Blockchained education: Challenging the long-standing model of academic institutions.

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Abstract.

The model of higher education institutions have remained widely unchallenged over time. Although the topics of study keep evolving and the inclusion of increasingly sophisticated technologies have revolutionized the format of lectures and learning experiences. Their value chain persist unchanged, with institutions acting as intermediaries, between professors (knowledge) and students (recipients), and as central authorities granting and validating a student knowledge.

The coupling of blockchain technology - whose prime novelty constitutes an incorruptible digital ledger of transactions, capable of recording virtually any nature of value exchange - with other emerging technologies such as the internet of things (IoT) and big data, casts light towards novel paths for the decentralised exchange of education and recording of gained knowledge and skills.

The work here presented is a review on blockchain technology and its application on education, with an emphasis on the opportunities for disrupting the current value chain of academic institutions.

The result is a broad analysis of the evolution of blockchain technology for education applications, along with a forecast of plausible scenarios of disruption for academic institutions. Blockchain technology is steadily advancing at accelerating rates; applications aimed at the decentralisation of academic institutions are already available. Meanwhile, the technology keeps gaining momentum in a growing base of adepts.

Introduction.

Distributed ledger technology (DTL) has enabled the rise of cryptocurrencies, which allows the digital transaction of value through complex algorithmic functions. Research on the technology is advancing rapidly (Fig 1). In 2012 there were only two academic articles with the word “Blockchain” in the title as listed in google scholar. Since then, research has grown exponentially and today there are over 2,010 articles with the word “Blockchain” in the title appearing in google scholar searches.

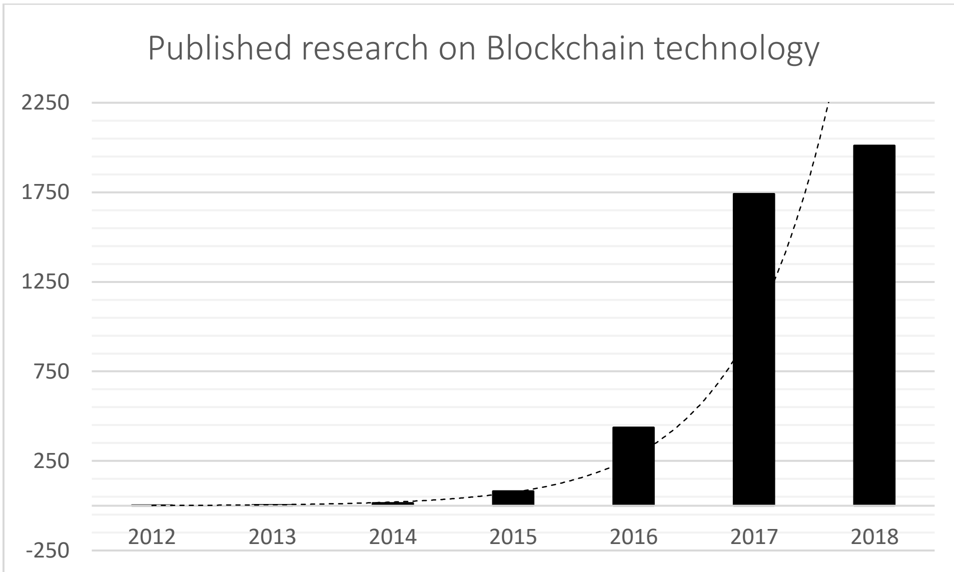

Fig 1 Approximated number of published articles, listed on google scholar, with word "Blockchain" on title.

Blockchain is the technology behind the most popular cryptocurrencies such as Bitcoin and Ethereum (2018), and perhaps the most widely known DLT representative. Nevertheless, is worth noting that Blockchain is just one of the *distributed ledger technologies*; there are other technologies with similar capabilities such as the *Tangle*, used by IOTA (2018). However, it is not the intention of this paper to deal with the technicalities of DLT and rather with its possible application for education or in academic institutions. Throughout this work the terminology DLT and Blockchain are used interchangeably.

