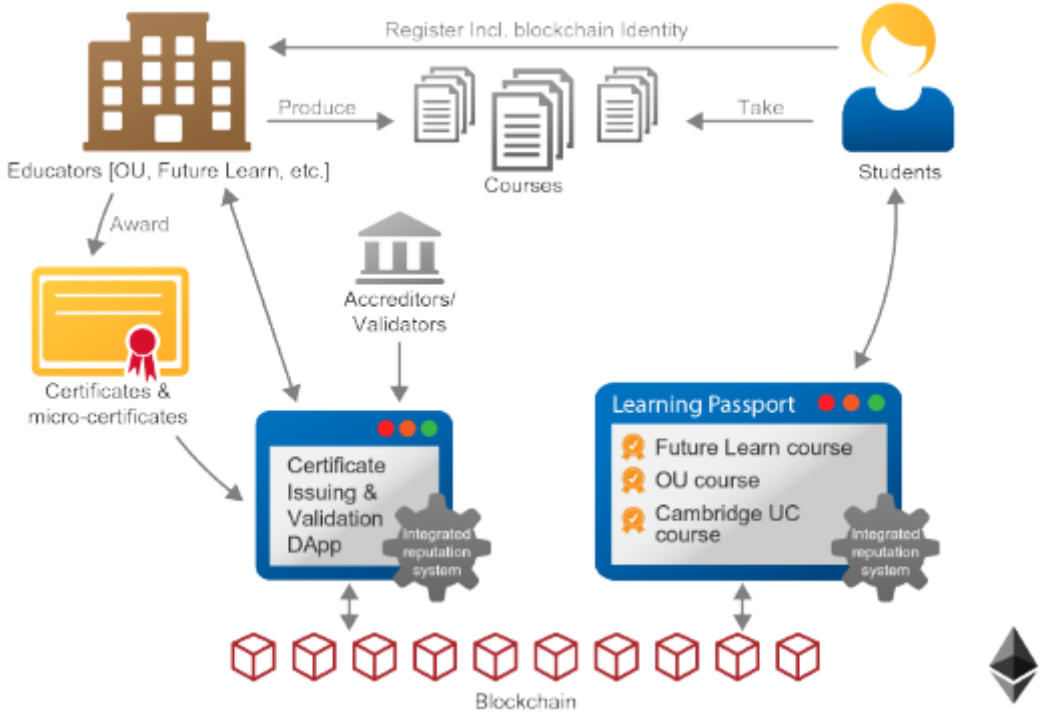

Figure 5. *Blockchain for certification and accreditation scenario (English et al., 2016)*

SONY Global Education

In 2016, SONY announced that it has been working on an in house blockchain based certification system using blockchain technology (Sony, 2016; Russell, 2017). SONY has employed Hyperledger, an open source project from the LINUX Foundation and IBM' blockchain and cloud. In 2017, SONY launched a demo website that stored the transcripts of the participants from the 5th Global Math Challenge, which was held from December 1 to 10, on the blockchain. One of the aims for these projects undertaken by SONY is to create a new blockchain based ecosystem by integrating the current 'student information systems' and 'learning management systems' safely into the new environment and making it conveniently accessible to both students and institutions as well as serve as live resumes.

University of Nicosia

The largest university in Cyprus, University of Nicosia has been leading the way in employing blockchain in education context in multiple ways. According to their website

- In 2013, it became the first global university to accept Bitcoin as a valid payment method for tuition fee
- In 2014, it became the first university to offer a Master of Science degree in digital currency as well as free MOOC on the same topic
- In 2017, it also became one of the universities to issue blockchain verified certificates to its students

Anyone can verify the authenticity of the diplomas and certificates issued by the University of Nicosia on its website and the process takes just a few minutes to complete as opposed to traditional universities where it might take from days to weeks.

Other Major Initiatives

There have been efforts on a global scale to utilize blockchain technology and unsurprisingly, a lot of them come from the private sector. The table below is a brief summary of some of these initiatives.

Table 3. *Blockchain initiatives in higher education.*

Name	Description
Woolf University	The idea to create the first blockchain university has come from a group of academics at Oxford University. In their white paper, the creators claim that Woolf University will be 'geographically agnostic and medium agnostic'. Its distinctive elements are Ambrose

	(the university itself), Woolf Trust (Managing endowment), Woolf Reserve (0.035% of each financial transaction is stored here), tokens called WOOLF and a connected network of universities. There has not been a demo so far but hyperledger fabric is being employed. In a practical sense, the idea is to issue blockchain based contracts between a teacher and an individual student that dictates the course implementation, grading and certification process. In a way, this would create an ideal unbundled ecosystem in a higher education context.
TrustED	Originating from Australia in 2017, TrustED is a product that aims to create a platform to enable universities, and online educational and training Institutions to store, as well as authenticate grades, credentials, or certificates by using blockchain technology. It aims to cater to the interests of students, universities as well as employers. It is based on 'Ethereum smart contracts and Hyperledger, combined with advanced security measures and novel data storing techniques'. TrustED plans to create its own ERC20 compliant TrustED token (TED) and a native Trust Credit (TCRD) token. They plan to launch their Initial Token Offering in the beginning of 2019.
Peerbud	Peerbud originates from the Silicon Valley and plans to create an 'open decentralized protocol that tracks everything you have ever learned in units called Gyan and rewards it with tokens called Karma.' Its focus is lifelong learning. There has not been any demonstration or publication yet.
edChain	edChain is an 'open-sourced, decentralized library using blockchain to solve for needs in the education and careers space'. According to their website, edChain stores the educational content on the distributed network. Users can connect to an edChain node via LAN's and Wifi connections to access content without connecting to the Internet. edChain uses the IPFS protocol for network connectivity and plans to issue its own token soon.
BitDegree	BitDegree is a blockchain powered and gamified digital education platform which is similar to many other digital education providers except the underlying technology. They have their own tokens called BTG which have not been very successful in practice and thus, BitDegree is looking into other ways of financing.

4.2 Possible Application Scenario

The review of the literature study done so far establishes a direct link between the needs of an unbundled higher education system and the features accompanying blockchain that could potentially fulfil those needs. In theory, blockchain could provide a technically plausible system of governance and self-sovereign digital identities, which has built in trust, that is needed to unbundle education as we view it today. To understand unbundling, it makes sense to break it up into smaller units for better understanding as shown in the figure below.

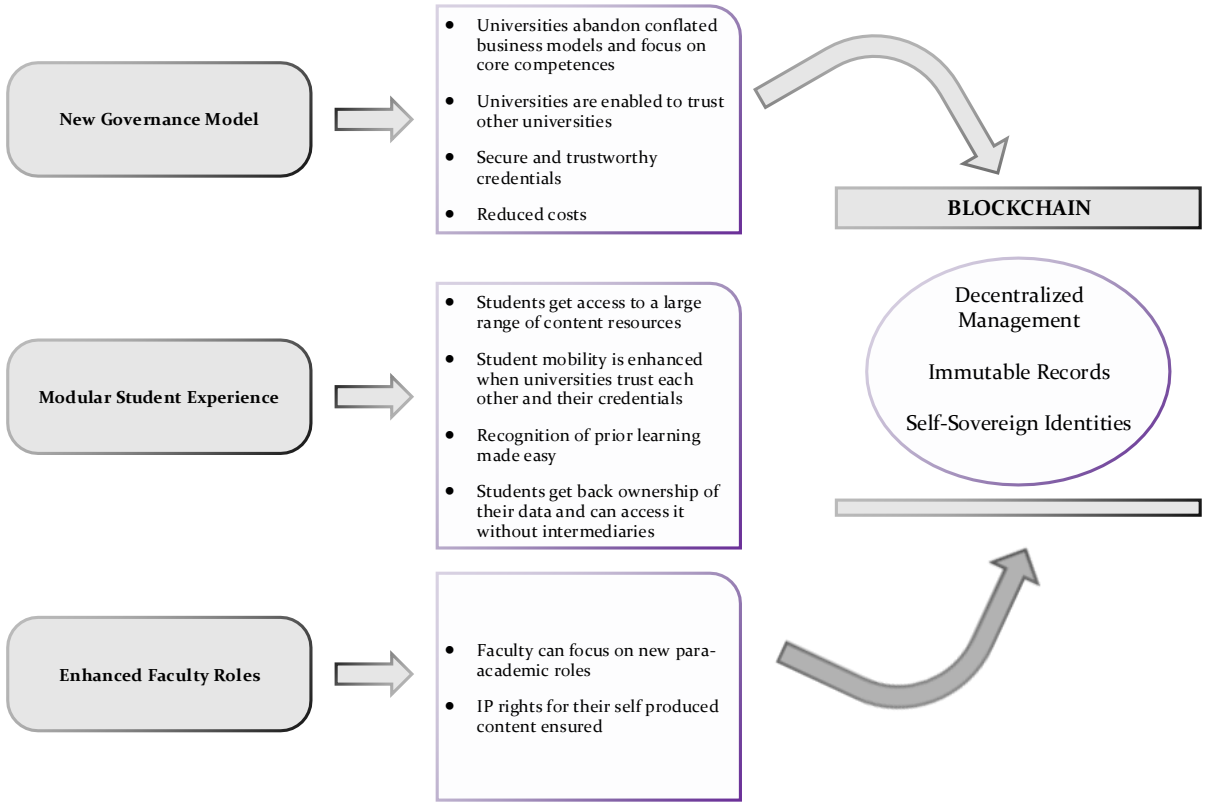

Figure 6. *Blockchain and Unbundling*

Figure 6 is a representation of how the blockchain technology fits into the picture when cogitating an unbundled higher education scenario. Unbundling has been divided into three aspects. Firstly, the need of an unbundled higher education system is simplified governance models. There is a need for new models that inculcate trust among universities so as to facilitate the creation of an ecosystem where secure and trustworthy credentials can exist. Secondly, a modular student experience which includes increased student mobility, better ways for recognition of prior learning, offering students the possibility to learn from a broad curriculum and giving them back the ownership of their own data. Thirdly, the need to look out for the interests of faculty is an important aspect of an unbundled ecosystem. Therefore, in an unbundled ecosystem, faculty would have the bandwidth to focus on themselves as well as the new para academic roles of mentorship and counselling. The question is why blockchain? The elementary features of blockchain

mainly decentralization via consensus management among its peers in order to create an immutable set of transactions or records have the capability of creating trust by technological means. For instance, a consortium blockchain could create a common governance model where only authenticated partners are allowed access. As such there is a possibility of building a future where universities are enabled to trust one another. In other words, by establishing trust synthetically, there could be a possibility that a trusted system of credentials can be created using blockchain which can be verified by all its stakeholders. Such a system would have numerous benefits such as:

- Enormous reduction in costs (of maintaining and verifying credentials) by getting rid of intermediaries hence, reduced overhead costs
- A verified system of accreditation could create an entirely new world. Student mobility will be simplified and convenient for everyone involved in the process as credentials will become trusted by all universities in the network. Consequently, lifelong learning will become much easier to conduct than how it is done presently
- Students will get access to limitless educational resources and will no longer be limited geographically, all learning will matter
- Professors, teachers and subject matter experts could create content and own it at the same time, meanwhile focusing more on the new para-academic roles including providing mentorship and career guidance to students

So far, there has been a detailed discussion based on the existing literature available regarding the research topic. In the following section, an overview of the data collection method will be provided. In this thesis, the data is collected through interviews with experts in the field of higher education reform as well as blockchain experts. Transcripts form the interviews have been analyzed and used to understand the various facets of these phenomena.

