Blockchain: An Enabler of Efficiency, Choice and Agility in Education

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August 2018

Blockchain: A Future Foundational Technology[1]

While blockchain, thanks to Bitcoin, is becoming a household name many are still unaware of the potential social, financial and economic impacts of it in our everyday lives. Despite still being in its infancy, blockchain technology has already proven to be a significant catalyst for disruption across multiple industries, possibly touching their business models in the same way as they were impacted and disrupted by the Internet. Being considered as part of the fourth industrial revolution, it is believed by many that blockchain technology has a capacity to transfer the current Internet from "The Internet of Information Sharing" to "The Internet of Value Exchange"[2]. Due to its decentralized, traceable, immutable, smart contracts and token properties, the hope is that in the same way that the Internet restructured patterns of communication and impacted social behaviour, blockchain may similarly help address the current lacunae in transactions, contracts, and trust – key underpinnings of business, government, and society[3]. In particular, it provides a new approach on how to share and manage the lifetime history of data related to people, places and things, disrupting any activity that requires timestamped record-keeping of titles of ownership. Consequently, this could lead to a significant transformation from today's products and services to tomorrow's blockchain technology-based ones. Some of the emerging opportunities for mobile, identity and aid have been highlighted in the GSMA report[4].

While majority of attention in blockchain is focused on Fintech, this will change in the near future. Like many other verticals, blockchain technology could become a truly transformative force in education, changing the current expensive education system from a deficit-based instructional system toward one based on student growth. Today in the UK entry rates to universities have significant geographical variability, with 28% of 18-year old's in the South West and 29% of those in the North-East entering higher education compared to 40% in London[5]. Exacerbating the problem is the fact that the drop-out rates among the UK domiciled full-time students not continuing in higher education after their first year have gone up for the third year in a row, according to official statistics[6]. In the US, only 60% of students earn a bachelor's degree in a six-year graduation window, while just 28% complete an Associate's degree or certificate in a three-year graduation window, yet 65% of jobs will require postsecondary credentials by 2020[7]. It can be argued that this is due to current systemic flaws in the way we teach and learn. The striking similarities of today's classroom and one of centuries past is undeniable evidence of our education system being behind the times, and yet as said by Nelson Mandela education is the only weapon which can change the world.

Blockchain technology can disrupt the global education model as we know it today, making it more joyous, applicable, affordable and accessible. However, with few exceptions, education is not currently at the top of the agenda of most countries with national blockchain initiatives. That is mainly due to the fact that, most of the stakeholders within education are not familiar with the technology, neither aware of the social advantages nor potential of blockchain[3]. In recent years, several studies have focused on how blockchain technology can be applied in education. Their findings show how this innovative technology could become a new infrastructure to secure, share, and verify learning achievements; how it can revolutionise education by its smart-incentive based platform; how it can help transfer today's macro-accreditation education system to an emerging model of micro-accreditation; and last but not least how the combination of AI and blockchain enables an interactive education market allowing students to acquire skills that are currently required by the market, and business to recruit tech talents with the maximum match to their requirements.

1 https://hbr.org/2017/01/the-truth-about-blockchain
2 https://link.springer.com/content/pdf/10.1186%2Fs40561-017-0050-x.pdf
3 http://publications.jrc.ec.europa.eu/repository/bitstream/JRC108255/jrc108255_blockchain_in_education(1).pdf
4 https://www.gsma.com/mobilefordevelopment/wp-content/uploads/2017/12/Blockchain-for-Development.pdf
5 http://www.sciencecampaign.org.uk/resource/ucas-end-of-cycle-report-2016.html
6 https://www.hesa.ac.uk/news/08-03-2018/non-continuation-summary
7 https://ptopnetwork.jff.org/why-pathways