DLT networks can be classified as public, private, and semi-private (consortium). Public networks allows anyone with the software to access and potentially add to the Blockchain, examples of these are Bitcoin and Ethereum (2018). Private networks are used within and organization or consortium via an intranet style system, where a select group of nodes are given access to the network e.g. Multichain (2018) or Monero (2018). Semi-private - like Ripple (2018) - uses public-based architecture, yet is privately controlled by centralized ownership of the currency and software (Bauerle, 2017). Each type of Blockchain network has its own rules and specific type of assets to trade encoded in its structure (Grech & Camilleri, 2017). Blockchain aims to create a decentralized network were no third parties are in control of the information (Turkanović, Hölbl, Košič, Heričko, & Kamišalić, 2017). This is achieved by enabling a distributed record of digital events, in a long chain of linked information, redundantly stored on every participant node, and where additional blocks of information are added by consensus of the majority of the participants (Sharples & Domingue, 2016). Turkanović et al. (2017) offers a detailed technical description of the mechanisms in Blockchain.

Those interacting with the network can do it either as users or as nodes. Users require a local software commonly known as crypto wallet in order to trade assets across the network. The wallet provides a unique network address and private key (Devine, 2015), and can be installed directly on a device or accessed by a web browser (Grech & Camilleri, 2017). Nodes need to install the Blockchain software directly in their devices, which stores a complete copy of the Blockchain, and allows them to write directly into the ledger, validate the information in the network and synchronize all the copies of the ledger (Grech & Camilleri, 2017).

The nodes are constantly verifying the validity of the Blockchain by mathematical protocols, ensuring that it is identical to all other copies in the network, the version running on the majority of the nodes is taken as the official version. This is known as "mining" and miners receive coins/tokens in exchange for their processing power (Devine, 2015). This process makes the hacking or destruction of records near impossible or at least extremely difficult, as it would require altering over half the nodes in the network, considering that public networks such as Bitcoin or Ethereum already count with hundreds of thousands of nodes and is constantly growing, the computational power for the task might be beyond current technology. Moreover, to destroy the Blockchain it would be necessary to eliminate all the records of the ledger in the world (Grech & Camilleri, 2017).

The ledger in the Blockchain network only allows appending information, forming new blocks with every recorded transaction. Each block is chained to the previous blocks in the network creating a chain of blocks, this means that transactions can only be added but not edited or deleted (Grech & Camilleri, 2017).

The before mentioned traits of Blockchain technology - i.e. distributed computing, thorough tracking of events, revision by consensus, enduring quality of information and resilient data infrastructure – results in a differentiated value proposition encompassing 1) self-sovereignty and identity, 2) high levels of trust, 3) transparency and provenance, 4) immutability of registered events, and 5) disintermediation (Grech & Camilleri, 2017).

Distributed computing.

Blockchain technology is at its core a distributed digital ledger, different to centralized networks and central systems in two ways; i.e. the information is distributed on a network of machines, with changes to the ledger reflected simultaneously for all holders of the ledger, and the use of a cryptographic signature to authenticate information (Deshpande, Start, Lepetit, & Gunashekar, 2017).

Grech & Camilleri (2017) explains the concepts rather well, describing how in the case of centralized databases, information is stored and executed on a single central node e.g. national land registry. Then its variation, a decentralized ledger where several parties share responsibilities of a single central ledger e.g. national land registry administered by regional offices, each with the authority to store and process transactions within is region. In both cases if the server is down, there is no access to the ledger. Finally Blockchain, a decentralized and distributed ledger, with no central controlling authority, instead every node keeps a complete copy of the ledger, any modification to the ledger requires consensus from the other nodes, and where every copy of the ledger is authoritative with changes and addition to it recorded on every copy on every node (Fig 2).