5. RESEARCH METHODOLOGY

Research methodology is a set of systematic and structured guidelines that can be used to define and confine the research process into certain thresholds with the purpose of either establishing or extending existing knowledge through proof or by creating new knowledge (Patton, 2002). Research in itself can be defined as the process that is undertaken to make sense of complex phenomena by breaking them down into components and drawing connections between the actual phenomenon and the variables and constants that share a cause and effect relationship with it (Gummesson, 1993). The purpose of research methodology is not to provide solutions but to understand which set of methods make a better fit to analyze a specific case. Saunders et al. (2009) have characterized research as a process which has a clearly defined purpose and where data is collected and interpreted systematically. Any research process is made up of stages that usually follow the order: formulating and clarifying a topic, reviewing relevant literature, designing the research question and process, collecting and analyzing pertinent data and finally drawing conclusions based on the results (Saunders & Lewis, 1997). Therefore, a well done research project can potentially serve as a blueprint for not only contributing to existing theory but also turning theory into practice. In order to streamline the research process it is important to analyze the research approach undertaken from the very beginning and to match the case at hand with the approach that best suits it.

The goal of any research is to develop a descriptive framework and explore possible relationships among variables (Campbell & Stanley, 1963; Denzin, 1978). It is vital to conceptualize the purpose of a research undertaking as different purposes may give rise to distinct ways of hypothesizing issues, designing, data gathering and interpreting the findings from the gathered data (Patton, 2002). According to Patton, classification of research may differ based upon the reviewer due to the overlapping nature corresponding to the adopted approach. This section explains the research methods chosen and the reasons behind choosing them.

5.1 Research Background

According to Edmondson & McManus (2007), the decision to approach a research from a quantitative or qualitative stance depends on the nature of the research questions that drive the study, any previous work undertaken, the structure of the research design and the ultimate output and contributions that the researchers are aiming for. In this case, the research stance taken is purely qualitative. When it comes to qualitative research, Saunders et al. (2009) have illustrated the research process through an approach commonly known as ‘the research onion’ as shown in figure 1. The purpose of the onion model is to provide a researcher a visual guide to traverse through different stages of research. This

model has been considered as a perfectly adaptable tool that can be used in different research contexts (Bryman, 2012; Bryman & Bell, 2011).

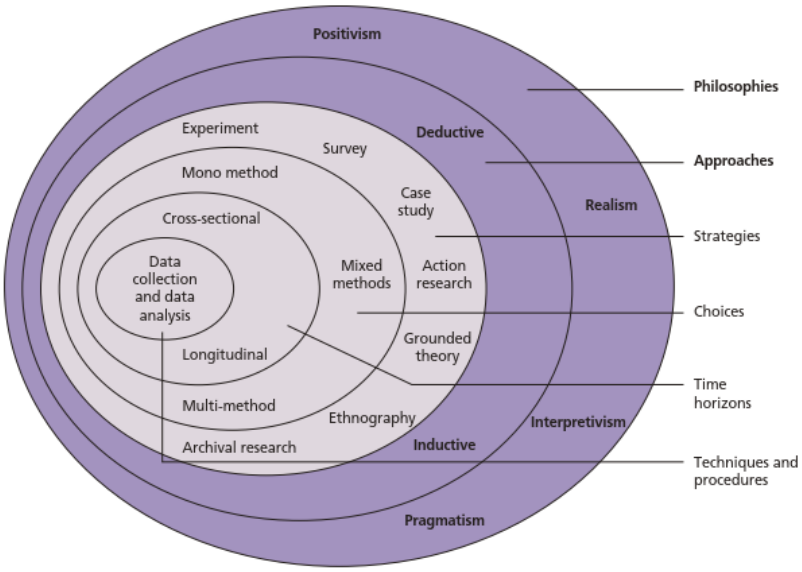

Figure 7: *The Research Onion (Saunders et al., 2009)*

The outermost layer suggests the research philosophy one might adopt during the research process which is generally an amalgam of the researcher's own values, valid assumptions and some practical considerations as required by the situation as shown in Table 4.

Table 4. *Comparison of four research philosophies (Saunders et al., 2009).*

	Positivism	**Realism**	**Interpretivism**	**Pragmatism**
Ontology: *the researcher's view of the nature of reality or being*	External, objective and independent of social actors	Is objective. Exists independently of human thoughts and beliefs or knowledge of their existence (realist), but is interpreted through social conditioning (critical realist)	Socially constructed, subjective, may change, multiple	External, multiple, view chosen to best enable answering of research question
Epistemology: *the researcher's view regarding what constitutes acceptable knowledge*	Only observable phenomena can provide credible data, facts. Focus on causality and law like generalisations, reducing phenomena to simplest elements	Observable phenomena provide credible data, facts. Insufficient data means inaccuracies in sensations (direct realism). Alternatively, phenomena create sensations which are open to misinterpretation (critical realism). Focus on explaining within a context or contexts	Subjective meanings and social phenomena. Focus upon the details of situation, a reality behind these details, subjective meanings motivating actions	Either or both observable phenomena and subjective meanings can provide acceptable knowledge dependent upon the research question. Focus on practical applied research, integrating different perspectives to help interpret the data
Axiology: *the researcher's view of the role of values in research*	Research is undertaken in a value-free way, the researcher is independent of the data and maintains an objective stance	Research is value laden; the researcher is biased by world views, cultural experiences and upbringing. These will impact on the research	Research is value bound, the researcher is part of what is being researched, cannot be separated and so will be subjective	Values play a large role in interpreting results, the researcher adopting both objective and subjective points of view
Data collection techniques most often used	Highly structured, large samples, measurement, quantitative, but can use qualitative	Methods chosen must fit the subject matter, quantitative or qualitative	Small samples, in-depth investigations, qualitative	Mixed or multiple method designs, quantitative and qualitative

The penultimate layer defines the research approaches that can be associated with the chosen research philosophy and it can be either deductive or inductive. While deductive research is a narrowed down approach where the main aim is to test a theory or hypothesis, inductive research is a bottom up approach where the aim is to generate a new theory from available data. The next three layers of the research onion include a structured plan to establish the research strategy, choices and time horizons.

Saunders et al. (2009) have stated that no research strategy is superior to another, thus, it is a matter of relativity as to which strategy or a combination of strategies is a better fit for the research question at hand. Crotty (1998) has highlighted the importance of being able to blend different methods of research in improving the overall research design. The major research strategies as listed by Saunders et al. (2009) are: Experiment, Survey, Case study, Action research, Grounded theory, Ethnography, Archival research. Each of the research strategies serves a different purpose and can be used alone or in combination to achieve results. First, experimental research can produce comparative results between dependent and independent variables in a simulated or natural setting. Second, surveys consist of questionnaires that can be used to collect a large amount of data in a standardized manner. Third, case study involves choosing a single unit to assess and study. Fourth, action research helps researchers identify a specific problem, diagnose it and suggest balanced solutions (Bryman, 2012). Fifth, grounded theory is based on patterns that are derived from both induction and deduction (Bryman & Bell, 2012). Sixth, ethnography is a behavioral research method in which observation is the key (Crotty, 1998). Last, archival research is based on a study conducted on available documents and information (Flick, 2011).

The research choice pertains to the way in which the researcher chooses to use either qualitative or quantitative or a combination of the two methods for research and data collection. Saunders et al. (2009), have described three research choices namely, mono method, mixed method and multi method. Mono method consists of using a single technique to collect and analyze data (quantitative or qualitative), multi method consists of using more than one data collection technique and analysis method, and mixed method consists of using both quantitative and qualitative methods either at the same time or in parallel. The next layer is the time horizon which decides whether the research is conducted as a constrained snapshot in time (cross-sectional) or over a duration of multiple snapshots (longitudinal) (Goddard & Melville, 2004). The final layer consist of the data collection methods such as analysis of secondary data, observations, interviews and questionnaires within the selected research strategy.

5.2 Chosen Methodology

In this thesis, the research methodology is based directly on the research question and Saunder's Onion model has been used to choose the different aspects of the research process as shown in the figure below.

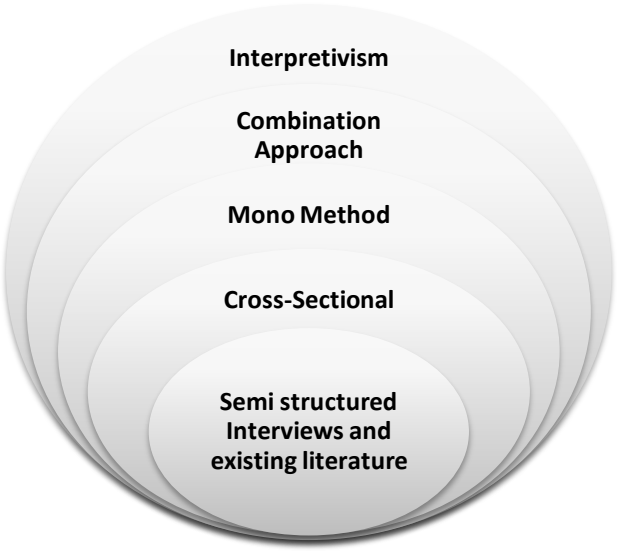

Figure 8. *Chosen Research Methodology.*

Starting from the outermost layer, the research philosophy was chosen as interpretivism. According to Bryman & Bell (2007), interpretivism is based on a naturalistic approach towards data collection using a number of different methods which are all based in interpretation of the meaning that researchers attach to their thoughts and actions. It assumes that that reality is only created based on an individuals perceptions and experiences (Robson, 2002). An interpretivist position was adopted in this research because it is considered that there are multiple perspectives on reality which make analysis impossible, therefore, in order to understand a phenomenon it needs to be evaluated within the context in which it occurs. A combination of deductive and inductive approach were used in succession. As the main goal of the thesis is to answer the questions already raised, a deductive approach was used in a broader sense. The potential of blockchain in creating a hypothetical unbundled higher education sector was already proposed and examined, thus, fitting in with the deductive approach. However, in the course of the research many new themes emerged inductively based on the data analysis. As none of the suggested strategies in the Saunder's model seemed clearly fit the chosen strategy, the research strategy cannot be clearly classified as one single method. Consequently, thematic analysis was adopted as the research strategy to interpret data collected from semi structured interviews. Thematic analysis facilitates the determination of the diverse aspects of relationships between different concepts and compare them to the existing as well as collected data (Namey et al., 2008). Since this is a qualitative study, mono method was chosen using a cross-sectional time horizon, due to the nature of the study.

5.3 Data Collection and Analysis

A literature review was conducted based on the existing literature regarding the topics involved to understand their foundation. Due to the relative lack of relevant literature

regarding the use of blockchain technology in higher education, especially related to unbundling, interviews were chosen as the main data collection method. The data was collected using first hand semi-structured interviews. Semi structured interviews were chosen as they offer a moderate amount of control over the conversation to the interviewer, thus, minimizing missed opportunities and at the same time ensuring that interviewees can express their thoughts and opinions spontaneously (Burgess, 1984; Berg, 2007).

