Blockchain in education: What are the benefits for lifelong learning?

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Abstract

How could blockchain support global lifelong learning, defined as the self-motivated and voluntary, ongoing pursuit of knowledge for either personal or professional reasons? Interjecting a technology supported learning offering between the global and the self, and between the personal and the professional, poses complex design challenges that keep changing for every new technological breakthrough. In order to understand what blockchain has to offer global lifelong learning this paper develops a conceptual framework to grasp the essence of distribute ledger technology (blockchain) in education. The main properties of the technology may be described as self-sovereignty, trust, transparency, immutability, disintermediation, and collaboration. In this paper we see how these properties could be exploited by new technologies, and analyse how global lifelong learning would benefit.

The paper builds on desk research and collection of use cases in the context of the International Standardisation Organization's ad hoc group on blockchain in education. Analysis of recent reports shows that issuing of certificates and issuing of digital signatures is the application area that has received most attention when discussing blockchain. However, other fields of importance to global lifelong learning may as well be supported, like identity management, management of IP, design of courseware, analysis of learning processes (learning analytics), etc. The paper will contribute to an overview of application domains, and will help educational strategists to develop a coherent picture of benefits and pitfalls of blockchain in education.

1 Introduction

The application of blockchain to education is new – with little peer-reviewed published literature in the area (Grech & Camilleri, 2017). When the European Commission researched this field in 2017 they concluded that

(a) blockchain technology will accelerate the end of a paper-based system for certificates; more advanced blockchain implementations could also be used to automate the award, recognition and transfer of credits, or even to store and verify a complete record of formal and non-formal achievements throughout lifelong learning.

(b) Blockchain technology would likely remove the need for educational organisations to validate credentials; and the technology would also be applied to intellectual property management, for the tracking of first publication and citations, without the need of a central

authority to manage these databases, which, in turn, enables, e.g. the possibility of automatically tracking the use and re-use of open educational resources.

(c) Blockchain technologies could to create data management structures where users have increased ownership and control over their own data could significantly reduce educational organisations' data management costs, as well as their exposure to liability resulting from data management issues.

(d) Finally, blockchain-based cryptocurrencies are likely to be used to facilitate payments within some institutions, and be used in grant or voucher-based funding of education in many countries. (Grech & Camilleri, 2017).

A recent summary of global use cases and case studies by an ISO study group on blockchain in education (SC36 Ad Hoc Group 5, 2020) found that the last 3 - 5 years a great number of educational institutions in all regions of the world experiment with blockchain solutions, some of them part of national policies. New applications beyond the ones identified by the European Commission report are now being tested.

 China has been an early adopter of distributed ledger technologies (DLT). In 2016, the Chinese Ministry of Industry and Information Technology published a whitepaper on blockchain and its applications (Chinese Academy, 2016). Addressing education and employment, the whitepaper positioned blockchain as a window of opportunity for teaching and knowledge disseminations, enabling a "seamless connection between students, educational institutions and employment units in order to improve the operational efficiency and transparency of education and employment institutions" (Google translation from Chinese). It is the characteristics of the *transparency* of the blockchain system and the *immutability* of data the whitepaper claims give benefits to "healthy development of education and employment", especially regarding aspects of student credit management, further employment, academics, qualification certification, and industry-academia cooperation, etc. (Chinese Academy, 2016)

The Chinese Government, compared to other countries, did early acknowledge that blockchain has relevance for education, giving some directions on where the focus should be for further investigations. Later, also other nations have issued whitepapers on blockchain and education, most notably the European Union (Grech & Camilleri, 2017), . What is interesting with the Chinese direction for development is the pinpointing of the intersection of education and employment as the important area to explore. This is the area of lifelong learning, where learning, training, and employment interchange seamlessly as students progress their learning trajectory and build their skills based on the offerings of educational systems as well as the needs of the workplace. In this paper we will put the needs of lifelong learning at the centre and explore what blockchain has to offer. In the Chinese whitepaper, it was the characteristics of transparency and immutability that was emphasised; however, we will carry out a more complete exploration of blockchain's abilities to extrapolate benefits that may be exploited when education meets the workplace.