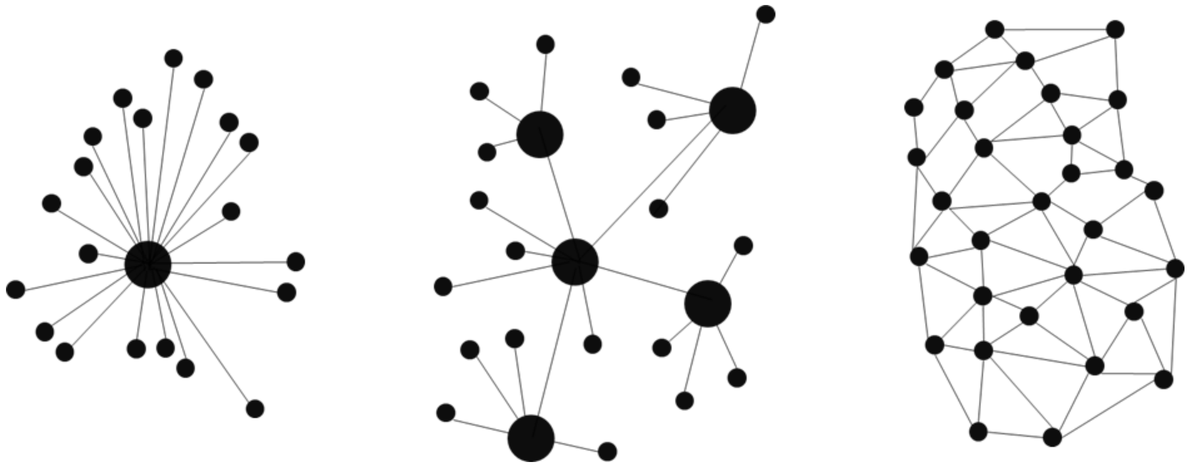

Fig 2 Different types of databases: centralized (left), decentralized (middle), distributed (right).

The foremost features of the technology could be define by redundancy, distribution and decentralization. Blockchain creates multiple copies of the ledger (redundancy) that are held by different parties (distribution) and data in the Blockchain network is added by consensus without the need of a third party (decentralization). This gives Blockchain potential gains in efficiency, trust and data reconciliation across all ledger participants, which in turns grants specific characteristics to the technology such as (Deshpande et al., 2017):

- Immutable records: Data added to the ledger is, in theory, unchangeable, secured and preserved by the ledger.
- Direct mediation: No intermediaries are required as nodes are able to interact directly.
- Decentralization: Auditions to the ledger or changes to the governing structure are made by consensus of the multiple participants.
- Data management and sharing: Various forms of data could be added to the ledger e.g. digital assets such as cryptocurrency, or physical assets such as land titles or fiat currency.

As previously mentioned, Blockchain is not exclusive for cryptocurrencies, in fact it can be used to exchange a variety of assets e.g. land titles, ID documents, certificates and more (Grech & Camilleri, 2017). As the technology advances and is better understood, novel applications beyond the financial sector keep arising e.g. in the creative industry managing intellectual property rights (Hoy, 2017; Sharples & Domingue, 2016), or open innovation processes (de la Rosa et al., 2017). For the integration of the internet of things (Prabhu & Prabhu, 2017). In medical sciences for diverse purposes (Hoy, 2017; Irving & Holden, 2016; Skiba, 2017). For the management of devices in the internet of things (Prabhu & Prabhu, 2017). And in education (Bore et al., 2017; Chen, Xu, Lu, & Chen, 2018; Devine, 2015; Grech & Camilleri, 2017; Rooksby & Dimitrov, 2017; Sharples & Domingue, 2016; Sony Corporation, 2017; Tapscott & Tapscott, 2017; Turkanović et al., 2017), to name a few.

Recently the Government Office for Science, UK (2016) noted three primary opportunities derived by particular functionalities of the Blockchain technology i.e. cryptocurrency exchanges, development of novel by third parties to create new efficiencies, and the creation of new form of contracts e.g. “Smart Contracts”. Being the latter a potential derivation of the technology worth analyzing.

Smart contracts.

Melanie Swan (2015) forecasts three stages of adoption for Blockchain technology. In the first stage, named Blockchain 1.0, the technology founds applications mainly as an online cryptocurrency. The second stage, Blockchain 2.0, will exploit the functionality of smart contracts, finding applications to track contracts, financial records, public records and property ownership. The third stage, Blockchain 3.0, expands beyond financial services and smart contracts, and finds application in science, medicine and education; and envisions a future in which the technology makes openly available through distributed networks, hidden information that otherwise would have been inaccessible to the public (Hoy, 2017).