It was a complex process to find experts due to the scarcity of live research projects being conducted in these specific domains. Interviewees were selected based on two methods: Firstly an internet search for people with expertise in at least one and/or both the domains (higher education and blockchain technology), second method was utilizing existing connections using the snowballing technique (Spreen, 1992; Hendricks, et al., 1992). Interviewees were divided into three categories based on their area of expertise.

Table 5. *Classification of interviews.*

Type of Interview	Number
Interviews pertaining to unbundling in higher education	7
Interview pertaining to blockchain technology	2
Interviews pertaining to both unbundling of higher education and blockchain	8

Semi structured in depth interviews were conducted either in person or over internet using tools such as Skype for Business. The length of the interviews was between 35 minutes to 70 minutes. The interviews were recorded, manually transcribed and iteratively analyzed to find commonalities. The themes emerging from the interviews were continuously refined over the course of the research. Interview questions varied depending on the interviewee, and were open, closed and probing to enhance the interview process. There were roughly three categories of questions; firstly the questions were specific to higher education, secondly, questions related to higher education and the use of blockchain technology for it and lastly, there were blockchain technology specific questions. A summary of the interview questions has been attached as appendix A.

The table below provides a description of interviewee demographics based on their location and organizational background. Geographical locations were specifically taken into account in order to understand the numerous implications of unbundling higher education and blockchain applications from a localized standpoint.

Table 6. *Interview demographics.*

S. No.	Organization	Type of Organization	Role	Location
1	HEI a	University of Applied Sciences	eLearning Specialist	Finland
2	HEI b	Distance Education University	Associate pro vice chancellor of technological innovation	Spain
3	HEI c	Polytechnic University	eLearning Expert and Project Manager	Italy
4	HEI d	The Association of Long Distance and eLearning	President	Lithuania
5	HEI e	Technical University	Director of Centre for Learning Innovation and Adult Learning	Hungary
6	HEI f	Technical University	Vice Dean for Education with the faculty of Business and Built Environment	Finland
7	HEI f	Technical University	University Teacher & Smart Campus Innovation Laboratory project manager	Finland
8	HEI f	Technical University	Project Researcher	Finland
9	HEI f	Technical University	Coordinator for Open University	Finland

10	Company a	Consultancy focused on knowledge innovation	Research And Development Associate	Scotland
11	Company a	Consultancy focused on knowledge innovation	Director	Malta
12	Company b	Blockchain Based start up	Founder & CEO	Slovenia
13	Company c	Non profit for development of open education and education technology	Chief Operating Officer	Slovenia
14	Professional Development Institute	Part of HEI f specializing in EMBA	Account Manager	Finland
15	Education Technology Forum	Nordic countries	Co-Founder	Estonia
16	Association for HEIs	European Level	Vice President	Germany
17	Multidisciplinary R&D Lab	Open University	Director	United Kingdom

As is clear from the table above, interviews were conducted with experts from different domains, work experience and geographical backgrounds in order to obtain a holistic dataset. Five of the interviewees were females and the rest were males. Keeping in mind the backgrounds of the interviewees, the age group range was between 30 and 55 years. Semi structured interviews were conducted with experts from the field of higher education as well as those involved in blockchain technology. The interview results were analyzed to study the level of understanding, perceptions and general approaches associated with unbundling of higher education and the role of blockchain technology in achieving the same.

The first step in the analysis was to identify recurring themes occurring throughout the interviews. The identified themes were then categorized to elaborate on the findings from the analysis of the data. In the next step, these themes were compared with the findings

from the literature review to be used as a basis for reasoning, argumentation, contemplation and conclusions. The results of this analysis, led to identification of several barriers with regard to the use of blockchain technology in the higher education sector. Finally, the conclusion draws upon the outcomes of the discussion to establish the results of the entire research process. The proceeding section discusses the results of the research process in detail.

6. RESEARCH RESULTS

As stated previously in the chosen research strategy for this thesis, semi structured interviews were conducted with a setoff interviewees carefully chosen based on their professional background and area of expertise. Experts were chosen from the field of higher education as well as from those involved with blockchain technology. The interviews were iteratively analyzed to recognize recurring themes which are analyzed in this section. From the semi structured interviews, four common themes emerged:

Theme 1: *Noticeable problems plaguing higher education*

Theme 2: *Unbundling higher education as a solution*

Theme 3: *If unbundling is the goal, blockchain could be the key*

Theme 4: *Skepticism about blockchain technology*

6.1 Theme 1: Noticeable problems plaguing higher education

Some of the major problems that have been pointed out through the interviews have been found out to be as follows:

1. Current HE institutions are not making most of technology
2. There is not enough provision for lifelong learning
3. Disconnect between learning and requirements of the labour market
4. HE is slow to evolve and follows one size fits all model
5. Flawed governance model and incentive systems
6. Some other genuine problems not classified in the above categories

Firstly, there has been a consensus among the interviewees that although we are in the golden age of technology now, to the point that it is almost inescapable in everyday life, higher education institutions have not embraced technology to the same extent. Consequently, there is a huge scope for technology adoption in order to create a better learning environment for students. One of the interviewees, Director at a multidisciplinary R&D Lab has stated the following regarding the lack of essential technology in current educational environments

"If you look at the tech industry and big tech companies such as Facebook, Google, Spotify, Uber, EBay, Amazon etc. and if you think about the applications you can get on your smartphones, they are a long long way ahead of most things you see in education.

Too often, universities hold on to practices that are 100 of years old. So we are not making the most of technologies out there which could improve the life of a university student"

The COO at Company c (Non profit for development of open education and education technology) expressed a similar opinion when it comes to the lack of innovation in educational technology as compared to other industries.

"Universities have not been able to innovate to the same extent as the rest of the industry. There are very few technology based innovations that could make a student's life easier. To get access to some of that students have to go either online to basically US based companies or simply bear with the Moodle installations which are anything but optimal"

One interviewee who serves as the Vice president of a European level association of HEIs has emphasized upon the need for higher education institutions to figure out how their future is linked to developing an understanding of the digital society.

"The model we have right now for HE is the same we had specially created to solve the needs of industrialization. Industrialized societies needed pretty much standard workers for standard jobs. Now we are moving into a new society and we have not yet understood what this society will really look like. We know it will be largely defined by digital processes and digital communication but we have not understood yet how to deal with these overflowing possibilities of communication"

The same sentiments have been echoed by a research and development associate at company a, which is a consultancy focused on knowledge innovation, who has also pointed out the lack of agility in the current universities when it comes to keeping up with the world of technology.

"Universities in their current structures are not agile enough. They are absolutely not in pace with the technological advancements. Technological research is progressing so fast that educators cannot incorporate new developments into curricula fast enough"

The second problem identified is that in the current higher education model there is no clear provision to account for lifelong learning. This has been reverberated in the theoretical background by researchers equivocally regarding their views about increasing the possibility of student mobility. One interviewee, who manages an EMBA program for working adults at HEI f has shed some light on the need to acknowledge learning that happens outside the context of a traditional classroom.

"A basic university degree is not enough for your life time. We see more need for lifelong learning and different kinds of solutions to provide for that. Mainly because learning does not just happen in a classroom, it keeps happening everywhere, but what we don't have right now is a system that gives us credit for the learning we do everywhere, not just in a classroom, in a university"

The co-founder of an education technology forum for Nordic countries has also pointed out the obvious limitation of the number of professional degrees that one person can possibly obtain.

"Lifelong learning needs to be embraced. How many master's degrees can one person possibly get? Seems like a waste of public money as well as time and resources. Everyone has a certain bucket of learning energy and you can only fill it to a particular extent. Learning activities are not being accounted for today"

In one interviewee's opinion who serves as the President of HEI d, which is the association of long distance and e learning, a digital society has a new kind of learner that needs flexible learning options and universities need to fulfil such needs.

"Traditional universities still prefer face to face modes of learning. They want students to come to the class and learn in a traditional set up. A lot of learners are working and need more flexibility. They would prefer personalized learning. The traditional good practices are great and have worked so far but are not in sync with the requirement of the students in a digital society"

Director at the R&D lab in UK has observed that the existing learning model in a traditional university lacks the capability to recognize the learning that happens once a student leaves the university, which leaves students underprepared for their move to a professional environment.

"We have a model which is still based around the fact that historically, learners would learn for a fixed amount of time, once they are lets say 22, they do not formally need to learn ever again and will be employed in some factory and do the same repetitive tasks forever. We still have not seriously considered what it means to learn for life and how that means that people in the future will be transitioning between learning and working in a seamless fashion"

Third challenge has been identified as a massive disconnect between university learning and the needs of the labour market. As has been stated earlier, the requirements of the industry today are much different and are changing continuously all the time. Many major companies have already expressed their desire for an employee with a demonstrable competence instead of an employee with just a degree. Two of the interviewees, have respectively expressed the lack of preparedness of universities to deal with this situation.

According to the COO at organization c (Non profit for development of open education and education technology), *"The discrepancy between the dynamics of the university and marketplace is another huge problem. There is a very weak connection in most places; there are always exceptions of course. Even then, it is limited to localized environments. The skills that job markets need are not provided for well enough"*

According to the Vice dean of education at HEI f, *"The emphasis should be towards quick responses for industrial demands and hence fulfil the lack of competent workers. There is the question that to what extent can we fulfil that with our traditional degree programmes due to a lack of flexible learning pathways and slow speed of response"*

An eLearning expert in HEI a and the Vice chancellor of technological innovation at HEI b have respectively highlighted the need to modify existing university curriculum to make way for the experts of the future that fulfil the needs of the society and businesses in a more meaningful way. It is further suggested that the kind of jobs that students need to be prepared for in the upcoming future.

"Hybrid experts in the future are required with a very wide skill set including a focus on soft skills and adaptability. Universities need to keep up with the working life requirements"

"The problem is that we are training students to achieve certain academic degrees which have been designed a while ago and these degrees do not necessarily translate to the realities of practical life. What the industry and real world wants is usually very different. There will be only 2 jobs that will exist in the future 1. Jobs that robots cannot do well 2. Jobs that artificial intelligence cannot do very well. So if you think about this kind of labour market and retrace your step backwards, you can see what kind of education is needed to prepare people for that world. The more sophisticated these technologies get, the more our needs for education and qualifications will change as compared to what they are now"

Vice president of a European level association of HEIs, has identified the disconnect between learning and the needs of the labour industry as one of the driving factors for change in the existing universities with a highly relevant example of an event similar to Brexit.

"The labour market and the changing need for work are major drivers. For e.g. if you live in a society where one day something like Brexit happens, that will change your life a lot in the coming 5 years. These are societal issues as well and not just labour market issues. The knowledge being developed at universities does not teach students to deal with uncertainties of such kind with which we are very surrounded right now"

The next challenge that has been highlighted is the speed of evolution of higher education institutions and there lack of flexibility and adaptability according to student needs. The competence based education model points towards the need for personalized learning. The one size fits all model has already been rejected by educational experts and researchers alike. Director at company a (consultancy focused on knowledge innovation) has raised a valid point regarding the failure of universities to innovate from their original Ford-era models to a modern flexible model that benefits the students of today.

