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THE BLOCKCHAIN AND THE FUTURE OF CREDENTIALING

Getting ready for smart contracts.

Martin Hall
April 2017
GetSmarter

Jisc PRESENTATION FIRST DELIVERED AT JISC BLOCKCHAIN SUMMIT, LONDON, NOVEMBER 2016

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INTRODUCTION

A blockchain is a series of encrypted, peer-to-peer transactions that, together, constitutes a distributed ledger. Starting with the conceptualisation of Bitcoin in 2008, both platforms and their applications are evolving rapidly. Following the launch of the Ethereum platform in mid-2015, "smart contracts" that are secured in a set of blockchain transactions have been proposed for just about anything of value. This includes education qualifications and several universities are now offering digital certificates that are recorded in a blockchain.

In parallel with with these digital innovations - part of the emerging Web 3.0 - the long-established ways of verifying university qualifications are becoming non-viable. Developed for a very different world, where few went into higher education and everyone could be expected to identify every university, the traditional systems of certification are non-scalable, increasingly unintelligible and inefficient. It is also inappropriate for new challenges, such as the widespread loss and destruction of records through contemporary wars and the extent of forced migrancy.

At the same time, the combination of the large numbers of those now qualifying in higher education, along with the ever-increasing sophistication of work, means that many people hold qualifications from several universities, along with a cluster of certificates attesting to specialised competencies. Both individuals and employing institutions need a system of verification that provides a secure, immutable profile of a person's full and constantly-developing professional profile.

This paper evaluates the fit between the new and evolving opportunities of the blockchain, and the requirements for the radical reform of the ways in which higher education qualifications are certified, and can be verified.

UNIVERSITY AND COLLEGE QUALIFICATIONS: WHY CERTIFICATION MATTERS

A qualification awarded by a college or a university is the basis for transaction in the labour market. A certificate verifies the authenticity of the qualification. In general, the more scarce and desirable the expertise that is verified by the qualification, the greater the monetary reward that comes to its owner.

This system of verification has been used in its present form for so long that it is largely taken for granted. The earliest qualifications were certified on parchment and verified with the university's unique seal; a system of recognition that goes back to at least the thirteenth century. Legitimacy is based on general recognition of the name and reputation of the awarding institution. Today, this reputational value is usually protected by national legislation that limits the right of an institution to call itself a university or to issue qualifications. Commonly held perceptions of relative value can have a direct effect on the monetary value of qualifications from different institutions.

For example, data released by the British government in 2016 showed marked variations in the returns on law degrees, five years after graduation: "while the median earnings of law graduates from the University of Oxford are £61,500 five years after graduation, median earnings for a law degree from the University of Bradford are £17,500 – £44,000 a year less. The University of Cambridge was just below Oxford with earnings of £54,500, while graduates of the University of Bedfordshire are only slightly better off than those of Bradford with salaries of £18,000" (Elmes 2016).

FIGURE 1: Seal of the Universidad de Salamanca, chartered by King Alfonso X in 1254

Today, almost all colleges and universities continue to provide certificates for their qualifications using modifications of this medieval system of verification. Records of qualifications that have been awarded are held by the issuing institution and, in some cases, by professional bodies as well. The authenticity of a qualification can be checked if necessary, either by direct enquiry or through the use of a professional verification agency.

WHY THE CURRENT SYSTEM IS UNSUSTAINABLE

This long-established method of certifying and verifying qualifications was developed and first implemented at a time when a small number of people, drawn from elite social and economic groups, attended a university. In many respects, it is remarkable that it continues to function today in much the same way as it did at the Universidad de Salamanca in the thirteenth century. However, it is increasingly clear that the status quo is unsustainable in its present form.

First, and perhaps foremost, the current system is not scalable. Until the mid-years of the twentieth century, university participation remained elite, rarely admitting more than 10% of young adults. Over the last half century, the number of young adults entering universities has increased at least fivefold, and continues to grow. The Global Gross Tertiary Enrolment Ratio (GTER) measures the proportion of each cohort of young adults admitted to universities. Today, the GTER is about 35% overall and is greater than 50% in 54 countries (UNESCO 2016). By 2025, the GTER is expected to exceed 50%. Looked at another way, some 50 million people will earn college or university qualifications in 2016, including some 8 million in China, 9 million in India and 4 million in the United States.

Second, and as a consequence of this exponential-like expansion in university participation, the traditional system of certifying qualifications is often unintelligible. Current processes depend on the widespread ability to recognise value through an institution's reputation. However mass participation has brought a proliferation of legitimate institutions, while the global migration of the skilled workforce requires recognition outside zones of everyday familiarity. There is no agreement on how many universities there are in the world; estimates are between 26000 and 40000; there are more than 2000 universities in Brazil alone. Even elite groupings are too large for common knowledge of the qualities of all in the group; the Times Higher Education's 2016-2017 world rankings grades 980 universities (THE 2016). The global higher education system is already far too large to provide common legibility.