Smart contracts work as programed triggers that execute pre-agreed transactions, as per a contract, yet without intermediaries (Devine, 2015), enabling business and legal agreements to be stored and executed digitally (Sharples & Domingue, 2016). Grech & Camilleri (2017) defined smart contracts as “small computer programs stored on a Blockchain, which will perform a transaction under specified conditions”, with declarations such as “transfer X to Y if Z occurs”. At the most basic level, smart contracts appear as “a set of promises specified in digital form, including protocols within which the parties perform on these promises (Murphy & Murphy, 2016). The technology could find a variety of applications in the form of automated invoicing (Sharples & Domingue, 2016).

Smart contracts are self-executing, meaning that once the contract has been embedded on a Blockchain, the transaction will take place automatically when the conditions are met, without the need of third parties or intermediaries (Grech & Camilleri, 2017). They exploit the capabilities of immutability, decentralization and direct-mediation of the Distributed Ledger Technology.

Their applications has been explored for financial instruments, self-governing processes, decentralized gambling, student loans, legal processes to name a few (Gazali, Hassan, Nor, & Rahman, 2017; Luu, Chu, Olickel, Saxena, & Hobor, 2016; Murphy & Murphy, 2016).

Blockchained education: categories for innovation.

Various authors agree on the obvious application of the technology to store student records, which could then be shared publicly with third parties, providing a safe and enduring record, resilient against data loss (Devine, 2015; Sharples & Domingue, 2016). E.g. the University of Nicosia is already running their academic certificate records on a Blockchain network (UNIC Blockchain Initiative, 2017); thus, third party users could verify a student record directly by accessing the University Blockchain (Sharples et al., 2016). Sony (2017) has developed a system, applying Blockchain technology, for the authentication, sharing and rights management of educational institutions records. Blockchained records could allow the integration of creative works, artistic developments, among other types of intellectual work (Sharples et al., 2016).

As the technology its better understood, sophisticated applications keep arising, most of them based on analogies of the value transaction with financial tokens, changing what is refer to by value (e.g. intellectual value) and mining (allocation of value blocks).

Tapscott & Tapscott (2017) described four main categories for innovation in higher education, their challenges and the possible use of Blockchain technology to address them. These categories were used to classify the area of innovation of the various Blockchain projects analyzed in this research.

The first category 1) Identity and student records; presents three main challenges being a) to maintain the privacy and security of data stored digitally, b) the validity of the information recorded, and c) time spent studying. In this case, Blockchain technology could be used to securely encrypt the data collected by institutions. The information recorded and encrypted would remain valid and official within the chain i.e. certificates, student information etc, and with the development of adequate tools, a Blockchain system could be able to recognize students for everything they learn, independently of settings i.e. within a university course, on a job experience, on life experience and more.

The second category described as 2) New pedagogy. Universities rely on the prestige of their academic models to ensure third parties about the quality of education acquired by the students. The broadcast model of learning remains common in many Universities, with teachers acting as broadcasters and students as recipients of a one-way message. Such model might not be any longer appropriate for the digital age. With information widely available online, self-paced computer learning programs could carry the mastery of knowledge (situations where there is a right and wrong answer) while classroom time is allocated for debate, discussion and collaboration around projects. New pedagogy models would be based on learning by doing, exchanging orthodox curricula for heterodox learning processes in which students capitalize what they have learned in topics they are really passionate about, such as the case of Vitalik Buttering, the founder of Ethereum (Tapscott & Tapscott, 2017). An approximation of this model is the Thiel Fellowship program, which awards *"$100,000 to young people who want to build new things instead of sitting in a classroom"* (Thiel Fellowship, n.d.). Blockchain is enabling new collaborative models; one example is Consensus System (ConsenSys), one of the earlies development under Ethereum code, the models allows for a *holocratic* management of science based on collaboration rather than hierarchical structures. ConsenSys allows its members to choose between two to five projects to work on. Everyone owns a piece of the project, in the form of tokens under the Ethereum platform. For the classroom the key objectives are agility, openness, and consensus; i.e. identify what needs learning, distribute the work among students, agree on their roles, responsibilities and rewards, and codify these rights in smart contracts.