Blockchain and Challenges of Today's Education System

Blockchain is a digitalised, decentralised and distributed ledger that provides a way for information to be recorded and shared by a community, with an unprecedented degree of trust and transparency. When a new information is recorded onto the blockchain by a community member, the data is first parcelled in a block, verified and sealed. The new block is then instantly and automatically distributed onto all of the other nodes in the network. After being validated by each node, it will be added to the previous block to form a chain. This can ensure that every member of the community sees the most up-to-date records in a network of nodes with no single point of failure. Using this process, blockchain may improve any predictable, repeatable process where information needs to be sent, stored, accessed, and verified securely while enhancing their immutability and resiliency. As there is no central authority in charge, a fundamental problem in a distributed environment like blockchain is to achieve overall system reliability in the presence of a number of faulty or potentially corrupted processes. To achieve that a set of "cryptoeconomic rules" is enforced by a blockchain in order to maintain distributed consensus across the blockchain's peer-to-peer network such as Proof-of-Work, Proof-of-Stake, etc.. Such rules have economic incentives i.e., Learning Tokens, to ensure that the rules are followed. The token is considered to be the least common denominator to align interests in a multi-stakeholder network like a blockchain. It can be either in a form of a core token or an application one, covering many applications ranging from sub-currencies representing assets such as USD or gold to company stocks, individual tokens representing smart property, secure unforgeable coupons, and even token systems with no ties to conventional value at all, used as point systems for incentivisation (reward system)[8].

Another important area of inquiry is "smart contracts"- a series of instructions written using a programming language which automatically moves digital assets according to a codified set of rules, e.g. "if house sale recorded as completed, transfer tokens from buyer to seller". Although the "successful" version of blockchain concept is new, smart contract is not. It was first introduced in 1996 as "a computerized transaction protocol that executes the terms of a contract. The general objectives are to satisfy common contractual conditions (such as payment terms, liens, confidentiality, and even enforcement), minimize exceptions both malicious and accidental, and minimize the need for trusted intermediaries. Related economic goals include lowering fraud loss, arbitrations and enforcement costs, and other transaction costs." [9]

Implementation of blockchain powered smart contracts could allow individuals to build their own projects and applications based on a contract that is automatically enforced between two or more parties, in a decentralized and immutable fashion. This can eliminate the need for intermediaries that previously provided trust or external enforcement mechanism. Resistance to failure, fraud reduction, direct communication with users, transparency, cost efficiency, accuracy through record keeping, and last not least more security and trust would be the benefits of using such systems.

Among certain verticals such as banking, government, insurance, transportation, and health which are expected to be disrupted, education is one that blockchain looks set to play a major role in addressing some of its challenges. Today's education is in need of a change to become more affordable and efficient; to empower learners with the quality education they deserve and they need for today's market; to embrace other forms of learning; to recognise the need and choice of each student as an individual and most importantly to motivate and encourage learners to learn.

8 http://www.the-blockchain.com/docs/Ethereum_white_paper-a_next_generation_smart_contract_and_decentralized_application_platform-vitalik-buterin.pdf
9 Tapscott, Don; Tapscott, Alex (May 2016). The Blockchain Revolution: How the Technology Behind Bitcoin is Changing Money, Business, and the World. ISBN 978-0670069972

Agile education system and Distributed Universities

The current model of higher education today is very rigid with little flexibility. It expects all students with different levels of intelligence and interest go through the same extremely structured course of education. Its tightly defined learning methods provide students and teachers with little opportunity to explore their creativity; its heavily standardised curricula make it hard to meet the need for new skills and for continuous learning of emerging technologies; and its exam-oriented and score-based approach to evaluate the capability of students leaves little room to identify diverse, creative and innovative talents. In today's rapidly changing world students need to know how to equip themselves with market-driven skills, how to discover their talents in diverse areas and how to demonstrate their ability in a range of different topics. While the current education system constrains students with the four walls of their physical classroom, learning happens increasingly outside of lecture halls[3]. Today there is a growing interest in online-learning, distance-learning, like-minded individual communities and the concept of badges and micro-accreditation instead of macro-ones among students, while at the same time the report by Universities UK shows that registering with a university and spending several years on a statically defined subject is becoming less appealing for students[10].