Third, the traditional system is inefficient. Employers who wish to verify the qualifications of applicants usually have to pay fees to intermediary organisations, which either hold secondary databases on behalf of subscribing universities or conduct searches. Graduates almost always have to pay a fee to have their qualifications verified or to obtain verified transcripts, despite having already paid fees for their education. In addition, verification is increasingly difficult. We are in the world of the simulacrum, of innumerable perfect copies. It is difficult to prevent fraud using traditional systems of qualification verification.

Fourth, new kinds of challenges are becoming commonplace. The traditional system of verification depends on institutional stability; on the preservation and archiving of records and on the expectation that most people will have the means of keeping their personal documentation safe and secure. Today, though, more people than ever before have been displaced by violence; current estimates are that some 60 million people are refugees inside or outside their countries, and that half of these are under the age of 25. Archives may be unavailable, or destroyed, as a result of warfare. Consequently, increasing numbers of people have no feasible way of verifying the qualifications that they hold.

NEW DEMANDS

These circumstances are further complicated by new expectations. Some of these are given emphasis by the rapidly increasing participation in higher education across the world. As more and more people gain university qualifications, a summative certificate decreases in its value as a means for discriminating between competitors for employment. As a result both graduates and employers seek additional information, such as a detailed transcript for the learning path that led to the qualification, or certified evidence of co-curricular activities that set a person apart.

Other new expectations are enabled by technological innovation. Online learning is now commonplace and the earlier distinction between "distance" and "residential" education no longer has much meaning. In the United States, for example, a large majority of campus-based undergraduate students take at least one of their courses completely online. Many universities are rolling out flipped classroom models, putting course content online for all students to improve the quality of small-group, face-to-face teaching.

A logical next-step in this direction is to "de-stack" curricula, certifying sub-units within an overall qualification. Employers are increasingly interested in such micro-credentialing, particularly where specific aptitudes are required. For example, the leverage that a graduate has in the labour market may not rest in a summative qualification in Archaeology, but rather in a strong showing in a senior-level module in non-parametric statistics. There is a renewed interest in competency-based education, which requires the demonstration of successive layers of mastery, and new attention to credit accumulation and transfer schemes. The overall effect of these varied initiatives is a demand for information that cannot easily be communicated using traditional certificates and supporting transcripts.

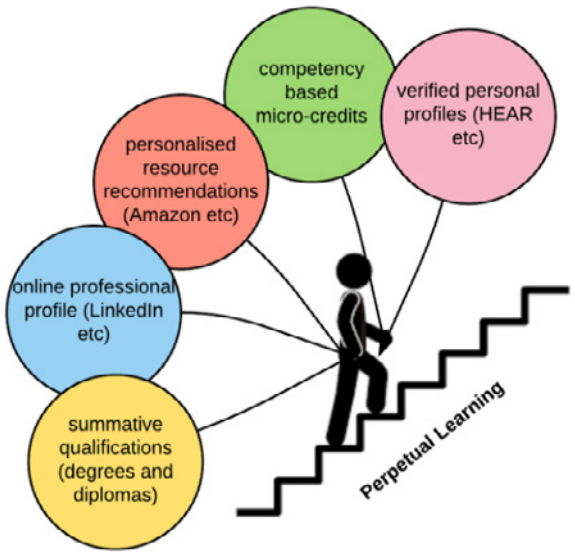

FIGURE 2: The world of perpetual learning.

The continuing expansion of initial participation in higher education, measured by indices such as the GTER, is driving a secondary expansion of graduate course enrolments. This expansion is driven in part by the increasing complexity of workplace demands - many fields of work now have requirements that are too complex to meet through a first degree alone. Postgraduate expansion is also driven by the need for differentiation; as an increasing proportion of young adults enter the labour market with a first degree, the returns on the investment in a postgraduate qualification increase.

An overall consequence of the expansion of further higher education qualifications is that a large number of people now require certification from multiple institutions. This trend will be further accentuated as branded and recognised online short courses continue to expand - the evolution of initial-phase open MOOCs into fee-charging courses. The traditional system of verifying qualifications rests on the assumption that, for the most part, people will identify with a single, primary institution; a lifetime association that also underlies the concept of a university's alumni community. This assumption is rapidly becoming an anachronism in a world of perpetual learning.