The third category is 3) Education costs. Blockchain technology allows for a) a reliable proof-of-truth mechanism e.g. to confirm if students signed in MOOCs completed the course, took the tests, and mastered the material, b) payment mechanisms, and c) learning plans established under smart contracts (Swan, 2015). The Blockchain "pay for success" scheme (Swan, 2015) could enable private companies support the development of skills they are interested, by financing individual students achieve specific learning goals and reward them accordingly, making students accountable for their own progress. Blockchain could be used to reward the application of the learned skills e.g. a student could payback the student debt by teaching the topic he previously learner, the Blockchain database would match skills with market demand. The system could be developed to such a level where it could to calculate the precise value of each element of the learning curricula, allowing funding providers to pay for a student complete education in exchange for a student's future earnings (Tapscott & Tapscott, 2017).

The fourth category relates to 4) The meta-university is related to the brainchild idea of MIT President Emeritus Dr. Charles Vest, who offered a vision in which the open access movement created an accessible, empowering, dynamic and communally constructed framework of open material to construct or enhance higher education worldwide. Where the web provides the communication infrastructure and an open access library would provide the knowledge (Tapscott & Tapscott, 2017). According to Dr. Charles, such a system could accelerate the diffusion of knowledge and education. Under this framework, Tapscott and Tapscott envision three stages for the application of Blockchain. The first stage involves content exchange, the second is content co-innovation, and finally in stage three Colleges and universities become a node in a global network of the education ecosystem. Under a vision of a global network of learning, students would receive custom learning experience, coming from a diverse source of institutions, while Blockchain serves to track the students' progress and performance (Tapscott & Tapscott, 2017).

Blockchained education: projects review.

Devine (2015) described two possible applications of Blockchain in education. One with Smart Contracts to shape an autonomous learning experience by using an analogy from the financial application of Blockchain, in which a unit of value is created to represent learning achievements, with one side being the financial value, and on the other the learning and teaching activity. In this model, which he named Blockchain learning, teachers function as miners placing learning blocks, and creating the opportunity for the learning to occur through their actions of teaching, comparable to an income, ready to be spent by students. The second application is the use of Blockchain to offset the cost of learning using peer-to-peer networks, providing financial reward for students offering services to the university.

Sharples & Domingue (2016) proposed a permanent distributed record of intellectual effort and associated reputational reward that would go beyond the academic community, making use of rating mechanisms similar to those found in multi-sided platforms such as Uber or Amazon. Their system acts as an hybrid between institutional records and a fee system payment, in which students are awarded "Kudos" (a fictional educational reputation currency) as they complete milestones like passing a tests or completing a course, while students pay the institution in cryptocurrency (e.g. Bitcoin) for the mentoring to achieve the milestones. In this model, educational institutions would carry the "mining" process to obtain reputation credits. The proposed educational Blockchain, would also work as a record of authorship for intellectual works (e.g. scholarly articles, artworks, poems, great ideas), that could add to a student e-portfolio. A version, including major characteristic of the proposed system, is already on operation by the Open University through their OpenLearn platform, where students earn OpenLearn badges that can be viewed in a student Learning Passport.

Blockcerts is an open standard for Blockchain credentials developed by the MIT Media Lab in collaboration with Learning Machine, a software developer. The platform allows users to register official records, giving individuals *"the capacity to possess and share their own official records"* (Blockcerts, 2016).

Hoy (2017) described the potential use of Blockchain to help librarians gather, preserve, and share authorship information, for example, with the use of timestamped, verifiable versions of journal articles, and comments how such application has already been tested for the authentication of medical science archives by Irving & Holden (2016). Another application described by the author, is the use of Blockchain as a digital rights management (DRM) tool, allowing digital materials to be uniquely identified, controlled, and transferred. These applications could be implemented in education to have verifiable records of academic achievements.

Turkanović et al. (2017) talks about the problems with the lack of interoperability of student records in educational institutions, and calls the example of students emigrating to a foreign country and the problems involved in retrieving their academic records. That is the motivation behind EduCTX, a Blockchain platform for global higher education credits, based on the concept of the European Credit Transfer and Accumulation System. EduCTX consists of a trusted, decentralized higher education credit, and grading system, offering a unified record for students and academic institutions, where peers of the Blockchain network are higher education institutions and user of the platforms are students and other organizations. A proof of concept for EduCTX was implemented based on Ark Blockchain Platform.