The use of blockchain as a distributed leger, its token-based platform and smart contracts can facilitate the establishment of agile education and distributed learning. By breaking down curricula into micro pieces, the intrinsic flexibility of smart contracts can allow the system to validate the knowledge and skills acquired by students through formal and non-formal means. By using a token-based reward system as a proof of knowledge, students would no longer be restricted to their degree certificate to demonstrate their skill. The token-based reward system can also open new doors to accelerate the crowd-sourcing of skills and expertise on demand, encouraging students to use their knowledge and expertise in the market as soon as possible instead of waiting until the end of their degree. Such a system can not only bring agility to the learning process, but can also provide more transparency, efficiency and fairness to the education system. It can help authorities to have a better control over performance of the students receiving bursary and encourage them to work harder if they would like to remain eligible for receiving the fund. Another example would be establishing a fairer system for student loan repayment. Having a smart contract in place between authorities and students, they can only repay their loan if they find a job relevant to modules they received funding for.

Lifelong digital learning identity and Educational Ledger

Some of the challenges faced by Europe today are[3]: the need for continuous professional development and re-skilling of its workforce; the facilitation of the recognition of non-formal learning based on individual's portfolios – this being particularly pertinent for open learners and migrants; and the standardisation and scaling up of the process of credentialing, issuing and recognition, as well as their access by interested parties[11]. The essential part of any solution for these challenges is the possibility of keeping record of an individual's learning journey and making it available to all stakeholders with the ability to prove the authenticity of a claim. Today there are few solutions allowing users to record their lifetime learning and achievements. However, what they all lack is the possibility of automatically verifying the experience and credentials claimed, without human intervention.

Moreover, existing credential systems are more in favour of formal education over other forms of education such as informal and non-formal education. The European guidelines identify the educational process in any activity undertaken by people, in the various stages of life, in order to improve their knowledge, skills and competences, from a personal, civic, social and occupational point of view, in a formal, non-formal or informal way. In reality, that refers to the overall skills and knowledge individuals have acquired through the education system, paid and

10 https://www.universitiesuk.ac.uk/facts-and-stats/data-and-analysis/Documents/patterns-and-trends-2017.pdf
11 http://publications.jrc.ec.europa.eu/repository/bitstream/JRC108255/jrc108255_blockchain_in_education(1).pdf

unpaid work, organizational work, family life and life in society. The concept of education in formal, non-formal and informal contexts in a lifelong learning perspective is crucial because it should be one of the solutions to improve the employability of people and the responsibility of individuals in uninterruptedly feeding their own social, intellectual and cultural capital[12].

Blockchain technology is ideal as a new infrastructure to secure, share, and verify learning achievements[13]. The immutability of its distributed ledger make it possible to digitise, store and manage learners' degree and academic certificates. Apart from the formal education, information about learners' research experience, skills, online learning experience etc. - in the context of the informal and non-formal learning- can be stored and made available for relevant uses. This can be particularly applicable for qualifications such as advanced and higher apprenticeships, where the programmes are delivered by more than one organisation. As a blockchain network can be built using multiple nodes, various stakeholders can provide and participate in these nodes to enhance data reliability[14]. All records can be accessed and verified via other stakeholders- such as other institutions, employers, etc. Once institutions enter a new record in the ledger such as issuing a certificate, there is no need for them to spend any further resources to confirm the validity of the formal/non-formal certificate to third parties, nor there is a need for a centralised system for degree verification. Having access to such platform not only can facilitate cross-border learning mobility, it can expedite the process of formal recognition of non-formal and informal learning through certification.