MO'S STORY

- *Mo is applying for a job with a long-established firm. The recruitment manager requires proof of his qualifications*
- *His first degree is in Archaeology but he lost the certificate*
- *He's proud of his gap year in China and his language proficiency but his certificate is in Mandarin*
- *Because he was unemployable as an archaeologist he re-qualified with a Masters from a private university in Texas. But no-one in Britain seems to have heard of this university*
- *He has completion certificates for two HarvardX MOOCs, but will these count for anything?*
- *None of his universities are signed up for the HEAR so he can't verify that he was Student Entrepreneur of the Year*
- *By the time he assembles all the information he needs, the job's gone; it was easier to verify the legitimacy of a candidate with a traditional Russell Group profile. Mo sighs and starts looking for another opportunity. The recruitment manager is sad. Mo was an interesting prospect, but she can't take the risk*

ENTER THE BLOCKCHAIN SATOSHI'S LEGACY

A legacy of practice with a direct lineage to the thirteenth century is formidable. Why does a new, still-esoteric digital technology with an odd name have the potential to shake the foundations of higher education credentialing?

To understand how the blockchain will be a key disruptive technology of the next few years, it is necessary to go back to 2008, follow a path through the chequered history of Bitcoin and understand why the world's largest financial services industries are seeing this as such a significant set of developments. From this foundation, the implications for education provision become clearer. As Sony Global Education put it, in announcing a major new initiative, "the technology has the potential to realise an entirely new infrastructure system for sharing records securely over the network in any number of ways, opening new doors of possibility for academic records and how they are assessed" (Sony Global Education 2016).

The blockchain is a distributed ledger of time-stamped electronic transactions that are very difficult to reverse. It was first described, with great clarity, in a 2008 White Paper by the eponymous "Satoshi Nakamoto" as "an electronic payment system based on cryptographic proof instead of trust, allowing any two willing parties to transact directly with each other without the need for a trusted third party" (Nakamoto 2008; see also O'Hagan 2016). This resulted in the first cryptocurrency - Bitcoin - "a chain of digital signatures" verified by proof-of-work on the principle of "one CPU, one vote". The incentive to produce new bitcoins is through "mining", in which bitcoins are earned by solving ever more difficult algorithms. There is a direct analogy with gold mining and, by implication, with the gold standard: "the steady addition of a constant amount of new coins is analogous to gold miners expending resources to add gold to circulation. In our case, it is CPU time and electricity that is expended" (Nakamoto 2008).

Subsequent developments have replaced the narrow definition of a cryptocurrency with the wider concept of the "smart contract". The leading example here is Ethereum, a decentralised platform that runs "smart contracts", which are applications that run "exactly as programmed without any possibility of downtime, censorship, fraud or third party interference". This shared, global infrastructure enables markets in almost anything, as well as registries of data and records of obligations and commitments, including "instructions given long in the past (like a will or a futures contract) and many other things that have not been invented yet, all without a middleman or counterparty risk" (Ethereum 2016; see also Allison 2016).

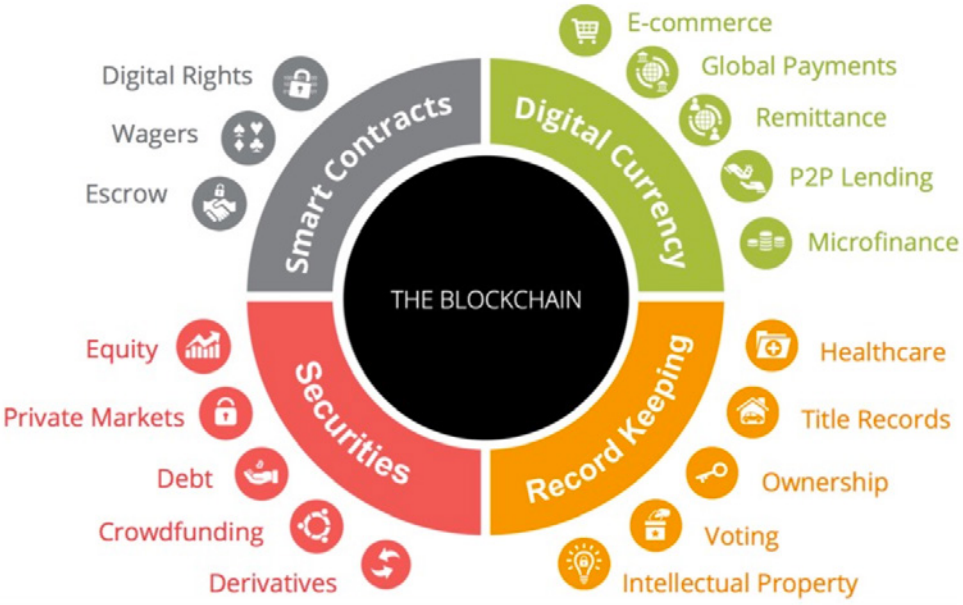

FIGURE 3: The scope of the blockchain

Today's blockchain, and the extent of its effects on established practices, is built directly on the concept and vision behind Bitcoin (Economist 2015). The expansion of these implications, over just eight years, has been exponential-like (Figure 3). Given that a higher education qualification is both part of a contract between an individual and a college or university, and that its certification is an asset of considerable value that depends on secure and lasting record-keeping, it is inevitable that blockchain technologies will have, in one way or another, significant implications for higher education.