This research will be guided by a simple model, see Figure 1, describing how blockchain abilities—or more general, properties of distributed ledger technologies (DLT)—are *enabling* technologies that are *illustrated in* specific usage scenarios described in use cases. The model also includes standards (and other policies or guidelines) that *support* (make it possible or easier to build) the solutions that are described in the use cases.
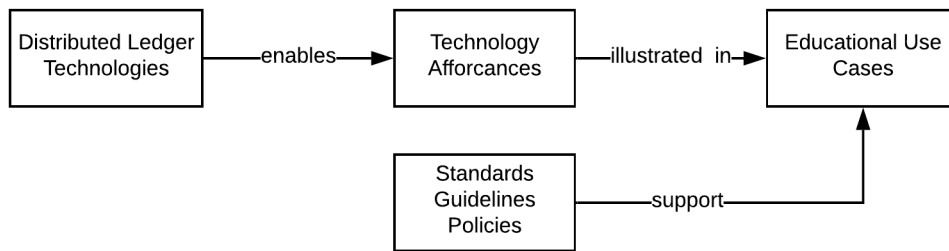
Figure 1. *Model of research process into the relationship between blockchain and education.*

We note that seamless relationship between education and employment was the prominent issue to solve, as identified in the Chinese Ministry of Industry and Information Technology's whitepaper. We will start the desk research by analysing policies for Chinese lifelong learning to get a more detailed view on what problems there are to be solved.

2 Literature review

Till now, the main focus of blockchain application research has not been education. Alammary, Alhazmi, Almasri, and Gillani (2019) did a systematic review of research literature starting out with over 2000 articles, ending up with 31 on blockchain in education. Most of these papers were published since 2017. It is interesting to note that the geographical distributions of these papers put China at the front together with the UK (6 each), with USA next with 3 papers.

> Of the 31 articles included in this review, four articles (13%) described applications that have been already developed and are now being used. In 16 articles (51%), a prototype of the proposed application is developed and evaluated but not yet used by real users. In 11 articles (36%), the application is proposed and its features are described, but no implementation has been made yet. (Alammary et al., 2019, p. 7)

The review of the 31 papers highlighted 10 different types of benefits and 9 different types of challenges that blockchain could bring to education, see Figure 2.
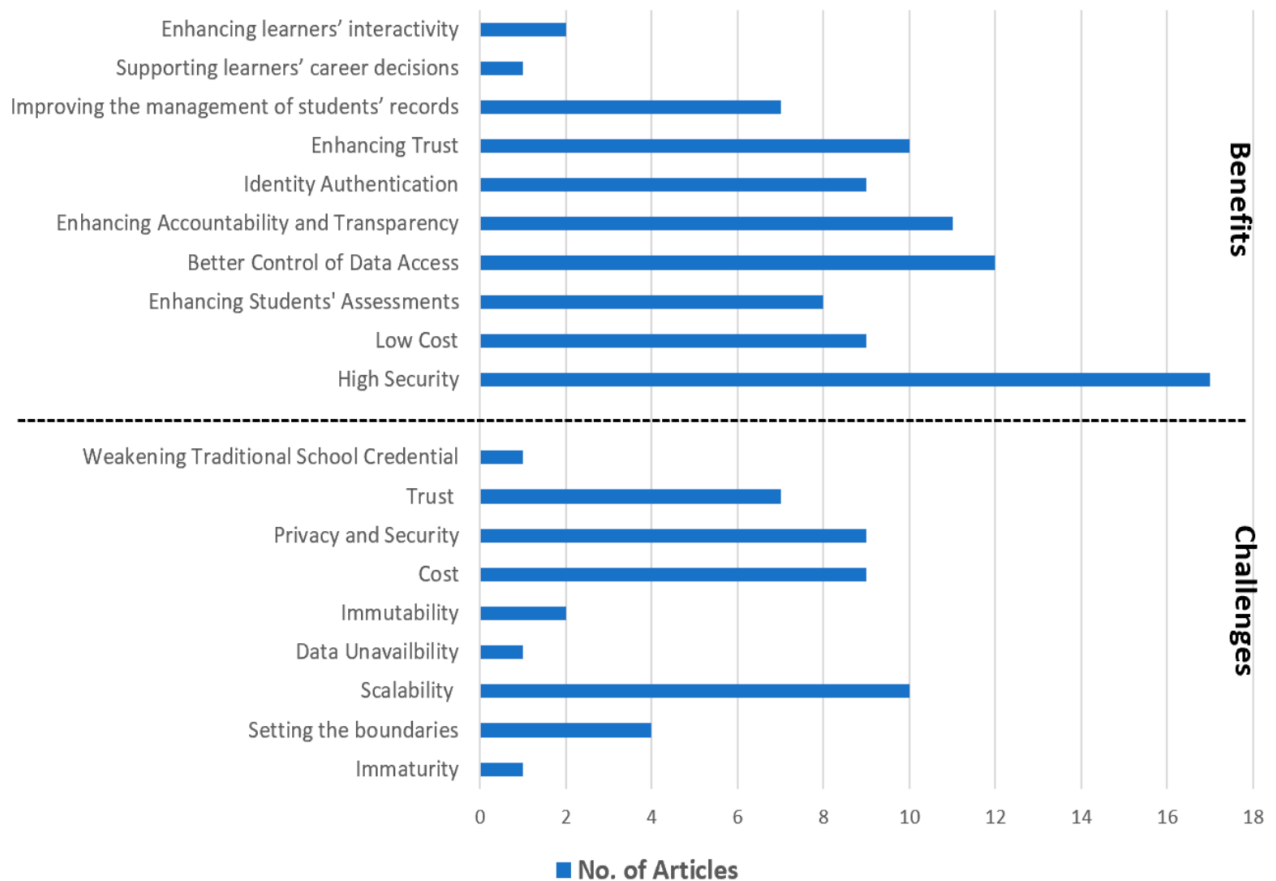
Figure 2. Benefits and challenges of adopting blockchain technology in education (Alammary et al., 2019).