"If you look at our education system, it was built for a different era, it was built for the era of industrialization where the purpose of education was to produce people for the industrial society which means that effectively what you wanted was to educate a large number of people in a very Ford-ist model in the same way. In the meantime we have now been seeing the economy and society evolve towards a much more personalized and flexible type of jobs while education is still doing what it was designed to do very well which is essentially mass production of graduates. What it's not doing very well is personalizing learning and enabling true flexible learning pathways for students"

Two other interviewees have similarly echoed their views on the importance of flexible learning models that are personalized in nature and offer recognition mechanisms for students meanwhile, keeping in mind the different learning pathways that might be suited to specific learners.

According to the eLearning specialist at HEI a, *"The popularity of something like badges and MOOCs is a clear indication that students need means of learning that are well suited and personalized to their needs"*

According to an account manager at a professional development institute, *"It is important to understand that people learn in different ways. Also if you are working, you're going to learn and you have to learn, but personal learning methods are important to understand. Some people are going to take a huge leap while some will learn gradually. I think it's also important to understand, motivation behind learning and in some cases the personality of the learner itself. We need to cater to these needs"*

While one interviewee who is an eLearning expert at HEI c has drawn attention to the internal resistance that universities face from within towards changes, another interviewee, who is the associate pro vice chancellor of technological innovation at HEI b, has pointed out that the ability to adopt newer learning models such as blended learning have made it rather easy to keep up with the continuously evolving curriculum needs.

"In an Italian context, I can say that whenever we want to implement something that is related with innovation, not necessarily online, not necessarily technology, we still have some sort of reluctance from many teachers, they still teach the way they always did in their career and so forth. Although the situation is slowly changing"

"The teaching and learning models are very old especially in the traditional face to face universities. In our university, we conduct Blended learning, a lot of it is online so it is very easy to update the learning material, students take a more proactive role and we can use data analytics to see where people are finding it a tad bit difficult. But when you enter face to face mode, it is still very old fashioned"

The next challenge that was pointed out by some of the interviewees was the existence of flawed governance models and incentive systems in higher education institutions. As

pointed out in Figure 6, governance models need to evolve in the interests of students. Director at company a (consultancy focused on knowledge innovation) has raised a legitimate concern regarding the incentive models as well as evaluation models that drive the universities in general.

"From a higher education management perspective, depending on the country, a university in public sector might get incentives based only on the number of students they enroll. You might think of a very basic evaluation model such as Kirkpatrick, most universities don't actually do the bottom level of that. So I mean you are not actually seeing the proper social impact assessment of what they do"

"There is a huge case to make when arguing about the indicators for teaching excellence. If you are an excellent teacher but an average researcher you will not progress in an institution even if you are the top rated teacher that there is, at least in most places in Europe. This is a good system for producing researchers but it is also a holdover from the time when universities' higher level of academia meant you were going to become a researcher. In today's era of degree inflation, where master's degree is nearly table stakes to an entry level job, these types of indicators start to seem a little outdated"

Research and development associate at company a (consultancy focused on knowledge innovation) has also pointed out the failure of similar incentive models in fulfilling the personal development needs of an educator.

"In the current model teachers have a lot of burden on them. For e.g. they have to do a lot of research in order to get more funding for the university and themselves. Besides that, they have to divide time with teaching activities and other personnel work. There are only so many hours in a day so there is hardly any time for personal development"

Vice dean for education at HEI f has stated that there is a need to re-recognize student as the customer when it comes to higher education. The limitations imposed on universities when it comes to their ability to innovate also arises from the fact that they are usually evaluated and funded based on the number of graduates produced by organizations such as ministries who are less in touch with the ground reality as opposed to the universities themselves.

"In the current system the customer is not the student but it is the ministry of education because they have the money and hence, have control. The laws from ministry of education forbid some changes that universities would themselves like to implement. They only want degrees from us therefore, we can only experiment and innovate to a limited extent. Therefore, there is a hope that ministries should reconsider some of these rules"

ELearning specialist at HEI c has highlighted the need of less hierarchy in the university structure in order to adapt at a faster pace.

"What needs to be changed is the structure of a university which is most commonly now like a political structure. So we have rectors, we have counselors and so on, we have a very structured, system of decision making and nowadays the labor market and needs of the society is changing very, very quickly, so universities have to respond to this kind of changes with the same speed which seems hard in this hierarchy"

The coordinator for Open University at HEI f has also blamed the traditional university structure that prevents resource utilization towards more innovative ways of learning.

"There is a clear lack of resources and infrastructure in the current university system to manage more flexible ways of learning, although the demand for such a model of education is high among students. For e.g. TTY (Tampere University of Technology) for now has only 2 people managing open education"

Lastly, some light was shed on other relevant problems that also need to be handled in the context of higher education. The increasing costs of education in most countries of the world has been a major concern. According to the eLearning specialist at HEI c, *"I know that in UK and some other countries, studying is very expensive. This has to change because education is a basic human right and should be affordable".*

The lack of a smart system to verify and accredit skills has been identified by some interviewees as below.

Project Researcher at HEI f*: "The problem is when you get out of the university all you have is a piece of paper which is your degree and you cannot communicate your skills in a reliable way. You can put them on LinkedIn or in a CV, but there is no trust in that because it is self –reported"*

Vice Dean for education at HEI f*: "Verifying credentials of foreign students is something that we face a lot of challenges with especially from universities without ECTS"*

Associate pro vice chancellor of technological innovation at HEI b, pointed out some logistical errors that may occur locally in institutions due to an inherent resistance to change, *"Some teachers actually might be really keen to change how things are done but the process of change itself might be difficult to begin with. The process might take a lot of time in setting up, which the average teacher does not have. There are institutional barriers. There might be teachers/professors in the same university who do not wish to be innovative and like things as they are"*

6.2 Theme 2: Unbundling higher education as a solution

This theme emerged from discussions related to the advantages and disadvantages of unbundling of aspects of higher education. While most interviewees were favorable towards unbundling, they raised some valid concerns as to how institutions can and should go

about implementing such changes. They pointed out some reasonable considerations that must be paid attention to. Their views can be categorized into two; firstly the views in support of unbundling and secondly, how unbundling should happen.

1. Views in support of unbundling higher education

To cater for lifelong learning

Interviewees pointed out that an unbundled education could cater to the needs of lifelong learning. If learners are provided the opportunity to engage in signing up for modular elements of learning, it would be beneficial for them on many levels. The goal is to create an ecosystem which enables students to learn in a granular way based on their needs of time, space and methodology.

According to the associate pro vice chancellor of technological innovation at HEI b, *"Today one has to think about constantly upgrading and retraining. But not everybody can do that. When you start working, life happens. You have life to focus on and it is almost impossible to put your life on hold and go for a 2 years master's degree. There should be the option of lifelong learning so someone can easily upgrade. That's the value of unbundling"*

Similar sentiments are echoed by other interviewees in the following statements respectively,

Co-founder of an education technology forum for Nordic countries: *"People are constantly learning today and they need to, there is no other choice. But getting a full time degree should not be the only place to get an acknowledgement for learning. Lifelong learning needs to be embraced and accounted for. In the future there will be other options such as those to the effect of artificial learning simulations, universities need to provide for student needs better to keep up with the global virtual classrooms of the future"*

Vice President of a European level association of HEIs: *"Two mega trends are driving the unbundling, first is the need of society to account for lifelong learning and second is the technological means available to do that"*

To provide student-centric flexible means of learning

Many interviewees stated that unbundling education could possibly enable student-centric learning which is flexible and adaptable in nature. Higher education needs to respond to their main target which happens to be students, in a more proactive way than is currently done.

According to the director at company a (consultancy focused on knowledge innovation) who remarks on the presented analogy of the Netflix model of business, *"In the Netflix scenario, at any point if I want to watch my video, I can buy it from Netflix, I can watch*

it from broadcast television, I can buy it and download it on DVD. Here we are talking about the same unit of video but now I have many different ways to conceive it based on what is good for me. Unbundled learning means the same thing for me. You move away from accepting a ready-made package of studies from a university to a world where you build your own packages from different institutions"

He goes on to further define the benefits of a modular education drawing on his own experience as a young student activist vying for student rights and points out he immense pressure to perform and make the right choices that is put on an average student today, "*In an unbundled world, students don't have to know at 18 years of age, exactly what they want to do with the rest of their life or be forced to take a blind guess and then follow a program for 4 years. It means that they can try a little bit of this and a little bit of that and have a meaningful journey to figure out what they actually have aptitude for and then build up their education experience by themselves. I believe that in our current system we actually put too much responsibility on students. They are 18 and have spent one day in a working environment, and are supposed to choose a 4/5 year course that is supposed to take them directly to a workplace and we assume that a three hour guidance session is enough for them to make that choice".*

The research and development associate at company a (consultancy focused on knowledge innovation) highlights the importance of self-paced learning which will be easily afforded to students in an unbundled world. She also makes an analogy with her own educational experience, stating that an unbundled education can offer students an opportunity when it comes to following a career pathway that is not imposed on them.

"If you have self-paced learning available you don't have to wait half an year to retake a course in case you didn't like the one you initially started with. When I was at university many years ago, if I made the wrong choice I had to wait a whole year to retake it. If I took the wrong programme to begin with, then the choice to rethink would almost disappear because of the investment already made into my studies. That won't apply if an unbundled world. So I think if any student is given a choice for more unbundled education, students will take it happily to follow their wished career"

According to the project researcher at HEI f, in an unbundled scenario, students could have the chance to collect credentials in parts for the study modules they complete and that could provide them the much needed flexibility in their private life and career paths.

"It would be very beneficial for students would to know that even if they quit their degree programme at some point for some unforeseeable reasons, they would have already collected at least a certain number of skills that they can use for employment activities. It would also be a positive feedback loop similar to collecting achievements in an Xbox. The world of learning is so abstract so it would make a lot of sense to visualize everything for

students. For e.g. a student could see that they have software skills but may be they need some project management skills and that could open up new avenues for them."

To provide for the disadvantaged

Some interviewees pointed out to the far reaching socio-political aspects involving higher education and were able to shed some light on how a modular educational offer could advantage those who need it the most.

According to the associate pro vice chancellor of technological innovation at HEI b, *"We usually talk about a European middle class background, where you graduate high school, go to university and get a job. But majority of students in the world do not fit into that bracket. Talking about people who do not have these opportunities. For them the idea of pursuing a full time educational degree might just be impossible. So the idea of breaking down a qualification into modules, some of which might even be free actually is very useful for them. Imagine the opportunity. How many better skilled people we can create. Once their blindfold is removed they might realize that it is not that big of a deal as they thought it was and there are more possibilities"*

Project researcher at HEI f also pointed out to the benefits of unbundling for those who are outside the context of a traditional university setup.

"The present systems are okay, but what happens when you leave a university. You essentially carry a piece of paper with you as a proof of your credentials. Then there are extreme cases also such as those of displaced populations in Syria. Unbundling education securely could do wonders for lifelong learning for them and everyone else"

To give universities a way to attract new students

The associate pro vice chancellor of technological innovation at HEI b emphasized upon a unique benefit of unbundling which could create value for newer educational institutions trying to attract new students.

"For newer educational institutions it might be hard to get new students so by offering students an option to access flexible pathways might be a good way to attract students"

2. Views about how unbundling should happen

Interviewees were asked about their opinions on how an unbundled higher education sector would look like and what kind of considerations should be taken into account in future. Most opinions were careful evaluations of the benefits and limitations of such a system. While some interviewees made some reasonable assumptions about the technological future, some others were more guarded in their views. A holistic approach emerged that highlighted the need for additional support that would be needed to implement the said system. Some interviewees raised their support for a hybrid mixture where universities

are not completely unbundled but maintain a careful mix of traditional aspects while unbundling, some aspects. When it comes to unbundling the curriculum, they suggested the need to keep the fundamental knowledge which leads to fundamental skills such as reasoning intact.