SMART CONTRACTS AND QUALIFICATIONS

A consequence of the steep innovation curve for blockchain technologies has been both an appropriation for very different purposes and an over-hyping of potential implications. "Satoshi Nakamoto's" seminal White Paper was written in the depth of disillusionment with banks and financial institutions following the 2007 crash; Bitcoin was founded as a peer-to-peer cryptocurrency that would make banks - or any other intermediary organisation - unnecessary. Not surprisingly, the large investments made by the financial services sector into further research and development have not been in support of Satoshi's millennial vision. Rather the opposite; new generations of cryptocurrencies and other forms of value transactions are designed to be "permissioned" (closed) and in some cases editable (Financial Times 2016; Tapscott and Tapscott 2016).

Given this, a first and appropriate consideration is whether or not a blockchain-based system is required for the reform of higher education qualification verification. This is because there are other digitally-enabled alternatives to the thirteenth century "Salamanca system". For example, there is no reason why a university, or a group of universities, cannot put in place a secure database of qualification records with the levels of cybersecurity that are now standard for online banking.

In thinking about the applicability of the blockchain, or derivatives of the original conceptualisation of the blockchain, to the qualification verification problem, it is useful to apply the tests formulated by Gideon Greenspan; "avoiding the pointless blockchain project" (Greenspan 2015). Here, there are four key questions: is there a requirement for a database with multiple writers? Is there the possibility of mistrust between these multiple writers? Will there be interactions between the transactions written by multiple writers? And are intermediaries - gatekeepers - required for verification?

For the first three of these four "Greenspan tests" the principles behind blockchain applications are directly applicable to the verification of qualifications:

- "Blockchains are a technology for databases with multiple writers. In other words, there needs to be more than one entity which is generating the transactions that modify the database" (Greenspan 2015). As outlined earlier, the expansion of postgraduate education, combined with the proliferation of short and certified online courses, means that individuals require a personalised qualification record across multiple education providers, each writing to their own database.
- "If multiple entities are writing to the database, there also needs to be some degree of mistrust between those entities. In other words, blockchains are a technology for databases with multiple non-trusting writers" (Greenspan 2015). Trust depends on mutual recognition. The sheer scale of global higher education, and the number and range of qualification-awarding institutions, denies the feasibility of mutual recognition, and therefore counts out the dependability of trust.
- "Blockchains truly shine where there is some interaction between the transactions created by these writers … Transactions can be created collaboratively by multiple writers, without either party exposing themselves to risk … Transactions from different writers (can be) cross-correlated with each other, even if they remain independent" (Greenspan 2015). There is increasing demand for joint qualifications provided ("written") by two or more education providers, further developing traditional Credit Accumulation and Transfer Systems (CATS). The blockchain will facilitate this need.

Greenspan's fourth test - whether or not there is a need for a third party to a transaction - is more complicated when it comes to educational certification.

Before considering this fourth test for fit, it is necessary to decide who are the primary parties in the transaction. In the Salamanca tradition, the primary parties are assumed to be a graduate and her or his university. But in practice, the need for certification is at the point where a person is securing an arrangement with another person or organisation that is not the issuing authority; this will often be a prospective employer, but could also be a government agency (for example, in applying for a visa) or a different university (for example, when applying for a postgraduate programme). When considering the applicability of blockchain technologies in education, then, the primary parties in the transaction are the qualification holder and another person or organisation. It can reasonably be assumed that the issuing university has its own records of qualifications it has awarded; in blockchain terminology, the university that grants the certificate is a third-party intermediary.

At first glance, this appears to make blockchain technologies inappropriate for higher education qualifications; evidently, a qualification-awarding institution must be involved in the transaction in order to confirm the validity of the certificate. However, Greenspan's tests were designed for first generation cryptocurrencies; it is the subsequent development of "smart contracts" - and particularly the Ethereum model - that open up opportunities across higher education. The key issue is rather the purpose and nature of third-party intermediation.

If the purpose of intermediation is a gatekeeping function that extracts value from a transaction, then this is at odds with the core peer-to-peer structure of blockchain transactions. In their comprehensive assessment of the blockchain's potential, Tapscott and Tapscott (2016) use the example of transnational remittance payments, for which traditional agencies such as Western Union extract between 10% and 20% of the value of each transaction in fees. Evidently, embracing a cryptocurrency on an open blockchain would be a bad option for Western Union because it would make its intermediation unnecessary. Similarly, if a university's intention is to compete with other universities through barriers that make it difficult for its graduates to go elsewhere for additional qualifications, then the blockchain is a bad idea.