The following application categories were identified in the papers analysed by (Alammary et al., 2019):

- Certificates management
- Competencies and learning outcomes management
- Evaluating students' professional ability
- Securing collaborative learning environment
- Protecting learning objects
- Fees and credits transfer
- Obtaining digital guardianship consent
- Competitions management
- Copyrights management
- Enhancing students' interactions in e-learning
- Examination review
- Supporting lifelong learning

These categories represent an applications space that needs to be explored and related to policy goals set up for lifelong learning institutions.

One Chinese paper not included in the above review is Wu et al.'s 2020 paper, which does a thorough review of the research status in China and abroad related to blockchain in education. These authors see cooperation across schools, across school and enterprise, and across borders driving the integration of blockchain in the learning space. The problem that needs to be solved is the 'trust crisis' related to learning track records and credit certification. This highlights issues of security, distribution, and transparency, according to

Wu et al. (2020).

The research group from East China Normal University did a quantitative analysis of 8,775 papers related to blockchain retrieved from China Knowledge Network resulting in identification of three stages of development: pre-accumulation (2013-2015), application surge (2016-2018), and application landing (2018-2020). Wu et al. selected 296 Chinese papers that put blockchain in relation to education and found an interesting trend when looking at the keywords of these papers. In the first stage the most frequent keywords were learning communities, followed by learners, education, certificate, credit certification, learning experience, and blockchain transcript. In the second stage (2017-2018) the most prevalent keywords changed to online education, credit bank, education information, learning achievement certification, open education resources, vocational education, and intelligent education. In the last phase, 'learner' was the most frequently used keyword, followed by education teaching, online education, credit bank, mixed reality, and learning experience. The authors conclude:

> It can be seen that the application of blockchain in education reflects the "learner-centric" application model. In addition, the emergence of "privacy protection" reflects that researchers at this stage are considering the impact of blockchain on education in terms of ethics and security. "Lifelong education" indicates that researchers will explore the long-term development role of blockchain in education from the ultimate goal of education. (Wu et al., 2020)

Wu et al. also did a qualitative analysis of a subset of the papers exploring what were the domestic versus the foreign research hotspots. They found that research communities outside of China focussed mainly on blockchain-based credit and certificate management, blockchain-based learning evaluation, and blockchain-based identity authentication. This is also the focus of domestic research, in addition Wu et al. (2020) found that if classified by application purpose domestic research "is mainly reflected in the construction of digital education resources based on blockchain, file management, storage and tracking of learning data, and intelligent learning robot design".

In economic, educational and technological terms, Shanghai is a one of the most advanced cities in China. In document 10 of 2019 the Shanghai Education Commission (2019) outlines how lifelong learning education should be strengthened and how the education and training market should be supervised. The document, which is held in a rather abstract language, hinges on one particular and concrete vision: centralised deposit of information on Shanghai lifelong education in an educational credit bank. All workplace learning should be credited and deposited in the credit bank that *recognises, accumulates,* and *converts* learning achievements for all citizens throughout life.