Sony (2017) developed a Blockchain system to keep track of educational achievements and activity records, with the capacity to integrate multiple educational institutions in order to safely interchange school grades, educational records and digital transcripts. The applications also aims to analise data and records using artificial intelligence (AI) to provide improvement suggestions to the curriculum and management of institutional educations. The platform built on IBM Blockchain powered by Hyperledger 1.0, its main features are a) the authentication and control for the usage rights of educational data, and b) an application programming interface for handling such rights.

Bore et al. (2017) worked on a Blockchain-enabled School Information Hub (SIH) applied to the Kenya school system aiming at improving their record keeping process. Highlighting how problems such as the reliability of records of a transfer student could be solved using Blockchain technology capabilities i.e. establishing verifiable control points and manage compliance assurance (data), assuring the integrity of recorded transactions (immutability), and assuring the execution of transactions by identifiable entities (non-repuditation). This gives the capability to keep irreversible records of all entries and changes to school registers, assuring their correct attribution by contemporary means, and ensuring the immutability of the entered data by network consensus using cryptographic algorithms. The aim of the before mentioned Blockchain application was to solve four main challenges; 1) keep a reliable record of students and teachers registered in the public school systems, thus avoiding extra expenses created by "ghosts" teachers or students. 2) Improving the transparency and accountability of budget allocation and spending within the school system. 3) Improving the learning environment, correlating school performance data with teacher/students records. And 4) improving the learning experience with the creation of personalized education programs.

Grech & Camilleri (2017) discussed in depth the use of Blockchain for issuing academic certificates. The technical depth of their work is worth noting, as it is a good source reference to understand the mechanisms of Blockchain technology, especially when applied to issue certificates of academic value. Their work is strongly based around the capacity and benefits of using Blockchain technology to issue academic certificates, and provides thorough information on the products developed by various providers for this purpose. Their work is an important review, addressing issues on code and practices standardization. The authors provide eight usage scenarios for Blockchain in education in the short, medium and long term (Table 1).

Table 1 Eight possible uses for Blockchain technology in education ((Grech & Camilleri, 2017).

Scenario	Term
To permanently secure certificates.	Short term
To verify multi-step accreditation.	Short term
To receive payments.	Short term
For automatic recognition and transfer of credits.	Medium term
As a lifelong learning passport.	Medium term
To track intellectual property and rewarding its use and re-use.	Medium term
For student identification.	Medium term
To provide students with government funding, via vouchers.	Long term

Gazali et al. (2017) explores the use of Blockchain to re-invent the National Higher Education Fund Corporation (PTPTN) of Malaysia, which acts as the major source of financing tertiary education in the country. In this case, Blockchain could be used to ensure timely payments from borrowers as well as improving the management system of the funding institution, all these achieved through a Smart contract application based on the Ethereum platform. The proposed application would create a smart contract between the student and the financial institution, in which the academic institution is involved and in charge of reporting the student academic status. The correct use of smart contracts could reduce issues of transparency and management costs.

Raju et al. (2017) present the conceptual design of a *data bank* as an institution of trust based on Blockchain to govern healthcare and education. The proposed *data bank* aims to deliver substantial improvement in both the scope and quality of health and education services, this is achieved by the assessing data that is continuous and complete in order to make informed decisions.

Rooksby & Dimitrov (2017) implemented a Blockchain system based on Ethereum to store student grades and provide a cryptocurrency. Their system focused on student grades and had the functionality to store student records (course enrollment information, grades and final degree), support a University specific cryptocurrency (Kelvin Coin), and allow payments of Kelvin Coins automatically allocated to the top performing students via smart contracts. The system is a functional prototype to demonstrate the potential of the technology to provide trustworthy records (tamperproof and transparent), and transparency for awarding grades. During their exercise, they discussed several tensions between the concept of a university as an organization and that of distributed autonomous organizations, which reflect on the mechanisms of trust, the boundary of openness and values in procedures by the two types of organizations. They noted that for their exercise, Blockchain did not provided gains on efficiency or cost reduction of the administrative process of the University.

Methodology.