If, however, the purpose of intermediation is to add value to the transaction, then a third-party's role is not at odds with the major benefits of blockchain technology. This is where Ethereum's "smart contract" model for the blockchain, launched in mid-2015, is significant. Smart contracts - essentially sets of distributed and secure applications - enable more than two signatories to a blockchain transaction. A second example from Tapscott and Tapscott's overview can serve to demonstrate the transformative benefits of third party validation. In many lower-income economies, the inability to acquire title to the tangible assets of land and property serves to exclude significant proportions of the population from realising the benefits of ownership, including inter-generational accumulation of wealth, transfer values and financial services. Smart contracts founded in a blockchain provide a secure, accessible and low cost means of establishing secure and rights in property. Here, the third party - an independent and trusted authority that authenticates and validates the existence of the asset - is essential (Tapscott and Tapscott (2016).
If a university's intention is to put the interests of its graduates first, then the new generation of blockchain-based smart contracts offers significant opportunities.

An education qualification is similar to - but more complex than - an asset such as a title deed to a property. A certificate is like a deed, in that it is necessary to underpin the long-term return on an investment. It is also similar in requiring third party intermediation; in this case a guarantee from a legally-recognised awarding institution. An education qualification is more complex in that it is mutable; its award is itself the outcome of a contract between a student and a college or university. The award of an education qualification is also more prone to error; a dimension of certification that will increase in significance as traditional higher education curricula are "de-stacked".

An education qualification is mutable because its continuing validity depends both on the reliability of the information provided before a certificate is issued and - albeit to a lesser extent - on the subsequent behaviour of both parties. A qualification is awarded on the basis of tangible evidence such as examination results, but also and invariably on an assumption of good faith. The defining example here is plagiarism, which is a prevalent issue across all aspects of education despite the increasing sophistication of detection methodologies. If plagiarism is detected after the award of a qualification it is invariably rescinded. Bad faith can also take the form of misrepresentation, to which the Salamanca model is increasingly vulnerable because of its growing inefficiencies. The concept of good faith also plays forward, although largely for honorary awards; Robert Gordon University retracted the honorary degree awarded to Donald Trump after he proposed banning Muslims from the US. US universities are steadily revoking the 60 or so honorary degrees held by Bill Cosby.

The need for intermediation is likely to increase as summative components are de-stacked into smaller units. This is because the possibilities for error will increase significantly. Put another way, if each graduate has both their three year summative qualification with a value of 360 credits and also 18 component modules of 20 credits, each independently and immutably registered on the blockchain, it is inevitable that the need for dynamic intermediation will increase.

Earlier generations of blockchain technologies would not have allowed these complexities to be incorporated in a distributed ledger of peer-to-peer transactions. But the new generation of "smart contracts" covers all of these needs in an environment of rapid innovation that is constantly refining the ways in which a blockchain can be deployed. Setting the needs of higher education against Greenspan's 2015 tests, modified by taking into account subsequent developments of blockchain technologies, shows a goodness of fit.

LOOKING AHEAD
INNOVATORS

The foregoing evaluation of the blockchain's accelerating potential for the verification of higher education qualifications is consistent with the growing interest, and increasing pace of innovation, within higher education.

As in 2003, when it launched its OpenCourseWare initiative, MIT has led in verifying qualifications on the blockchain (Schmidt 2015). Following an initial pilot, MIT's MediaLab has proposed an open standard on the Bitcoin blockchain: "what would an academic degree look like if it was designed today? Or a professional certificate? These are questions we have been working on over the last year, and we are excited to announce the release of Blockchain Certificates (Blockcerts)—an open standard for digital academic certificates on the Bitcoin blockchain" (MIT MediaLab 2016).