The associate pro vice chancellor of technological innovation at HEI b: *"Universities of course try to maintain tighter control over what they are offering in order to keep the quality in check. I would advocate for a hybrid mixture where universities are unbundled but to an extent. You need to have some structure there. The process of making everything fit together should make sense. Each specific knowledge area should have certain core subjects, which are fundamental for it"*

Vice dean for education at HEI f: *"Foundational knowledge is necessary. It helps students to obtain a skill set that they may be able to apply in practical matters. Many people hate Mathematics, but when they do it they learn a certain way of thinking and analytical skills. Choices may manifest their effects in long term, which might not be visible at present. Unbundling can be done for sure but the question is to what extent. Competences are built gradually in bits and pieces but we need to have a starting point and a bigger picture always. Without that it wouldn't make sense. Students would require a lot of extra guidance and study advisory support in an unbundled model of education. It would also require a lot of work from teachers and administration, which means increased costs. I do think it will not replace the current way of studying but it will complement it"*

Meanwhile the importance of extra guidance to help students navigate a largely unbundled curriculum has been pointed out in many interviews. Students would need support functions in the form of mentorship and career counselling to guide them through the process in order to keep them in touch with the big picture when it comes to their educational pathways. The vice president of the association for EU HEIs has hinted towards the emergence of new roles such as that of a 'co-curator' whose purpose would be to direct students in finding the pathways that fit their needs and interests in a balanced way. ELearning specialist at HEI c has also pointed out the same need of extra guidance for students to prevent them from taking decisions that might cost them later in life.

"At the end of the day there is a limit to the granularity question. Extreme of anything will be bad. What will be needed would be is this function from the world of art, which we call 'co-curation'. The function of a curator will be very important and will be needed to orient and guide students in their efforts of studying in a modularized ecosystem so that they can bring these modules together in larger sense-making experience. This guided experience is very necessary"

"A completely unbundled world does not make much sense to me, there needs to be a balance between traditional university degrees and smaller chunks of study modules. But I do see the value in it. Although we need to analyze all the associated risks beforehand

because there is not much scope of error. The bundled packages of universities currently may offer courses that may not make sense to students at the time but at some point in their life, they might end up using it in a completely different context. With a lot of choices, students may feel disoriented and we need to have ways to provide them with guidance needed"

Director of Centre for Learning Innovation and Adult Learning at HEI e has stated that an unbundled education fits the needs of universities that specialize in liberal arts better than technical universities.

"Traditional theoretical degrees will always exist as they are the foundational knowledge that engineers need. However, in liberal arts there is more chance of experimentation. Unbundling has to be balanced for students and universities"

Two interviewees have shared their ideas on what an ideal unbundled world of higher education would like in future.

Director at company a (consultancy focused on knowledge innovation): *"Firstly, there is no perfect unbundled future and there will always be some issues. One scenario for an unbundled higher education could be something like this. There might be just six education providers in the world. Hypothetically, you might have Apple University, Coursera, EdX and probably something run by Pearson. Each one would have a closed platform and would commission the learning by themselves and that would be it. Even if they offer students an infinite choice, the truth is that each platform will have its own way of doing things and very quickly will lock students into a certain way of thinking. So we need to be careful about that. In a true unbundled future one can say, I need to learn this and these are my times and these are my availabilities and these are my purposes and then there exist enough variety of providers out there that can cater to that particular need from beginning to end"*

Director at the multi-disciplinary R&D lab in UK: *"I see a real link between learning that is happening and career paths. People would curate their own learning paths and be able to take part in study module selection from several different institutions. They would also be able to select online teachers, they would be able to look at a set of tutors and look at their ratings and teaching methods (somebody might be teaching face to face and somebody might be teaching online) and after each engagement there would be a mutual rating programme. I think what we teach will be very different. So less emphasis in general on text books and more emphasis on creativity, empathy, communication, collaboration will follow"*

COO at company c (Non profit for development of open education and education technology) has emphasized on the need to maintain quality considerations when it comes to unbundling education. The same interviewee along with the research and development

associate at company a (consultancy focused on knowledge innovation) have also hypothesized a future educational ecosystem that build on the strength of learning analytics and machine learning.

"Even if HE is unbundled, the important thing is that it has to be robust. Unbundled does not mean weak, it just means re-structured. But again, in a smart way. Quality concerns should always be there for obvious reasons like keeping us from degrading. In addition, students need to be informed properly why they are mixing up certain educational modules; they need someone to advise them. We can create an ecosystem where it is possible to suggest potential next choices for studying based on their existing skill set so they can be on their way to the optimum career paths. This will be supplemented by a combination of machine and man. In an 'educational Netflix', machine learning will definitely play a huge role".

"If it is granular enough and it is well explained then it may be made to happen. If students for some reason abandon their learning programme, they can take what they have accumulated as credential and move to some place else, they may not be able to use everything they learned. If there is a way that allows them to keep at least some parts of the knowledge they previously earned in the form of credentials, then it's a great idea. Mentorship will be a key from the institutions"

Thus, it can be concluded that unbundling has to be done in a balanced way keeping in mind the interests of all stakeholders involved-, teacher, students as well as universities. From the interviews, a clear need for a balance between the traditional university elements and new modular elements is clearly evident. The eventual materialization of such an ecosystem would require changes in the way education is imparted today especially, when it comes to teaching methods. It will also largely depend on advancements in emerging technologies such as machine learning, blockchain technology and artificial intelligence among other.

6.3 Theme 3: If Unbundling is the goal, Blockchain could be the key

One of the key aspects of unbundling education is to reinvent the student experience and one strategy to achieve that is via an unbundled curricula. Curriculum is made up of courses and finishing a pre-defined number of courses helps us attain credentials. Credentials are a currency and have been ever since formal education started. The reasons for that derived from figure 6 are:

- Credentials helps students get jobs by recognition of their prior learning
- Credentials make student mobility happen

- Credentials are the only way to acknowledge for lifelong learning

Before we entered the digital age, the only way to store this currency was on a physical piece of paper, very similar to financial currency. Just like financial currency, credentials have different values depending upon its origin. We were able to solve the issues that arose from non-equivalency in financial currency by coming up with common standards that were global in nature. With occasional fluctuations, we are mostly aware about the value of a financial currency with respect to other financial currencies, practically speaking, we know that 1 USD (United States Dollar) is equivalent to 0.87 EUR (Euro) at this moment. This kind of a system made international trade very convenient and fair (with very few exceptions of hostile governments misusing their currencies). However, we still do not have a similar global standard when it comes to the educational currency, also known as credentials. There are a few reasons why we do not yet have a consensus on the value of a credential. Most of them have to do with the non-fungible nature of credentials.

- Credentials are not interchangeable because they are awarded using variable methods based on the issuing authority. For instance, Oxford University has a very different self-defined criteria for offering a credential as compared to New York University, even for similar courses.
- The universities offering credentials may or may not assign the same value to the credentials obtained in a different university based on their personal understanding or the lack thereof.

So the question remains that in spite of the many benefits of the modern technologies, why do we still lack a common equivalency based system for the educational currency which in many ways, defines our lives and careers. As the director at company a (Consultancy focused on knowledge innovation) puts it,

"Today I can find every information down to the very last detail about a hotel in rural Gambia, but I cannot find even basic information about credentials online, let alone trade them online. The people standing behind credentials are universities, evidently some of the most intelligent bodies on the planet. So, there is definitely something wrong here"

European Union has been leading the way in reaching an agreement over both the financial currency as well as the educational currency in the form of credentials. 19 of the 28 countries in the EU also known as the Eurozone use the same currency. Similarly, countries also have a common credential system known as ECTS (European Credit Transfer System), which defines a standard value for a credential (1 ECTS is equal to between 25-30 hours of workload). So essentially these countries came to a common conclusion regarding the volume of learning based on the defined learning outcomes and their associated workload that could make up a credential. While it was a very well thought of idea, as has been discussed before it is not easy to quantify education, not on a collective basis, and definitely not on a global scale. Even with ECTS it is hardly possible to verify the

true workload that the stakeholders involved have put into achieving them. Different continents, countries, cities and universities are a lot of layers to permeate through to achieve uniformity similar to financial currencies. Apart from ECTS, there have also been other attempts to come to a common standpoint. According to the director at company a (Consultancy focused on knowledge innovation),

"We have produced a barrage of tools, ECTS, diploma supplement, qualification frameworks, 3 cycle systems, multi lingual translation databases etc. From the policy regulation side we have thrown everything at it. But all of that is still based around the idea that we will trust your institution but not completely. Everybody wants to keep autonomy over their institution, where institutions collaborate with other institutions but do not fully trust them. A centralized database requires full trust"

In this battle of trust between universities, students followed by teachers are the biggest losers. As pointed out by COO at company c (Non profit for development of open education and education technology),

"Students go to local universities mostly because moving abroad is expensive. Universities hold that power. However, if all the knowledge and high quality content is made available online in a trust worthy ecosystem, that power will die. So it might be beneficial for universities to try to keep up and say yes to innovation"

When the question of trust between universities arises, blockchain technology holds some answers. Blockchain could provide a system of governance that is based on decentralized trust. In the paper based credential world, we are naturally working in a very decentralized ecosystem already. There is no central educational network that makes decisions on defining and storing credentials, research or content. Almost everything is agreed upon by consensus among the educational community. The way that consensus is achieved is interesting to note, because usually it is based on personal relationships.

According to director at company a (Consultancy focused on knowledge innovation), *"The whole concept of academic freedom is predicated on the idea that there should be no single central source of truth for these things. Blockchain is a technology that is basically built with these principles inside the technology itself. So instead of saying we have a fully decentralized human network but we are going to need a centralized computer network, we can actually have a computer network that can reflect the reality of how our education system actually works"*

Similar sentiments are echoed by founder & CEO at company b (Blockchain based start-up) in more practical terms while defining the need for a blockchain based credential system using non fungible tokens which are in alignment with the non-fungible nature of credentials themselves.

"If you have a house you usually cannot split it into half, similarly, in our physical wallet, we have money which is fungible and then other things such as our credit cards, driver license etc. that are non-fungible. With non-fungible tokens we are just upgrading the system to something we know already occurs in the real world"

The characteristics of blockchain make way for a possibility to build a digital credential storage and verification system that universities can trust unanimously. Once that trust network is created it will be technically possible for learners to use their credentials as a valid currency anywhere in the world by making it possible for universities to verify their authenticity. The universities may still not place the same kind of value on credentials obtained from outside their own university but they would nevertheless, be able to verify them securely over the blockchain network that they are a part of. At the same time the issue of linking the digital credentials to their rightful owner remains. Blockchain seems to have a potential solution to the issue of digital identities as well. The concept of digital wallets has been made popular with Blockcerts. A digital identity wallet owned by a student which is encrypted via the public key infrastructure possible in a blockchain could serve as an immutable record of a learner's academic credentials across multiple institutions as well as those earned outside an institution. Thus, enabling learners to build a portfolio of traditional and stackable credentials.