Such systems can provide a complete picture of an individual's education and experience, while improving the transparency of qualifications, addressing the lack of smooth and seamless attestation of claims. Moreover, the system can help to verify the issuer of the credential, as well as the quality of the institution itself.

Student motivation and Gamification

One of the challenges facing today's education system is the decline of academic motivation[15]. One way to solve this problem is the use of gamification in a learning process[16]. Games, in any form, increase motivation through engagement. In education, the reasons for drop-outs or low performance can include boredom or lack of engagement, a pattern of escalating absenteeism where each absence makes the person less willing to return to university, and most importantly, being distracted by technology such as smartphones and the Internet[17].Small incentives can increase users' participation, loyalty and competition in activities such that their likelihood of completion is improved.

In order to apply gamification in the education system general instructional goals can be defined as objectives, such as having the student understand a concept or complete an assignment or a project etc. These objectives can be arranged as a series of stages or milestones in a way that clearly defines what the learners should learn or achieve by the end of each stage. Once the stages/milestones have been identified, the instructor can more easily judge which stages can be gamified and how, can a tracking mechanism be applied to the stages, what the rules are that can be implemented and what the award would be, and what determines the accomplishment of a level[17]. Gamification of learning processes, not only makes objectives more achievable and measurable in a series of small tasks, it also helps instructors identify gaps in each student's learning progress as well as any stumbling block within and between each stage.

12 http://www.young-adulllt.eu/glossary/listview.php?we_objectID=193
13 Smolenski, N;Academic Credentials in an era of digital decentralisation. Learning Machine Research
14 https://blockchain.sonyged.com/
15 https://files.eric.ed.gov/fulltext/ED532666.pdf
16 http://journals.sfu.ca/onlinejour/index.php/i-jet/article/viewFile/4355/3480
17 http://www.rotman.utoronto.ca/-/media/files/programs-and-areas/behavioural-economics/guidegamificationeducationdec2013.pdf

Blockchain with its tokens- acting as small incentives- and its smart contracts provides a powerful platform to create a gamification system for educational purposes. While the distributed ledgers of blockchain can keep the record of each student's progress, smart contracts could facilitate a highly automated process of evaluating the progress and token based reward for small achievements. Therefore instilling a sense of accomplishment.

Student expectations and Employability

One of the challenges facing today's education is ever-increasing student expectation. With the increase in the tuition fee cap students expect a lucrative return of investment for a hefty debt they carry upon graduation, in a way not seen in UK higher education before. A survey conducted by HEPI[18] in 2017 showed that there is a continued fall in perceptions of the value for money that undergraduate students feel they receive.

A report by King's College London indicates that across all subjects of study, the primary purpose for students entering higher education was to improve their career prospects and as a pathway for career enhancement[19]. Students expected institutions to offer advice and guidance to support them in developing their employability for future careers within and beyond their formal course.

Nevertheless, a regular comment heard from industry and employers indicates a growing skills gap and the fact that a degree is no longer an effective gauge of a student's employability. The skills gap is defined as a difference between the skills that employers around the world want in the workforce and the actual skills that the workforce has. Estimates suggest that by 2020, over 60% of newly created jobs will require skills that less than 20% of the workforce possesses[20]. As a direct consequence it may be necessary for businesses to provide graduates with long term and therefore potentially highly expensive and time consuming training. Tackling this problem requires a more agile education system - one that can empower learners with the right skills and competencies.

Adoption of blockchain technology with its token-based incentives, could help to reduce the skills gap. This could be done by providing a platform to exchange of value- i.e., tokens- between an incentive creator and an incentive taker. Potential employers or other authorities can signal specific topics and skills in demands in the labour market and the incentive takers e.g., students commit to building their knowledge around the topic in order to receive the tokens. The convergence of AI with the blockchain of data, allows employers to get sufficient "knowledge" from data and identify the most suitable candidates for the required jobs by tracing their progress and achievement in required subjects, etc. It also helps authorities, as another stakeholder of such platform, to recognise gaps in skills and take necessary actions to address it.