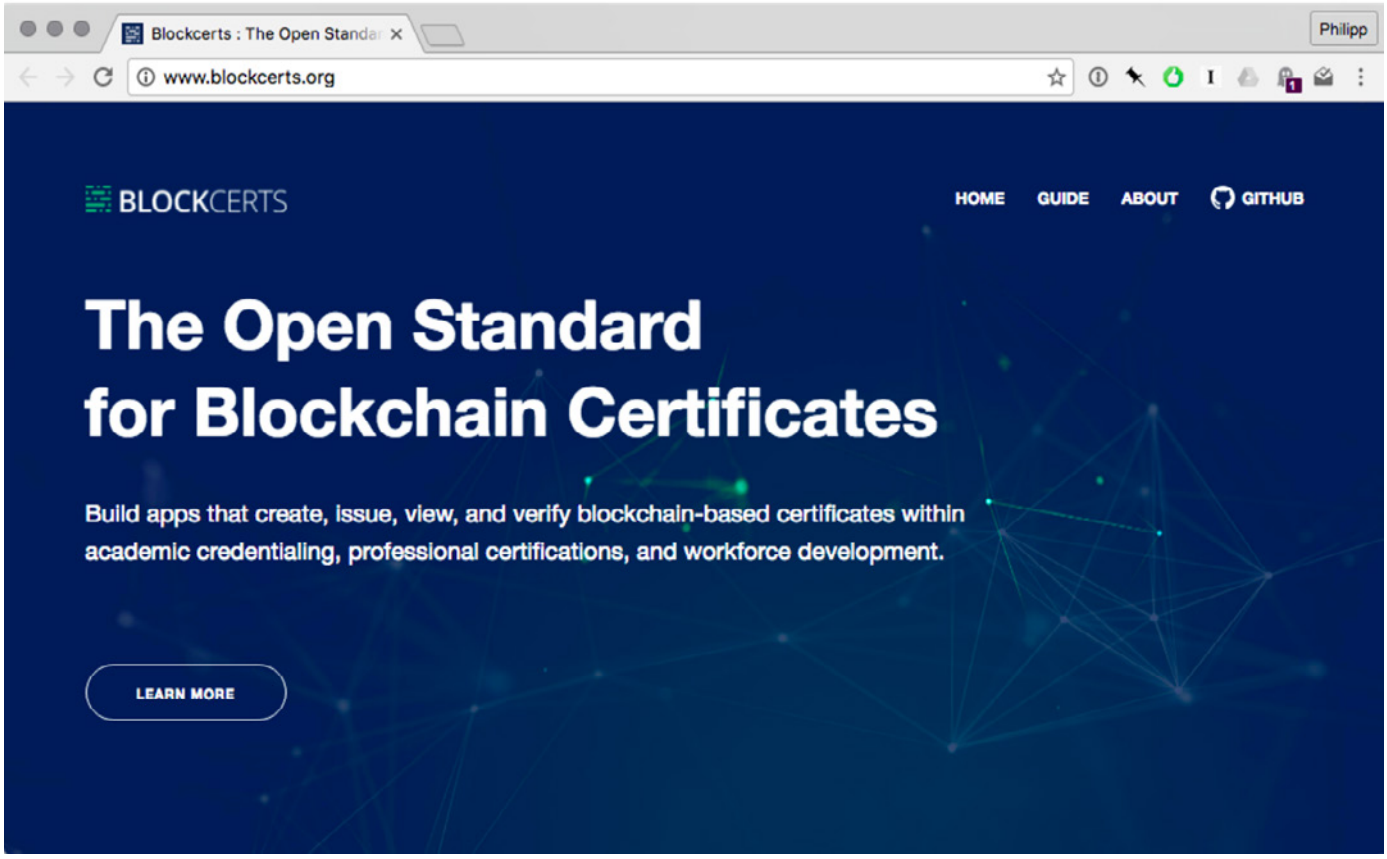

FIGURE 4: Open standard for blockchain certificates (MIT MediaLab 2016)

As with cryptocurrencies and the financial services sector, the commercial opportunities that blockchain technologies bring to higher education have been recognised. In early 2016, Sony Global Education announced a permissioned, fee-charging verification service:

"Sony Global Education, Inc. is announcing that it has adapted blockchain technology to the educational field and has developed technology that enables open and secure sharing of academic proficiency and progress records … leveraging blockchain's secure properties to realise encrypted transmission of data - such as an individual's academic proficiency records and measures of progress - between two specified parties. The technology has the potential to realise an entirely new infrastructure system for sharing records securely over the network in any number of ways, opening new doors of possibility for academic records and how they are assessed. For example, after taking an examination to demonstrate his or her academic proficiency level, an individual could direct the testing organisation to share the test results with one or more third-party evaluating organisations. This would be a first if implemented on a system-wide basis" (Sony Global Education, 2016).

Britain's Open University - with MIT, a pioneer in open courseware - is developing a broader conception of blockchain applications for higher education (Sharples and Domingue 2016). In this model, students, employers and validating institutions have their interests secured through multi-signatory smart contracts, as outlined earlier. In addition, the Open University's projection for the future anticipates teaching and learning provision on distributed blockchain platforms, superseding the use of present generation Virtual Learning Environments (Figure 5).