The justification this document no. 10 gives for building such a system is the goal to implement the spirit of a national vocational education reform, "to realize the *traceability, inquiry,* and *conversion of learning achievements*" (our italics). In order to go through an lifelong career in a workplace nobody knows will look like, there is a need to assist the individual in documenting learning achievements, validating competence claims, and converting the value of these claims to be compared to new standards in future jobs. It is interesting to note, especially on the background of the 2016 national whitepaper on blockchain, that the Shanghai municipality envisions a "centralized storage of corporate education learning achievement information in credit banks [as] an important part of establishing a personal learning record file that covers all citizens and accompanies for the whole life" (Shanghai Education Commission, 2019).

3. Characteristics of lifelong learning

Lifelong learning delivers varied forms of learning that traditionally involve adult education and learning, vocational education and training, and higher education—practices, which sit in the intersection between educational and employment policies. Lifelong learning has also civic engagement aspects that contribute to inclusion, social wellbeing and other social benefits as well as economical benefits and jobs (UNESCO, 2019; McMahon, 1998). Provisioning of lifelong learning takes place anytime and everywhere, using many systems of delivery, targeting different age groups. Many types of providers are involved, exploiting a wide variety of business models. In building up requirements for lifelong learning support systems we notice that the main common denominator of such a complex ecosystem is transitions between different states of such a system. There are transitions between different levels of education as students grow up. There are transitions between formal and informal education; between education, employment, and retirement; between on site training and campus education; and so on. And then there are the transitions that provisioners of education and training go through. School teachers make a difference for their students by teaching core skills and channelling learners through post-compulsory pathways of education and training. Other professionals, like higher education lecturers, adult educators, vocational trainers, employers and many types of public officers also tackle to the needs of people who approach education and training from very different perspectives at many points of their life course. As Rambla & Millan (2020) note, all these practitioners have to experiment with variable and always changing designs of national and local policies. While the lifelong learner may want to experience human empowerment, business and employment departments might be interested in reducing unemployment—and the point of interest might shift between the societal actors and the lifelong learner throughout the lifetime. The only constant is the need to bridge from one state to the other, mediating between the needs of the learner and the needs of society.

This paper is about how DLT may be integrated in technical systems to support lifelong learning. What to support depends on what benefits of lifelong learning are prioritised. However, a more elaborate model of lifelong learning would indicate that the wide variety of goals may be interrelated (UNESCO, 2017; Rüber, Rees, & Schmidt-Hertha, 2018; Myers, Sweetman, & Conte, 2014; McMahon, 1998). For example, inclusion contributes to a civic and equitable society, which is a prerequisite for good economic development—and the other way around.

In the following we will construct a simple requirements model for lifelong learning. The model will cover some—but not all—of the prominent aspects of lifelong learning with the objective to help map distributed ledger technology affordances to requirements of the lifelong learning space. The effort is purely conceptual, although driven by desk research, literature review and use cases collected by ISO/IEC JTC1/SC36 Ad Hoc Group 5, which explored the potential of blockchain in education (SC36 Ad Hoc Group 5, 2020).

Lifelong learning has a diverse range of stakeholders: learners in different age groups; formal educational institutions; informal educational actors; companies and employers; governments at different levels; and civil society at large. This observation alone alerts us to the fact noted above, that transitions are a key characteristic of the phenomenon. In Table 1, 2, and 3 we have selected some pertinent characteristics of lifelong learning from different

stakeholders' views and enumerated some of the relevant affordances of DLT.