Once the curriculum is unbundled, it will make way for unbundling other aspects of higher education as defined in figure 6.

According to project researcher at HEI f, "*You can build automated algorithms in the blockchain via smart contracts. This will remove a massive amount of administrative overhead from universities"*

According to the director at the multidisciplinary R&D lab in UK, *"Blockchain could cause dramatic lowering of process costs for things like issuing certificates, verifying certificates. It is a very resource and time intensive process. I have heard employers complain that they waited so long for someone's credentials to be verified that they actually hired the person before the process ended"*

Thus it can be pointed out that,

- If students are able to obtain content resulting in credentials in a trust based ecosystem from different sources, faculty can move their focus from classroom lectures to creation of high quality online content which is up to date and shift to the para academic roles.
- Self-executing smart contracts could take over most of the administrative work from a university and bring down the overhead costs

- Easily verifiable credentials could also reduce cost burden and create a seamless process not just for the universities but also for students and their future employers.

6.4 Theme 4: Skepticism about Blockchain Technology

The interviews provided some insight into the understanding of blockchain technology not just among experts but also among people from the higher education industry. While there was a strong interest in blockchain technology and its applications, it was evident that there was also a valid amount of concern and skepticism.

Most of the skepticism arose regarding the technological pitfalls of blockchain and its actual capability to be able to do what it claims to do.

According to the director of Centre for Learning Innovation and Adult Learning at HEI e,

"Blockchain can be used for unbundling but it requires a lot of computational power and environmental costs of that are high. But I think that problem will be solved once everyone uses it, because of economies of scale. But the implementation must come from public bodies otherwise it is of not much use"

There were also some concerns raised regarding elements of blockchain such as the incredible delicateness of the public private key, their loss could mean losing your data forever and the inability to modify data at all.

According to project researcher at HEI f,

"There is a need of some kind of fail safe. Some way to facilitate this error correction and recovery systems. We still need to put some kind of trust in the universities that they will do the right thing. Same problem with the public private key"

Some interviewees pointed out that the issues surrounding blockchain are not technological in nature but rather those related to lack of awareness as well as a lack of policy frameworks to support it.

According to the COO at company c (Non profit for development of open education and education technology),

"Blockchain as a technology is plastic and robust enough to adopt it quickly without any major technical or infrastructure expenses. But it will not work without a policy framework surrounding it. So the actual technological solution is very trivial, but for it to succeed there has to be a strong policy work around it that universities can identify with"

According to the director at the multidisciplinary R&D lab in UK,

"You have to be very careful when explaining blockchain to people in the education sector. Blockchain is only valid if you have a highly decentralized wok and if you explain that then people understand"

According to the director at company a (Consultancy focused on knowledge innovation),

"I often get asked how blockchain will improve education. To answer that question, we are talking about the administration of education here and not about learning or pedagogy. I was surprised just how rigid the disconnect between academia and administration is. In academia their job is to teach and research but for administration, their job is to support those activities and because blockchain offers solutions to the logistics of learning more than the technique of learning therefore, the academics are not very interested in what happens in administration. This lack of awareness is causing them to miss the big picture"

Some interviewees highlighted the need for scalability and mass adoption.

According to the CEO and founder of company b (Blockchain based start-up),

"Technologically speaking, the barriers can be completely removed via blockchain, but to be honest most barriers are social and regulatory in nature. Those are the issues that we need to deal with first. Studying in Harvard and studying in a very good university in Slovenia might both produce successful and smart people but the graduate from Harvard will always be perceived to be smarter. This is a fault in our system. Innovations need to happen on many levels. Technology is just a very small aspect of it"

According to the COO at company c (Non profit for development of open education and education technology)

"We need enough players to create trust. We also need to find a way to create some tangible leverage for universities in order for them to be a part of this network"

A conflict between principles governing blockchain and the new GDPR (General Data Protection Regulation) laws was also a common narrative.

According to the COO at company c (Non profit for development of open education and education technology),

"GDPR is obviously good. There is a data privacy problem when it comes to blockchain itself. The data is codified but traceable. But then again we are talking about hacks. I dont know if that is plausible. Universities everywhere lose data all the time, it just does not make the news. Facebook is in the news or some other big companies but when Moodle is down and you cannot access it at your university, nobody asks questions. It is a problem that we

cannot really solve. It is up to the big guns and the court of law. We are in a position to influence the education landscape and policy makers but it is definitely a huge problem that can end it al"

According to the director at company a (Consultancy focused on knowledge innovation),

"As soon as you start storing personal information, data privacy problems arise. Honestly, the only way it will ever be resolved is when it ends up in court. . At some point, these issues will be legislatively solved"

Finally, there were also some concerns regarding the immense hype surrounding block-chain technology which might lead to creating unachievable expectations.

As pointed out by eLearning specialist at HEI c,

"Blockchain has almost started sounding like a religion, now I am starting to believe in block chain and just praying that it will work"

As the director of Centre for Learning Innovation and Adult Learning at HEI e points out,

"Like any new technology. Blockchain is very hyped up. May be that is justified, may be it is not. Only time will tell. For e.g. we use credit cards in spite of the risks associated with them. Technology matures all the time and so do the political factors surrounding it"

Overall, the data analysis on one hand points out towards some uncertainty and skepticism towards blockchain technology in general, on the other hand there are also positive expectations attached to it which might enable development of the technology and its applications in future. The skepticism is based partly in well-founded concerns and partly in lack of awareness about the technology. These topics will be explored in the next section.

7. DISCUSSION AND CONSIDERATIONS

This section is an amalgam of all the research undertaken in this thesis based on the literature review and data analysis. The first sub section will summarize the results of the research process where the main conclusions are explained. The second sub section explains the social value proposition of blockchain technology in a general context as well as with reference to higher education. The third sub section delves deeper into the issue of the adoption of blockchain in the context of unbundling higher education and provides final recommendations. Following the first three main subsections, the proceeding sub sections will review the practical as well as theoretical relevance and implications of this thesis, the limitations encountered in the research process and suggestions for future research areas respectively.

7.1 Summary of Research Results

The goal of this section is to interpret, discuss and elaborate the research results. The four themes identified from the interviews were found to be consistent with the literature study and have been added in the figure below. The figure depicts in which area each theme fits best.

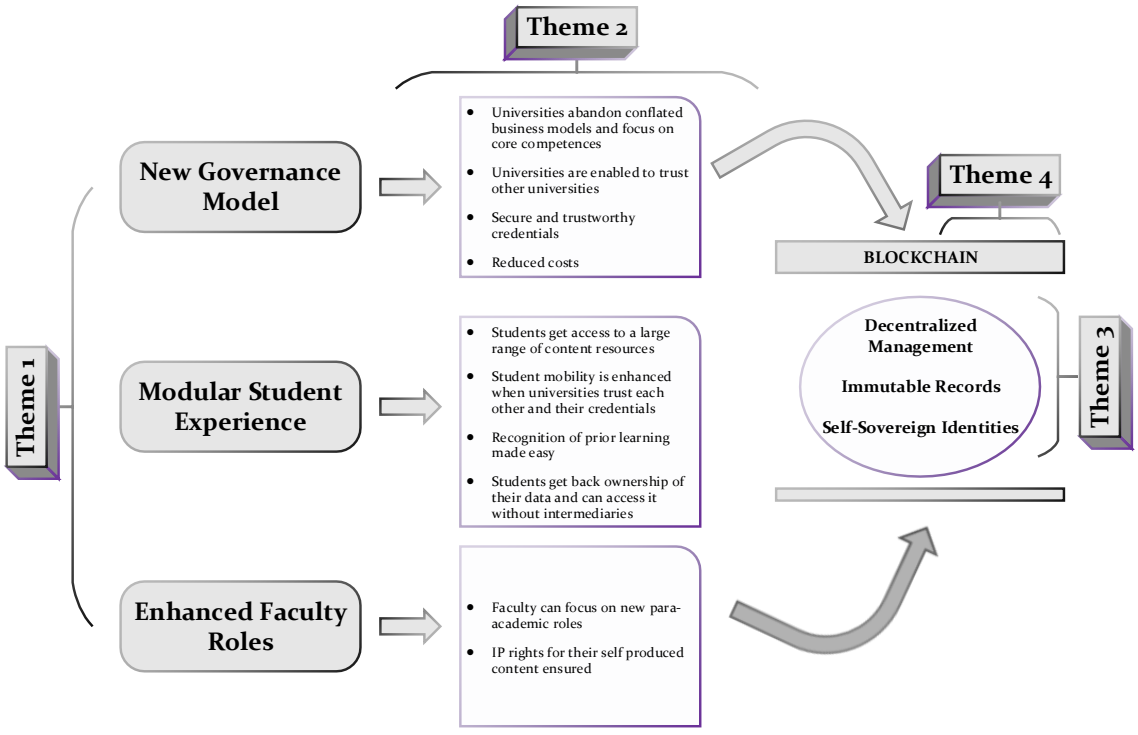

Figure 9. *Summary of research results.*

The first identified theme states that there are some noticeable problems in the field of higher education. This assertion, which was obtained from the interviews, corresponds to the change drivers for unbundling that were identified in section 2.1. The figure below sums up the direct relationship between the findings.

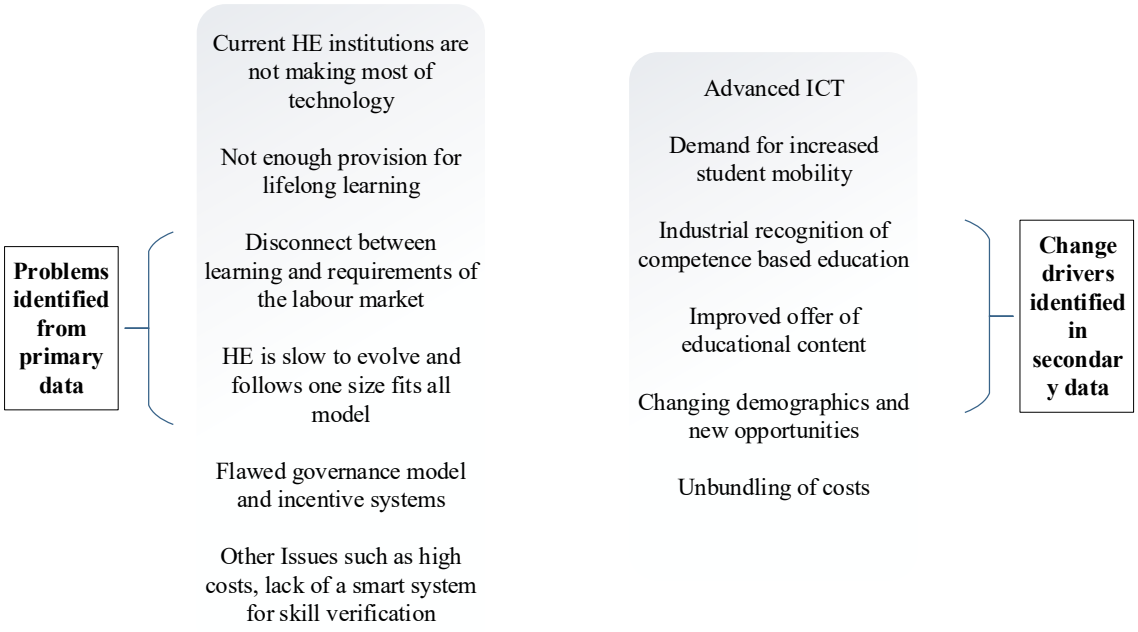

Figure 10. *Relationship between findings from literature review and analysis of interview data.*

From the above figure it can be seen that the problem areas identified in the interviews are consistent with the findings from literature. According to Acheampong (2018), Camilleri & Grech (2017) and Leliopoulos & Drigas (2014), advancements in information and communications technology have not yet been fully employed when it comes to higher education. Similarly, it was pointed out by several interviewees that recent advancements in technology are not employed in education to the same extent as in other industries which eventually prevents universities from innovating in the digital society of the future. Thus, it can be said that in order to develop beyond a certain threshold, universities might need to make way for technology based solutions. Some of the blockchain based initiatives that are already in practice, such as Blockcerts at MIT is a very good example of an attempt to bring technology into the daily life of learners. Students can access their diplomas securely just by using their smartphones and use them as proof in case of employment opportunities. Use of technology is a powerful tool when it comes to unbundling the three aspects of higher education as identified earlier.