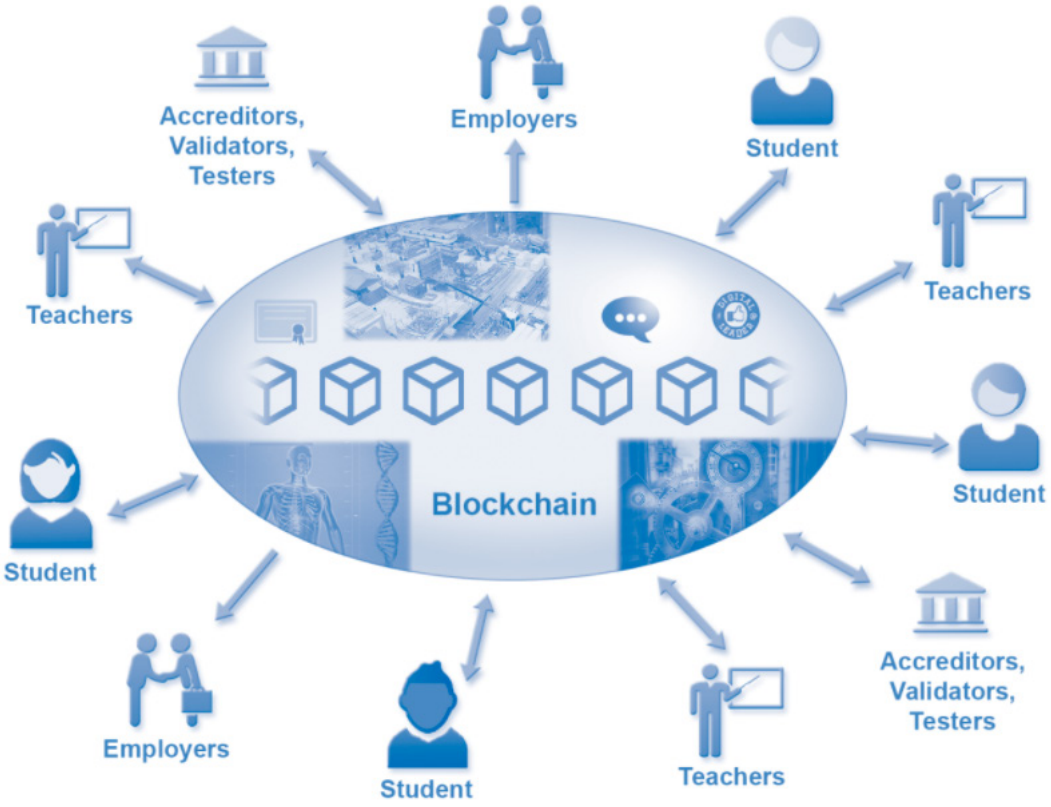

FIGURE 5: The Open University's vision for blockchains and Higher Education (http://blockchain.open.ac.uk/)

John Domingue, the Director of the Open University's Knowledge Media Institute, puts the opportunities this way: "we envision a world in which the awarding and validation of qualifications no longer occur exclusively under the management of an education institution or an employer and individual students, teachers, and peers take more ownership of the learning experience and its outcomes without compromising on safety, security, and accessibility. The centralised model of the present is no longer sustainable: learning happens increasingly outside the brick-and-mortar lecture halls of schools, colleges, and universities on online platforms, within communities of like-minded individuals, or by contributing to projects and initiatives in the real-world. Learning is far more international than it used to be: key education players open campuses abroad, while students travel to different countries to improve their employability prospects. In the networked, digitally empowered world of the 21st century, education providers often do not have remit or in fact the means and capacity to cover the range of activities learners engage with, which attest their achievements, knowledge, and skills" (Open University 2016).

SMART CONTRACTS AND PROFESSIONAL ENHANCEMENT

MIT, the Open University and Sony Global Education see clear opportunities for blockchain-based applications across a broad range of traditional higher education programmes and their certification, and they are certain to be followed by others. As early adopters set the basis for new expectations many other universities will implement changes, then increasing numbers of people holding degrees from more than one institution will be able to build up comprehensive, secure and verified professional profiles on the blockchain.

In turn, this will raise the significance of certificates of professional enhancement. These are awards made by universities, professional organisations and other specialist education and training organisations that provide certification of achievements outside the framework of formal degree programmes. As shown earlier, these forms of certification are increasing in importance as the world of work becomes more and more complex, and as the crowding of the labour market drives a need for differentiation and enhancement. Their ubiquity has been accelerated by the evolution of first-generation MOOCs into shorter fee-paying courses and the decision by some universities to accept these certificates in consideration of admission to degree programmes, or for credit equivalence.

Such certificates vary enormously in focus, scope, quality and price. At one end of the spectrum are professional enhancement courses delivered by some of highest ranked universities in the world. At the other extreme are certificates that are of little value, and that may have been issued fraudulently. Given this, the blockchain holds particular potential for verifying the outcomes from this form of provision.

The recognition of professional enhancement is of particular value for those who want to "trade up" in building a competitive profile. More specialised, fee-paying online enhancement courses, such as those in the recently-launched HarvardXPLUS collection, provide a certificate from a university that is consistently ranked as the best in the world. Given the strength of the university's general brand, its professional enhancement certificates carry assurance of quality and the value of reputation. This is attractive to employers, and also to those holding primary degrees from lesser ranked universities, who are able to enhance their profiles.

This signals a fork in the path that lies ahead as education embraces the blockchain. Will leading universities stay true to the Satoshi vision of an open system, in which awarding institutions limit their control to verifying the authenticity of their certificates, using smart contracts on Ethereum-like platforms? Or will top ranked institutions follow the lead of global financial services institutions in putting in place "permissioned" blockchains, limiting those whose access to groups is defined by their comparative status, such as US's Ivy League, or the UK's Russell Group (Hall 2016)?