*Table 1. Selected characteristics of lifelong learning lifelong learning and their relevance to affordances of blockchain technologies - **individual view***

Lifelong learning contributes to…	*Challenges DLT could help solve…*	*Blockchain will address…*

Learning and new skills
 	
- Flexible learning: anywhere & anytime
- Smoothening of transitions
  - between formal and informal learning
  - between educational institutions
  - between life phases
- Learning what you need to learn (competency mapping)
- Constructing a personal learner model—mapped against
  - skill sets in demand by employers
  - personal ambitions and interests
  - personal learning path,
  - knowledge gaps, etc.
- Provisioning of education of great variety and flexibility
  - Easy onboarding (making use of personal learner model)
  - Learning resources mapping against learner profiles or competency profiles
  - Targeted recommendations of OER and other learning resources
- Documentation of achievements
  - Learning record management
  - Copyrights and IPR management
	Interacting with educational offerings results in claims that position the learner in relation to actors who support the learning, and actors who benefit from the result of this learning. If the claims are easy to make and verify without involvement of a middleman this would make educational provisioning more effective and efficient, e.g., I have access to this course and this learning resource; I have copyright of this essay; I have this degree; I have passed these learning targets, etc.	• Micropayments (e.g., on campus)
		• Application process (identity; proof of prior learning, grades, diplomas; etc.)
		• Self-managed learner model (preferences, study targets, competencies, prospective pathways to further learning and work)
		• User-centred management of intellectual property contributions to education and research (learning resources, creative products, research contributions, etc.)

Job & Employment - Competency mapping & management (career development) - Upskilling - Reselling	DLTs promise to make it easier to track personal learning and activity paths, which will make it easier to prove claims about competencies and practice.	• Self-managed path construction and documentation (learning, work experience, creative work, personal

- Smoothening of transitions between jobs & retirement	Competency profiles may be matched against educational offerings and make it easier to manage one's own career development.	achievements, etc.)

Inclusion in society
- Social wellbeing
  - Contribute to participation in society
  - Build trust
- Develop identity
- Override differences through education
	Inclusion is often a challenge for minorities, guest workers, rural citizens and other citizens in the periphery of society. Identity and trust are part of the problem. DLTs provide identity solutions (e.g., Self-Sovereign Identity) and trustful inclusion through making it easier to prove one's learning and work record.	• Self-Sovereign Identity (SSI)
		• Trustworthy automatic verification of claims
		• Self-management of many processes, which used to depend on 3rd parties

Table 1 highlights different learning events through life and how the individual handles the transition between these events by managing claims about their relevance to what happens next. DLT could make these transitions more transparent and less dependent on controlling third parties. In Table 2 we explore this from the institutional perspective.

*Table 2. Selected characteristics of lifelong learning lifelong learning and their relevance to affordances of blockchain technologies - **institutional view***

Lifelong learning contributes to…	*Challenges DLT could help solve…*	*Blockchain will address…*
Educational system needs • Supporting smooth transition from education to a job • Supporting lifelong learning - to enhance skill base, to gain new skills as technology disrupts the work life, to re-skill to be able to transition into new careers • Supporting data transferability - to allow the learner to administer her personal learning pathway • Support harmonisation of educational frameworks (qualification frameworks, assessment, certification, etc.) • Recognition of prior learning • Support for mapping between different degree programs • Credential Ecosystem Interoperability: clarity regarding relationships between credential attributes (micro-credentials, subject exams, course exams, professional authorisations) • Access to lifelong learning log data **Companies / Employers needs** • Human Resources matches tasks • Recruitment	The certificates issued by an educational institution as proof of learning achievements are the end of a series claims that enter the loop of new claims as the candidate applies for a job or a new course at another institution. Verification of these claims takes a lot of human efforts that could be delegated to trusted automatic processes using DLTs.	• Support for recruitment process • Student management • IPR management • Issuing of certificates and diplomas • Research and innovation • Cooperation with private sector (commercialisation of R&D) • Course design and alignment with industry and societal needs (e.g., mapping between competency demands and courses)

| • Market relations | | |
| • Cross-institutional R&D | | |

Table 2 describes tasks of educational institutions and companies and how they are dependent on verification of information passed by students, employers and others. If DLT could make this verification easier this would make these institutions more efficient. When processes are changed this has Implications for how systems are designed and what technology they will use. This is the perspective of Table 3.