The lack of provision for lifelong learning finds proof in the literature in terms of demand for student mobility and learner demographics gradually shifting towards lifelong learners. Haug (1997), Adams (2001) and Karran (2004) have emphasized that the existing grading systems and practices (including ECTS) fail to provide a commonly agreed upon

and universally acceptable method of trustworthy credentials that facilitate student mobility and lifelong learning. Pelletier (2010) also identified the 'non traditional student', who is becoming more common with time. The traditional as well as non traditional students both could benefit from having a lifelong learning record. Most of the interviewees have echoed the same sentiment by pointing out towards a noticeable lack of the recognition of lifelong and personalized learning in universities, which is more flexible in nature to suit the needs of new students. Unbundling the university by modularizing the student experience could be achieved once there is a way to account for learning that happens in any context, within or outside the university. The blockchain initiatives by University of Nicosia, KMI, Sony Global Education and Blockcerts are all attempts at providing for lifelong learning by offering an ecosystem where learners can have verifiable credentials into their identity wallets, which are shareable. Woolf University has gone one step further by offering direct contracts between learners and teachers, in a way diminishing the need for a formal structure as an intermediary, thereby, giving students access to learning, irrespective of their educational status.

A disconnect between modern universities and the needs of the labour market was pointed out as one of the driving factors when it comes to unbundling. Recent trends such as major companies declaring their policy to overlook a lack of a university degree in exchange for valid competence proof (As stated by Glassdoor, 2018) and collaborations between companies and universities to design curriculum providing students with skills that much the needs of a workplace environment in a better way (Marcus, 2017) are all indications that universities are not fulfilling this need in the present. Similar views were also common during the interview process. Interviewees pointed out to the need for universities to adapt in order to fulfil the requirements of the labour market, which is continuously evolving as well. More and more jobs are being mechanized leading towards a future where higher education must focus on preparing students to adapt to uncertain environments. Unbundling could provide universities an opportunity to achieve that. When students have access to a variety of educational resources not limited to one or two universities, enough counselling and support to choose the pathways that suit their skills and interest and a technical system that can fulfil these needs, this disconnect might begin to diminish.

Despite the problems that unbundling can solve, there are some issues that need far more than just unbundling aspects of higher education (**Theme 2**). For instance, it has been pointed out in the results of the data analysis that higher education is slow to evolve. That is a problem which can only be solved by changing collective mindset and no amount of granularity can change it. Also, although unbundling certain aspects of education such as curriculum, assessment and credentialing could possibly lead to some innovation but according to Czerniewicz (2018), it could also possibly lead to commoditization of education and at the same time, universities could lose the leverage that they hold in the current environment (Garvin, 1993). One of the major concerns regarding unbundling curriculum

raised both in literature and interviews was regarding the enormity of the information available to students which might at times seem daunting to young students.

Theme 3 states that blockchain has the capability of making an unbundled higher education a reality. When all the technological layers encapsulating blockchain are peeled away, it simplifies the phenomenon that has created a colossal hype cycle and what remains is an innovation that has the capability to transform society at a monumental level, if used in the right manner. The characteristics of blockchain explained previously emphasize the potential that blockchain has to undo the traditional economic systems and create distributed solutions that move the power back to the consumers. The core arguments presented in Camilleri & Grech (2017), Boucher et al. (2017), Mattila (2016), Galen et al. (2018), AlSaqaf & Seidler (2017) and the latest WEF (World Economic Forum) report on building blockchains for a better planet (2018) all point to the same conclusion which can be summarized in the following points.

- Blockchain enables transparency to any imaginable transaction of value (money, goods, property, work or votes) by adding a trust layer into that transaction. This is done primarily by fulfilling three key components needed to create trust which are (verifiable) identity, (proving) ownership and (establishing) truth.
- Blockchains inherent characteristics have the capability of solving some of the major issues plaguing the digital world currently. The cryptography addresses the problem of data ownership by giving the power over one's personal data back to the individual instead of a central repository. This not only solves the highly contentious issue of data ownership but also weakens intermediaries such as search engines and social media platform that now use personal data for their own profit.
- Complementary factors such as advancement in other technologies like the smartphone revolution, artificial intelligence and IoT (internet of things) and the increasing awareness on a global scale regarding the downsides of centralized data servers and data ownership facilitate the adoption and usage of blockchain among masses.
- Blockchain has been identified as having major impact on not only a wide range of industrial sectors like agriculture, energy, healthcare, democracy and governance but also sectors such as philanthropy, human rights and education. Although studies predict that the estimated impact of global blockchain initiatives will be more visible in the year 2019 (or further depending upon the sector), the social impact has been estimated to be massive.

When it comes to higher education, six major areas have been identified where blockchain could be used to enhance the process: Issuing digital certificates, verifying academic and non-academic credentials, creating lifelong learning passports, identity management, payments/funding and intellectual property management (Camilleri & Grech, 2017; Galen et al., 2018). As a society, we rely on education to mold the children of today into contributing citizens of tomorrow. Historically, a good quality education implies a good

job in the future; however, as stated before, major companies today have repeatedly focused on the importance of demonstration of an actual competence instead of a university degree as a factor in their hiring policy (Horn, 2017). Learning happens constantly, not just in a classroom but in different real-time situations as well as on different mediums (Longworth, 2005) often outside the limitations of time and place. There are also widespread cases of wrongful representation of credentials and in some cases, complete loss of credentials, like those of displaced populations (Gollin, 2009). Due to the transparent and tamper proof nature of blockchain, secure credentials could be made available across sectors to not just students but to prospective employers as well as other universities. One of the interviewees have pointed out that blockchain technology reflects the current decentralized nature of higher education. It provides a mathematically accurate mechanism to enable universities to have trustworthy credentials. As the records stored on blockchain are permanent, there is a possibility of a future where moving or displacement does not mean the loss of all credentials (Jirgensons & Kapenieks, 2018). Thus, student mobility will become far easier, faster and less expensive (Adell et al., 2017).

While most of the benefits offered by blockchain technology pointed towards creating digital identity wallets for students which would be managed by institutions in a decentralized network, as theme 4 suggested, there are certain issues regarding the adoption of blockchain which will be discussed in detail in 7.2

The results from the research point out to three key ideas:

- Unbundling of higher education has a lot of advantages as well as some disadvantages
- Keeping in mind the scope of the research topic, the bright side of unbundled higher education was focused upon. Thus, the scope of investigation included analysis of blockchain technology specifically for facilitation of unbundling of higher education
- Blockchain technology was proved to be effective for the purpose, however, there are some issues regarding its adoption that need to be carefully examined

7.2 Making Sense of Blockchain Adoption for Unbundling in HE

Any new technology is accompanied by a set of factors that simplify themselves over time. Since its introduction, the majority of practical applications of blockchain technology have been in the financial sector. In the context of education, as of now there is no practical implementation that is mature in its scope. There are certain barriers to the adoption of blockchain technology in the field of higher education that have been identified based on the research. The three main barriers are technological, cultural, political & regulatory.

Technological Barriers

Blockchain technology is rather new and is still maturing, thus, there are clearly some technical issues in the picture that are being solved even at this very moment although there are not enough technical experts on the globe to tackle them. While it has been estimated that as the technology will improve, it will go into the background and work seamlessly in the same manner as the internet revolution happened, however, at this moment they pose a significant challenge in its adoption. Some of the questions raised are as follows:

- *Energy Consumption*: Every transaction (which in education could be something like verifying credentials for one completed course for one student) happening in a blockchain network consumes a certain amount of electrical energy. The very first application of blockchain technology, Bitcoin consumed the same amount of electricity in 2017 that could be used by the country of Ireland in an entire year. However, with new consensus protocols in picture, the situation is improving continuously. The proof of stake protocol which is used in Ethereum requires significantly less amount of energy consumption than proof of work protocol employed in Bitcoin. Moreover, blockchain is not the first resource consuming technology in the world, the current costs of data management are also heavy in their energy consumption and blockchain is a way to do the same thing in a more efficient manner.
- *Latency Issue:* The speed of a transaction has often been highlighted as one of the technical limitations of blockchain. Even though the transaction speeds of all blockchains are not as fast yet but it is improving all the time. Recently, blockchain platform Ripple has already overtaken PayPal in the race for most transactions per second.
- *Losing private key and total immutability of data:* One of the key features of blockchain security is its public key infrastructure. However, if one loses their private key, it may become almost impossible to access one's digital wallet. Although this is a very relevant issue, there are solutions on the horizon. One such solution has been suggested via the use of smart contracts. For instance, if a person loses their private key a self-executing contract which may contain pre built conditions for key retrieval based on previously stated third party approvers could be initiated. For an educational blockchain, it might be also beneficial to have a fail-safe as no student could afford to lose all their credentials at once. However, building a fail-safe could also mean that there is an entity that has central control thus, contradicting the element of decentralization.

  The immutability of data in a blockchain based system can be called a paradox. Although it is a major strength that the information on a blockchain cannot be modified, however, in education, students might sometimes need a fresh start and there might be genuine reasons to hide or remove some information. In the KMI

initiative, only the public elements of qualification data are put on the blockchain and the private elements are stored off chain on another platform called Solid. This could be one way to tackle this problem.

- *Integration with legacy systems:* Due to the lack of any consolidated application of blockchain technology in education, it is hard to estimate how the new systems will be integrated with the existing ones.
- *51% attack:* One of the most speculated upon problem associated with a public distributed ledger is 51% attack where one party assumes 51% control over the blockchain which in turn grants them the right to modify information thus, making room for a security breach. However, in the case of higher education, the kind of blockchain used would determine the amount of control the stakeholders have.
- *Scalability:* The scalability of a blockchain based credentialing and identity verification system would depend upon the accompanying infrastructure needs. The power of a decentralized network lies in its scale, thus, it would be important to consider this issue before any implementation. The use of the network effect theory has been suggested in the primary data as one of the ways to overcome this. For instance an educational blockchain between parties with a commonality (For e.g. Scandinavian countries) could be beneficial.