CONCLUSION

This review has demonstrated that the blockchain - and particularly the newer developments such as the Ethereum platform for "smart contracts" - has significant potential for credentialing across all dimensions of higher education (Raths 2016).

In particular, designs for these new technologies re-centre the learner - here the graduate - at the centre of the system of educational value. The blockchain has the potential to provide any individual with a full, secure and guaranteed profile of all the qualifications and professional enhancement awards that they have received from any awarding institution. In turn, this will provide employers with far more appropriate information than is presently available, adding to the efficiency and effectiveness of labour markets of all kinds.

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SARA'S STORY

- *Sara is applying for a job with a new organisation that is making waves across three continents. She's nervous because she knows what a difficult time her older brother Mo had five years ago*
- *The company she wants to work for is a "decentralised autonomous organisation" (DAO). Like other DAOs, it recruits talent through smart contracts on the blockchain. Sara's record of qualifications and experience, responsibilities, objectives, deliverables and remuneration are all part of the same initial agreement*
- *Sara logs into the ConsenSys portal and completes the required iris and fingerprint protocols to access her file of smart contracts – her Personal Learning Record (PLM).*
- *Reviewing her PLM, she notices that her university has entered the wrong grade for her second year Stats module – particularly important for the job she wants. She selects the automated query option and the university acknowledges the request and provides a query reference number*
- *Sara frowns as she sees the Coursera certificate for that MOOC in cheese making. A good idea at the time, she now believes it makes her look frivolous. She decides not to include this in the personal data release profile that's she's tailoring to her employment application*
- *By the next day, she's all set. Her university has corrected the error and the profile she's individualised for this application is ready to go. Sara completes her part of the smart contract proposal and presses send. The company agrees to the contract and a message to her smart phone tells her that her first payment is in her account*

REFERENCES:

Allison, Ian 2016. Ethereum reinvents companies with launch of The DAO. International Business Times, April 30th. http://www.ibtimes.co.uk/ethereum-reinvents-companies-launch-dao-1557576

Economist, 2015. The great chain of being sure about things. Economist, 31 October 2015

Elmes, John 2016. "Government publishes data on law graduate earnings by university". Times Higher Education, 1 December 2016. https://www.timeshighereducation.com/news/government-publishes-data-law-graduate-earnings-university

Ethereum 2016. Ethereum Homestead Release. https://www.ethereum.org/

Financial Times, 2016. Accenture to unveil blockchain editing technique. Financial Times, September 19th.

Greenspan, Gideon 2015. Avoiding the pointless blockchain project. Multichain, November 22. http://www.multichain.com/blog/2015/11/avoiding-pointless-blockchain-project/

Hall, Martin 2016. The blockchain revolution: will universities use it, or abuse it? Times Higher Education, November 28th. https://www.timeshighereducation.com/blog/blockchain-revolution-will-universities-use-it-or-abuse-it

MIT Media Lab, 2016. "Blockcerts: the open standard for blockchain certificates". MIT MediaLab, October 24th 2016.

Nakamoto, Satoshi 2008. Bitcoin: A Peer-to-Peer Electronic Cash System. https://bitcoin.org/bitcoin.pdf

O'Hagan, Andrew 2016. The Satoshi Affair- the many lives of Satoshi Nakamoto. London Review of Books, 30 June 2016.

Open University 2016. Investigating the potential of blockchains. http://blockchain.open.ac.uk/

Raths, David 2016. How Blockchain Will Disrupt the Higher Education Transcript. Campus Technology, 16 May 2016. https://campustechnology.com/articles/2016/05/16/how-blockchain-will-disrupt-the-higher-education-transcript.aspx

Schmidt, Philipp 2015. Certificates, Reputation, and the Blockchain., MIT MediaLab, October 27th. https://medium.com/mit-media-lab/certificates-reputation-and-the-blockchain-aee03622426f#.9uvaxitt9

Sharples, M. and Domingue, J. 2016. The Blockchain and Kudos: a Distributed System for Educational Record, Reputation and Reward, 11th European Conference on Technology Enhanced Learning, Lyon, France, Springer.

Sony Global Education, 2016. Sony Global Education Develops Technology Using Blockchain for Open Sharing of Academic Proficiency and Progress Records. Sony Global Education, 22 February. http://www.sony.net/SonyInfo/News/Press/201602/16-0222E/index.html

Tapscott, Don and Alex Tapscott, 2016. Blockchain Revolution: How the Technology Behind Bitcoin Is Changing Money, Business and the World. Penguin.

THE 2016. World University Rankings, 2015-2016. https://www.timeshighereducation.com/world-university-rankings/2016/world-ranking#!/page/0/length/25/sort_by/rank/sort_order/asc/cols/stats

UNESCO, 2016. Gross Enrolment Ratio by level of education. http://data.uis.unesco.org/?queryid=142

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