*Table 3. Selected characteristics of lifelong learning and their relevance to affordances of blockchain technologies - **design & technical views***

Lifelong Learning benefits from	*Challenges DLT could help solve…*	*Blockchain has these technical characteristics*
Design principles - Decentralization - supporting new actors (new business actors, learning communities, etc.) - Ability to trace learning as learners move from institution to institution, and from formal to informal (and back) - Personal data management and control - Shareable and Reuseable Learner Models (Ocheja et al., 2020) **Technical issues / requirements** - Interoperability (on semantic, data model, and syntax levels) - Ethics of data privacy vs access - Build down institutional silos	Lifelong learning of today must support educational ecosystems of tomorrow. We don't know how future systems work, but we know that they will be established in competition with existing ones. More decentralised solutions, on job training, and just-in-time learning may be just one scenario. Whatever scenario, the learners lifelong learning log will play an important role in negotiating transitions. The learner need to be in control of this process. DLTs will enable such control.	• Self-Sovereignty • Trust & Security-centricity • Transparency & Provenance • Immutability • Disintermediation & Collaboration • Decentralisation • Collective Decision Making

Table 3 highlights the the decentralising effect of DLT, which potentially could give new and less central actors (start-ups, local government, community initiatives, etc.) a more prominent role in coming up with new solutions.

4. A framework for blockchain enabled lifelong learning

Based on the characteristics of lifelong learning and the affordances of DLT described in Tables 1, 2, and 3 we have designed a framework to support discussion on how distributed ledger technologies may support lifelong learning (Figure 3).
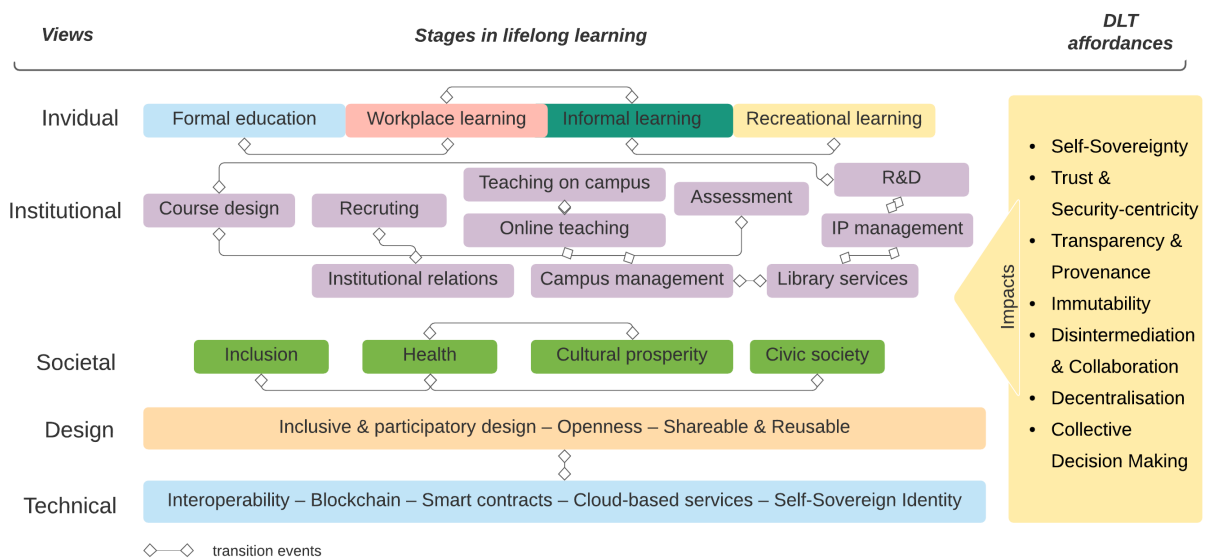
Figure 3. *Framework for blockchain enabled lifelong learning describing stages of lifelong learning according to points of view*

The framework describes stages in lifelong learning from individual, institutional, societal, design and technical points of view and highlights DLT's ability to connect the dots between the different processes and stages involved in lifelong learning provisioning.

From an individual point of view, you learn throughout life, alternating between formal education, workplace learning, informal learning, and recreational learning. You bring with you the skill sets you further develop from stage to stage, even if the contexts of a university course, a workplace training event, an online learning session on your spare time, or a community offering during retirement are not aware of your competency profile. DLT enabled learning support systems may smoothen the transitions from stage to stage, and make the different contexts aware of prior knowledge and skills—if you want so.

From an institutional point of view, there are a number of services that are loosely coupled and driven by data that are more or less available. For example, library data may not be shared with other services due to privacy concerns of the users of the library (Hoel, Chen, & Gregersen, 2018). The trust and security abilities of DLT may be able to connect the dots between library and other departments of a university without compromising privacy. Another example could be exchange of data between institutions for purposes of learning analytics, campus management, etc. Trust between competing institutions is not always easy to establish; DLT based solutions may delegate this trust to systems that are immutable, disintermediated and decentralised.