Technology adoption: Challenges and Considerations

Complexity of the technology

Blockchain can be in the form of public, private and permissioned one as a choice between a totally public and a totally private one. While in the public one anyone can join, the latter allows users to join the network upon successful verification of their identity, with the possibility of performing only certain activities on the network based on the set of permissions assigned to them.

18 http://www.hepi.ac.uk/wp-content/uploads/2017/06/2017-Student-Academic-Experience-Survey-Final-Report.pdf
19 https://www.kcl.ac.uk/study/learningteaching/kli/People/Research/DL/QAAReport.pdf
20 EY, Who holds the key to closing the skills gap?

When talking about blockchain, the first thing that comes to mind is a highly decentralized and open source network, owned by a community wherein each node has a copy of the entire ledger and agrees on changes. Due to the computational power required to process the cryptography, such system, inevitably, leads to the extremely high storage cost as well as high energy usage. Such assumption is valid for the public blockchain with the Proof-of-Work mechanism of consensus like Bitcoin. However, there are alternative solutions that are different from the stand point of componential power, transaction speed, privacy and consequently the level of openness.

As the heart of blockchain is the distributed ledger, there should be a way to ensure all nodes agree on changes to the ledger. There are different consensus mechanisms to verify the validity of a newly added record and the integrity of the previous ones. All of these mechanisms serve the same core purpose- coming to consensus- but use different methodologies. While in one like Proof-of-Work, any node can participate in the consensus mechanism, in some only designated nodes can, albeit under certain conditions. Each designated node/server maintains a unique node list, which is a set of other servers that it queries when determining consensus. Only the votes of the other members of its list are considered when determining consensus (as opposed to every node on the network)[21]. This can significantly reduce the computational power and the latency of adding a new record. However, it imposes more control over the ledger and hence cannot be seen as a truly distributed ledger system.

The diversity of implementation options in blockchain and high amount of research in this area is a clear indicator that there is no one-size-fits-all solution for different verticals or even different use cases within a vertical. While a truly distributed ledger might be a perfect solution for some use cases, it might not be the best for all use cases in the education system. In order to adopt the blockchain technology in the education system on a large scale, focused research should be conducted in line with the existing ones such as Open Blockchain[22] and MIT Blockchain Certificates[23], in order to get a clear understanding of the requirements and priorities of the education sector, identify potential use cases and choose or develop a right blockchain framework accordingly.

Pervasive adoption of the technology

Due to the distributed nature of the blockchain ledger, its beneficial effects can only be perceived by the wide-scale uptake of the technology. Therefore, having a long-term, nation-wide strategy for an open-standard and vendor-independent blockchain implementation with de-centralised verification will be key to achieving the promises of blockchain in Education. The key prerequisite for it is to define a standard way of recognising both formal and non-formal achievements with rich sets of standardized or commonly-agreed metadata. That is an effective way to guarantee the scalability of the system and portability of records between various stakeholders involved.

Current research shows that in spite of the complexity of the blockchain technology, it seems the most important work that lies ahead is not technical[24]. Much has to do with institutions and governance. It will require a concerted effort to ensure that the standards for digital credentialing systems are open and that they take into account the needs of all involved — learners, educational institutions, employers, and governments — and don't prioritise the interests of some organisations over others. This is the time to experiment, to collaborate, and to share experiences to realise the full potential of building a new ecosystem of digital credentials[24].