Political & Regulatory Barriers

Any new technology needs to be supported by a legal and regulatory infrastructure based on governmental and public policy. A lack of such frameworks and standards is a barrier in the adoption of a blockchain based system in higher education. Some of the key aspects are:

- *No Blockchain standards:* There is no commonly agreed upon definition of blockchain yet, let alone blockchain standards. For higher education specifically, there will be a need of industry-specific legislation
- *Government support:* No new technology can penetrate the public domain without the support of national governments. It has been observed that while some governments are pro-blockchain (Malta, Estonia with their blockchain initiatives), others are more hesitant. In order to get acceptance in higher education domain, blockchain initiatives would need government support in financial as well as legal means.
- *GDPR:* Data privacy laws such as GDPR have been identified as one of the biggest hurdles in blockchain based initiatives turning into reality. Blockchain and GDPR have been identified as incompatible because by design, blockchain is transparent and open, especially on a public blockchain. As discussed before blockchains are not completely anonymous but offer pseudonymity. The data stored on a blockchain in the form of a hash can be traced back to at least its owner's IP address. Its immutability means, that data once on the blockchain,

cannot be modified, which is in contradiction to the GDPR which stats that all EU citizens have a right to have their data erased. This problem could be solved in essence by using a private blockchain instead of a public one. However, more practical considerations need to be put into it.

- *Accreditation laws:* The current accreditation laws prohibit verified credentials from outside the context of accredited institutions. Blockchain technology makes way for creating a verifiable system of accredited credentials however, it would not be feasible without reforming current laws. Encouragement and open support from the business community could also help accelerate the implementation of any such system.

Cultural Barriers

Some of the major challenges surrounding the adoption of a blockchain based credentialing and identity verification system is related to the socio-cultural aspects surrounding it, chief among them are issues of a lack of general awareness regarding it as well as those related to cultural paradigms shifts needed for the adoption.

- *Perception Problem:* Although the awareness regarding what blockchain technology actually is, is continuously evolving, it is still often used synonymously with Bitcoin and other cryptocurrencies. The CEO of the blockchain based start up has used an excellent analogy to simplify the problem. Blockchain and Android Playstore. Just like the Playstore has numerous applications, some good and some not so good, similarly, blockchain has many applications and Bitcoin is just one of them. Nobody abandons the complete Playstore just because of a bad experience with a single app. Blockchain is a foundational technology upon which many applications can be built. It is important to educate people about the workings of the technology in the right manner. As the Director at company a (consultancy focused on knowledge innovation) has suggested, internet is used both for buying medicines and weapons, it depends on the user. Similarly, blockchain technology has a huge potential depending upon how it is used.
- *Cultural Paradigm Shift:* Universities are traditional and reputation centric entities. In order to enable the adoption of a radical technology such as blockchain which essentially requires universities to make a number of infrastructural changes along with psychological ones, it is important that this paradigm shift takes place. A shift in attitude is just as important for investing into researching the numerous applications as it is, for the practical implementation.

7.3 Contributions to Theory and Practice

7.3.1 Contributions to Theory

The first theoretical contribution of this research is building an understanding towards the concept of unbundling in higher education by categorizing and analyzing the main driving factors that aid it and the barriers that stand in its way. The literature review identified six key change drivers and three key barriers to the concept of unbundling higher education. This research delves into an area of reinventing modern education that has largely remained unexplored. Unbundling of education has often been studied on a standalone basis with little attention paid to its practical implementation. Similarly, blockchain technology has been explored in public sectors including higher education, but the clear lack of available literature regarding its application specifically when it comes to unbundling of education is a research gap that was the focus of this thesis. The second theoretical contribution of this thesis is providing a framework that breaks down an unbundled higher education into distinct units for better understanding and analyses each unit with respect to the ability of blockchain technology to tackle it based on its theoretical strengths.

To the best of my knowledge, there has been no academic research directly linking unbundled higher education to blockchain technology. Hence, this study contributes to research by exploring the concept of unbundling aspects of higher education by using blockchain technology. Once the ability of blockchain in facilitating an unbundled higher education was analyzed and reported, it was clear that in order to make that happen, there are distinct adoption barriers that would need to be overcome. These barriers are another theoretical contribution from this research after being identified in 7.2 are detailed in the figure below

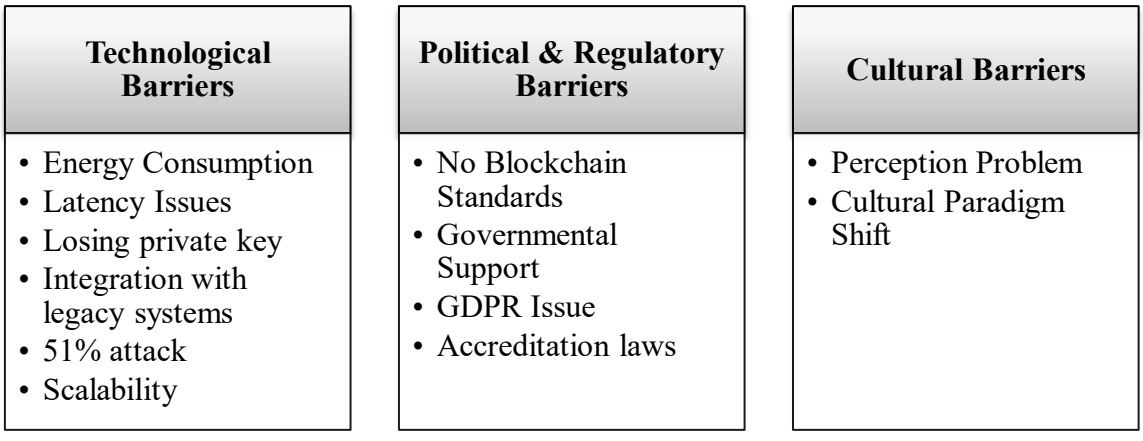

Figure 11. *Blockchain Adoption Barriers in Higher Education.*

While technological barriers are highest in their number, experts have repeatedly emphasized that those are the easiest to solve. As the technology matures naturally, the technical

barriers will slowly disappears as has been stated by a number of interviewees. The cultural, political and regulatory barriers are the vital focus areas for future research and development.

7.3.2 Contributions to Practice

This study aids universities that are exploring their options when it comes to modularizing their offer by providing an understanding of its numerous implications. Unbundling might suit the needs of some universities better than others, thus, it is essential for universities to understand their own needs first. The insights from the research might help universities make sense of this phenomenon and analyze it from their specific standpoint.

The blockchain industry is rather new and still developing, therefore, this study may contribute in creating an understanding for businesses interested in developing higher education sector regarding the needs of a university when it comes to adopting any blockchain based solution. The technical characteristics of blockchain suit the needs of an unbundled university, however, that cannot be put into practice without an insight into the different elements that make up a university structure. Thus, this research might aid that understanding.

7.4 Research Limitations

There are some observable limitations which need to be paid attention to in this research. Most of them are linked to the scarcity of knowledge resources related to a technology still in its early developmental stages and those related to the methodology used. Blockchain as a technology is fairly new and developing continuously. As such the literature resources available are rather limited. The resources shrink further when blockchain technology is studied in reference to the education sector. There are very few blockchain experts available and people are still trying to figure out the ins and outs of the technology. There is also a lack of existing practical implementations of blockchain technology in public sector, which makes the process of understanding and analyzing it in a pragmatic sense.

The research methodology used in this study was qualitative semi-structured interviews which has its own advantages and disadvantages. Qualitative interviews can lead to reduced reliability because of the unstructured nature of the data collected (Bryman & Bell, 2015). Therefore, the reliability of the results of this thesis might be affected by similar factors. During the interviews, it was challenging for the author to guide the conversation in the desired direction, many times questions were left unasked. This might lead to incomplete results. Another challenge was to find people with common expertise in the field of higher education as well as blockchain technology. While there are quite a few of such interviews included in the thesis, there were some where the focus area was only one of those subjects. Based on the results obtained in such interviews, conclusions were

drawn from the needs and issues identified by interviewees in their own experience. Qualitative interviews are also open to interpretation and personal biases and opinions often tend to seep in. Another major limitation of this research was the focus on only one aspect of unbundling (curricula) in the conducted interviews. This reduced the scope of the study in some ways.

7.5 Suggestions for Future Research

This thesis explored the possibilities of using blockchain technology as a tool to unbundle education theoretically. However, due to certain limitations such as lack of existing research and the scarcity of practical applications as well as sources available, there are some areas of research that can be explored further in future.

In the short term, more academics need to venture into research areas tackling the immense possibilities that arise from unbundling certain aspects of education. Something like blockchain technology also needs to be explored from an academic point of view for the vast potential it offers when it comes to benefits such as educational equality and student centric education models. It would not be realistic to expect something as radical as blockchain technology to be put into practical use without the support of policymakers. Therefore, the policy regulations needed to be put in place both for blockchain technology in general as well as those specific to the education sector must be researched. In the long term, some blockchain related pilots should be tested in live environment to understand the implications it can possibly cause to the current landscape. Apart from academic research, there is also a major need to educate people about the real benefits of blockchain as a technology, which shift the focus away from the hype to the things that actually matter.

8. CONCLUSION

This thesis was a theoretical research in an attempt to find out if blockchain technology can facilitate the unbundling of the current higher education system. The effects of unbundling aspects of higher education can benefit not only students but also teachers and the institutions themselves. However, the true ramifications of an unbundled higher education sector will be revealed only in time after a valid amount of research and practice. Technology will be the driving force behind such reforms but time should not be under estimated as a deciding factor as well. Blockchain technology shows a great deal of promise in solving most of the technical requirements needed to put an unbundled educational experience into place. The technological barriers it poses will become irrelevant as the technology matures. Accompanied by supportive policy and regulatory framework along with changing mindsets of institutions, lawmakers, business industry and society in general could lead to the much needed higher education reform.

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APPENDIX A: INTERVIEW QUESTIONS

Three categories of questions: questions related to higher education, questions related to higher education and blockchain, blockchain technology specific questions. Some of the sample questions in each category are shown below:

Higher education

- What kind of changes are needed in the current higher education system from a learner's point of view?
- What kind of changes are needed in the current higher education system from a teaching point of view?
- Are universities fulfilling the needs of the learners from the labour market point of view?
- Are universities fulfilling the needs for lifelong learning?
- What does the future of large and traditional degree programmes look like? How does micro learning fit into this picture?
- What factors are driving the move towards a more flexible and personalized learning environment?
- What is an ideal unbundled education scenario?
- What are the common reasons for universities' hesitance towards unbundling?
- What kind of problems emerge when verifying credentials of students from different universities and when quantifying previous learning experiences?

Higher Education and Blockchain

- How can blockchain technology contribute to higher education?
- Does the use of blockchain technology make it easier to unbundle education?
- What kind of pushback is common when discussing blockchain technology with respect to education reform in higher education related forums?
- Is there a probable 'education token' in the future of blockchain in higher education?
- What incentives do universities have to adopt a blockchain based credentialing system?

Blockchain technology specific questions

- What is the unique value proposition of blockchain technology?
- How does mining work in a blockchain network?
- Is there a need to build a brand new blockchain or will the utilization of an existing blockchain serves the purpose for education?
- How can we deal with the issues arising from the loss of private key to a wallet?
- Is blockhain's synonymization with cryptocurrency a problem? If so how can it be undone?

- What is your opinion about the issue arising from the conflict between GDPR and blockchain technology? Could it be the decisive factor when it comes to implementation?
- Can you address the issue of blockchain's environmental impact?
- Discussion related to the lack of awareness regarding blockchain technology among decision makers due to a low number of practical use cases.