Innovations can be catalogued into four types (Satel, 2017): sustaining, disruptive, breakthrough, and basic research which for ease of purpose and to keep with the simplicity of a single word will be referred as fundamental. These categories are based on two criteria i.e. how well is the problem defined and how well is the domain defined (Table 2).

Table 2 The types of innovation matrix (Satel, 2017).

How well is the problem defined?		How well is the domain defined? Not well	How well is the domain defined? well
	Well	**Breakthrough** Breaks an established paradigm.	**Sustaining** Improves existing capabilities in existing markets.
	Not well	**Fundamental** Uncovers new knowledge on the mechanisms of a given phenomenon.	**Disruptive** Develops new basis of competition in the market.

Products can also be classified according to their functionality. The concept of *Job to be done* (C M Christensen & Raynor, 2003) states that the reason a customer buys a product, service or a specific solution is due to the job these items fulfill. A "job" is the fundamental action a customer wants to achieve with a product. The *JTBD* involves the idea that we "hire" products for their functionality (Clayton M Christensen, Anthony, Berstell, & Nitterhouse, 2007). Silverstain et al. (2012) described four main types of organic growth strategies based on the functionality (JTBD) of a product i.e. Core growth, related job growth, new job growth and disruptive growth (Table 3).

Table 3 Functionality - Market matrix (JTBD organic growth matrix) (Silverstain et al., 2012).

Functionality		Market: Existing	Market: New
	New	**Related growth** Adds functionalities to the product.	**New growth** Adds new functionalities, offered to new markets.
	Existing	**Core growth** Improve the main functionality of the product.	**Disruptive growth** Enable the product to new (non-consumption) market.

The revised Blockchain education projects were classified according to their category of innovation (Tapscott & Tapscott, 2017), their type of innovation (Table 2) based on the model by Satel (2017), and their functionality (Table 3) based on the JTBD organic growth model by Silverstain et al. (2012).

First, it was necessary to identify the project category in order to establish the type of innovation it represented i.e. if the Blockchain project presented an improvement in the way identity and student records are taken it would be classified as "Sustaining". If the project developed new ways to carry the activities of the given category i.e. changes the established value chain of the activities in the category, classifies as "Disruptive". A fundamental innovation would require the project to uncover previously unknown mechanics or interactions within the given category of impact. Moreover, for a breakthrough innovation, the project should have presented a mechanism to completely replace the establish practices within the given category e.g. to eliminate education costs.

The project functionality was classified according to the features integrated into the given project category e.g. A project growth identified as "Core" represents an improvement in the way activities are carried in the given category. If the project presented an added functionality, e.g. the inclusion of big data analytics within the identity and student records, then it would classify as "Related" growth. The "Disruptive" growth applies in cases when the project enabled new dynamics or mechanisms, which enables the access of new users e.g. new mechanism to pay for education costs. Finally the "New" growth relates to a project that enables new dynamics or mechanisms for new markets into the given category e.g. The educational Blockchain model is enabling new mechanisms to provide education, and at the same time is enabling new users who could not attend an establish institution.

Table 4 Analysis of Blockchain education projects.

Author	Application	Category	Innovation	Growth
University of Nicosia	Official records and data integration.	Identity and student records.	Sustaining	Core
Devine (2015)	Blockchain learning: Smart Contracts to shape an autonomous learning experience.	New pedagogy	Disruptive	Core
Devine (2015)	Offset education costs.	Education costs	Disruptive	Disruptive
Sharples & Domingue (2016)	Educational Blockchain model.	New pedagogy	Disruptive	New
Blockcerts (2016)	Official records and data integration.	Identity and students records	Sustaining	Core
Hoy (2017)	Gather, share and preserve authorship information.	Identity and students records	Sustaining	Core
Turkanović et al. (2017)	Official records and data integration.	Identity and students records.	Sustaining	Core
Sony (2017)	Official records and data integration.	Identity and students records.	Sustaining	Related
Bore et al. (2017)	Official records and data integration.	Identity and students records	Sustaining	Related
Grech & Camilleri (2017)	Official records and data integration.	Identity and students records	Sustaining	Core
Gazali et al. (2017)	Ensure timely payments.	Education costs	Sustaining	Core
Raju et al. (2017)	Official records and data integration.	Identity and students records.	Sustaining	Core
Rooksby & Dimitrov (2017)	Official records and data integration.	Identity and students records	Sustaining	Core

Results and discussion.