21 https://ripple.com/files/ripple_consensus_whitepaper.pdf
22 http://blockchain.open.ac.uk/
23 https://www.media.mit.edu/projects/media-lab-digital-certificates/overview/
24 http://er.educause.edu/articles/2017/4/credentials-reputation-and-the-Blockchain

Third party dependency

While nowadays it is hard to imagine a life without the Internet, many of today's use cases were pure science fiction when it first became a mass phenomenon – imagine all the world's information crammed into an electronic "tablet", or a computer that you can speak to that understands what you are saying. The same might be applicable to blockchain in future. Research indicates that blockchain will present significant challenges and opportunities to the business models of educational institutions. The strategic application of blockchain may dramatically lower administration costs, increase transparency and reduce fraud by benefiting from other possible use cases such as citation tracing, managing intellectual property[3] . Prima facie, the advantages of blockchain technology are more likely to be readily embraced by higher education institutions with significant brand equity to protect[3].

However, apart from the research activities, the main focus of the education sector should not be on developing or changing the underling platforms, but rather on simplifying the adaptation of technology and identifying the right products to serve their purpose. Even with that, the complexity of blockchain technology will impose significant technical, and resource barriers to adoption and integration with existing systems. Consequently, the need will fuel a huge number of startup companies. As the number of players increases, so does the risk of vendor lock-in as a major barrier to the technology adoption. In order to have a pervasive adoption, having an open-source and open-standard solution is the key. Nevertheless, the complexity of architectures will make it very hard for the education community to make informed decisions about the best possible solutions.

Evaluating blockchain solutions

In a recent Jisc horizon scanning report[25], we looked at a range of potential blockchain use cases in research and education, and at how an institution might be able to understand whether blockchain was an appropriate solution for its needs. Three key issues emerge from this:

- Many products are emerging that are 'blockchain powered', but where the underlying blockchain technology and the distributed ledger itself are not accessible to customers. Whilst the product might use these technologies under the hood, customers may not hold a copy of the ledger. In these cases it is debatable what value blockchain adds other than as a marketing term;

- The key attraction of blockchain technology is in creating a 'third space' where people or organisations who do not inherently trust (or even know) each other can come together round a shared set of data – such as customers and suppliers, or members of a supply chain. Whilst permissioned ledgers are being developed, mature database solutions exist that may be preferable;

- Blockchain is an active research topic, with a few widely deployed products and services and many more that are at an early stage of technology readiness. We have recently seen a number of cases where funds held in cryptocurrencies have become inaccessible due to software bugs, or abstracted through backdoors or programming errors in smart contracts.

It follows that institutions which are interested in exploring blockchain and distributed ledger technology should be careful to calibrate their risk appetite accordingly. Where personal data is involved, care should be taken to ensure that the General Data Protection Regulations (GDPR) are followed, alongside best practice in cybersecurity and enterprise architecture.

25 https://www.jisc.ac.uk/reports/blockchain-in-research-and-education

Role of NRENs:

A National Research and Education Network (NREN) is the specialised Internet service provider dedicated to supporting the needs of research and education communities within a country. It is usually distinguished by support for a high-speed backbone network such as Jisc's Janet network[26] in the UK, often offering dedicated channels for individual research projects. Apart from connectivity, most NRENs offer digital services to their members in pursuit of the vision of having a digitally advanced education and research community. They also provide trusted advice and practical assistance for universities, colleges and learning providers.

As we look at the potential of blockchain technology in Education, NRENs can play a major role. They can:

- Provide the best platform to raise awareness about the technology and its potential benefits and limitations among the Education sector by disseminating blockchain project outcomes through case studies, conference presentations, workshops, etc. It also helps to explore and identify the best possible use cases and products;

- Provide a key role in open and standard implementation and governance of a permission based blockchain, representing their community members and liaising with different stakeholders;

- Facilitate an inter-country collaboration. Different NRENs across Europe are interconnected with each other via GÉANT[27]. Together, GÉANT connects over 50 million users at 10,000 institutions across Europe. GEANT Associations open the door for a Pan-European deployment of successful services through other NRENs, providing an opportunity for exploring the development of a Europe-wide blockchain platform for education. Such collaboration can facilitate the possibility of having pan-European certificates as well as other potential use cases.

26 https://www.jisc.ac.uk/janet
27 https://www.geant.org/