Lifelong learning goes beyond individuals and institutions and is core to the fabric of society. It contributes to inclusion, health and wellbeing, gender equality and all the goals described in United Nation's Sustainable Development Goals (UN, n.d.). DLTs have many affordances that contribute to these goals, and we will only mention one case that fosters

inclusion and civic society: In many countries, marginalised groups may have problems proving their identity, which is a key to take part in business, education and other participation in society. Though Self-Sovereign Identity technologies these groups could be included in interactions we take for granted without any intermediation by authorities or other parties that may not be trusted and even prone to corruption (Zambrano, Young, & Verhulst, 2018; Kshetri, Voas, & Voas, 2018).

In addition to the three views described above the framework also includes design and technical views in order to highlight important aspects that need to be discussed in developing these technologies.

5. Discussion

When the ISO standards group 2019 issued a call for use cases for blockchain in education they offered the following classification of scope for applications (SC36 Ad Hoc Group 5, 2020):
- Handling of certification (document verification);
- Identity Management;
- IP Management
- Human Resources support;
- Institutional Relations Management;
- Security and Storage;

The report from the group identified four clusters of issues blockchain may help to solve:
1. Achievement recording and verification
2. Identity and data ownership
3. Learning and creative activity management (IP, OER, learning resource exchange, educational data exchange, etc.)
4. Administrative support (HR, campus, library, institutional relations, etc)

The framework we have developed with different views and life stages set up against different affordances of DLT will guide discourse into the potential benefits of these new technologies which are still to be developed for education. We will give a few illustrations how this framework could structure discussions on DLT in education.

The first cluster identified by the ISO group is the most mature when it comes to applications and projects worldwide. Easy achievement recording and verification, without involvement of a notary public or other agents to verify the truth of claims, are a game changer when it comes to supporting transitions between different types of learning. When you get your first job the employer will have a detailed record of your competency profile—as detailed as you decide yourself—and automatic analysis of knowledge and skill gaps would allow the employer to offer the necessary workplace training. Getting to know a new job, the lifelong learner develops ambitions to learn more and to aim for new challenges. As the achievements, both from education and work, are recorded according to competency profiles openly shared in education and in industry and other sectors of society there are

counselling services available for the learner. Claims about prior learning and experiences are easily verified, so admissions back to formal education or embarking upon informal learning or training are efficient and benefit both learners, work and society at large.

The identity and data ownership issue cluster is of concern not only to education. Still we are waiting for solutions to manifest while there is a growing concern that identity management and control of personal data are in the hands of a few multinational private companies. There is no other solution to these challenges than to shift control to the individual and balance that with universal mechanisms for verification.

The third and fourth clusters focus on the provisioning of learning and the organisational efforts and creativity that go into this provisioning. Today's solutions are isolated systems that live on data islands with little or no exchange of data. There is a need to look upon lifelong learning as an ecosystem in need of exchange of data and results based on sound principles of interoperability, participation, decentralization and privacy. DLT will help developing this ecosystem over time; however, there is a need for a multi-voiced discourse on which dots to connect first. In some constituencies there is a need to streamline course development and teaching and make sure that the new needs for more online delivery are supported. In other, it is the research and development activities that need to be strengthened making it easier to maintain intellectual property while cooperating with at multitude of institutions and researchers in different stages of their careers.

6. Conclusions

Blockchain, preferably discussed under the broader term DLT, is an enabling technology that needs to be understood in it different application contexts. DLT is relatively new to education, but has the potential to change a sector of society that is under enormous pressure due to role knowledge plays in a rapidly changing world. In this paper, we have reviewed where DLT is positioned in global discourse and in China in particular. We have used new efforts to make sense of standardisation challenges for blockchain under the auspice of ISO to develop an overview of characteristics of DLT for education from different stakeholder's views. Then we have designed a first version of a framework that could be used to structure a much needed discourse on how these technologies could be harnessed in lifelong learning.

This work is conceptual of nature and has been driven by desk research and a motive to make it easier to discuss DLT in relation to lifelong learning. The framework needs to be improved through cycles of participatory design. There is also a need for more systematic case studies that build on a well understood model of how DLT relates to education and lifelong learning.

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