Most of the reviewed Blockchain projects presented a sustaining innovation, while providing “Core” growths (improvements) i.e. these projects presented mainly a replacement of technology, changing the previously used tools or methods, by new methods based on Blockchain technology. Such projects tend to present a modest improvement in the “Category” of innovation e.g. making student records more easily accessible, or increasing their security. However, these innovations are not “game changers” and do not represent a shift on the standing model of academic institutions, and their impact is more in the performance of the mechanisms of the standing model of academic institutions.

Fewer projects presented sustaining innovations with “Related” growths i.e. these projects presented an added functionality enabled by Blockchain technology that was previously not possible within the “Category” if innovation. E.g. Sony (2017) is planning to add artificial intelligence into the Blockchain platform for “Identity and students records”, similarly Bore et al. (2017) is adding data analytics to correlate information leveraging on the reliability of information provided by the Blockchain platform.

Devine (2015) presented a project of “Disruptive” innovation which enables “New pedagogy” mechanisms creating a new learning platform and educational system based on the “Smart contract” capabilities of Blockchain technology. Nevertheless, it remains a “Core” improvement on the way education is provided and accessed, and does not enables new users or markets.

Devine (2015) also presents a project of proposing new mechanism to cover “Educational costs” complying with “Disruptive” innovation qualities, which at the same time enables new users which otherwise would not been able to cover the educational costs, thus providing a “Disruptive” growth in the category of “Educational costs”.

Sharples & Domingue (2016) proposes a new learning platform and educational system based on the capabilities of Blockchain technology. Such platform applies as a “Disruptive” innovation in the category of “New pedagogy” as it changes the mechanism to access, provide and grade education. Moreover, such platform provides a “New” growth as it would enable new markets and new users to access and provide education.

Blockchain disruption.

Kelly (2016) noted, from a previous observation by Marshall McLuhan, how the first version of a new media imitates the media it replaces e.g. the first commercial computers employed the metaphor of the office, having “desktop”, “folders” and “files” (Kelly, 2016). Brian Arthur (2007) carried an in depth study on the fundamentals of technology evolution. He observed the autopoietic properties of technologies i.e. technologies build upon previous technologies, or said in another manner technology would spawn further new technologies e.g. the creators of internet never imagined the conception of Netflix, Facebook, the smartphone or WhatsApp.

Blockchain technology is an immediate improvement on the security, reliability and resilience of information in comparison with centralized databases. Is not surprising to find the first generation of Blockchain applications being merely a “one-to-one” replacement of the previous media, in this case centralized databases (first law of technology evolution). In addition, as stated by the previously mentioned second law of technology evolution, there will be new technology derived from the functionalities enabled by Blockchain technology. Blockchain might provide a “trustless “organization while Universities trade on trust gain by reputation (Rooksby & Dimitrov, 2017).

An arising concern of the trading of educational asset, is the commoditization of education itself, in a system in which a user could trade educational products without concern for their intellectual value, in such system, education is reduced to a marketplace of knowledge and reputation (Sharples & Domingue, 2016). This topic would require further study.

Conclusions.

Most of the current envision applications of Blockchain technology in the model of academic institution represent a sustaining innovation merely changing one technology (current data bases) for other (Blockchain platforms), making use of the improved qualities provided by the novel technology i.e. reliability and ease of access.

A few applications with disruptive qualities have been envisioned, affecting “Educational Costs” and “New pedagogy” methods. However, neither the technology nor the satellite infrastructure might be ready to support a change in the current model of academic institutions i.e. a Blockchain platform might not replace academic institutions in the short term.

Various technical issues need to be overcome in order to exploit the full capabilities of Blockchain technology in an educational or academic organization, or rather said, in order for a DLT to become a fully functional academic ledger that will replace current academic institutions.

We are merely in the first generation of the Blockchain technology, and most probably, the infrastructure required for the total disruption of the model of academic institutions is not yet available. However, following the observations from Kelly (2016) and Arthur (2007) we can infer that the first building blocks of disruption have already been laid.

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