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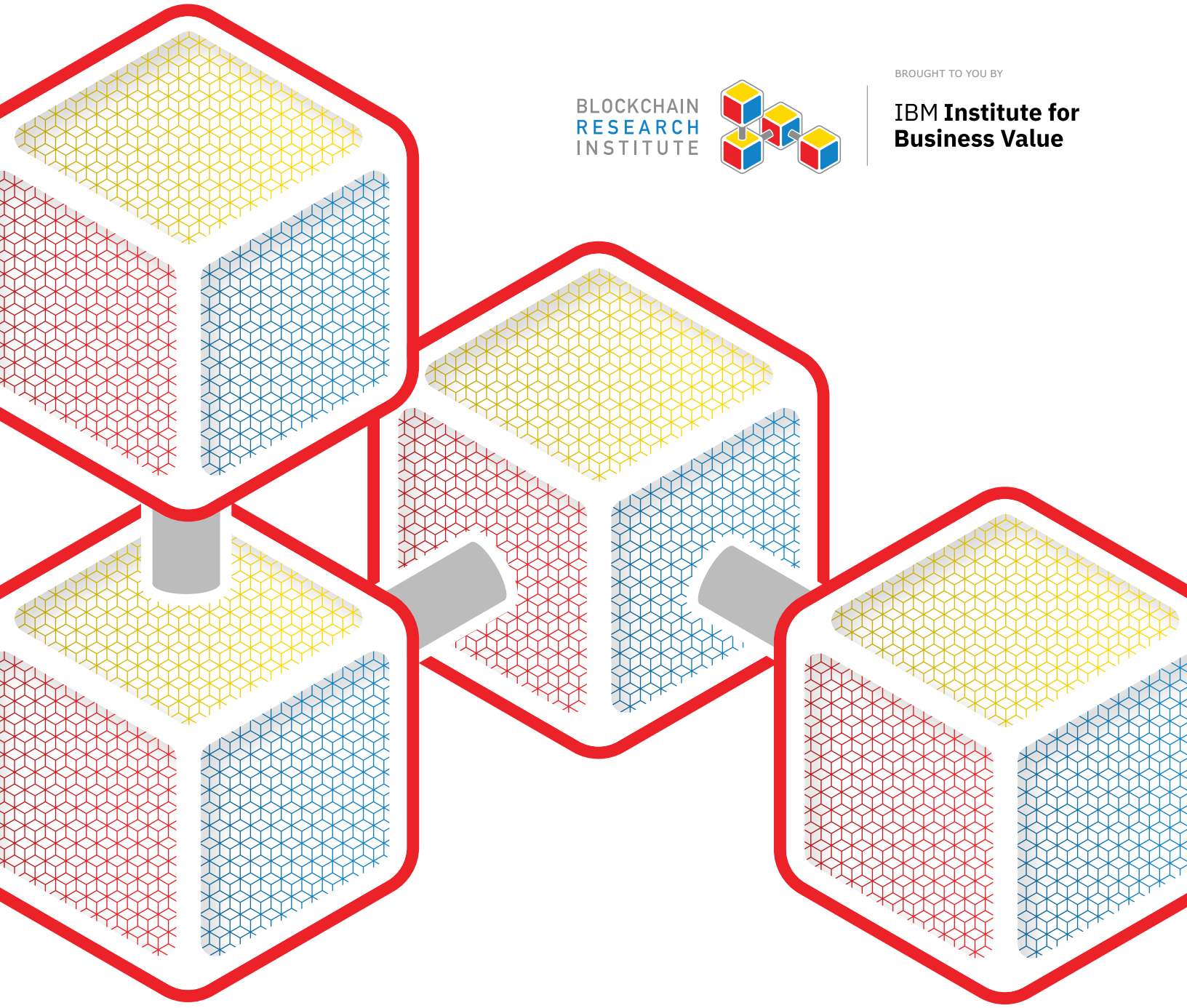

BLOCKCHAIN REVOLUTION IN EDUCATION AND LIFELONG LEARNING

Preparing for Disruption, Leading the Transformation

Don Tapscott and Alex Kaplan

Blockchain Research Institute and IBM Institute for Business Value

April 2019

A BLOCKCHAIN RESEARCH INSTITUTE BIG IDEA WHITEPAPER

Realizing the new promise of the digital economy

In 1994, Don Tapscott coined the phrase, "the digital economy," with his book of that title. It discussed how the Web and the Internet of information would bring important changes in business and society. Today the Internet of value creates profound new possibilities.

In 2017, Don and Alex Tapscott launched the Blockchain Research Institute to help realize the new promise of the digital economy. We research the strategic implications of blockchain technology and produce practical insights to contribute global blockchain knowledge and help our members navigate this revolution.

Our findings, conclusions, and recommendations are initially proprietary to our members and ultimately released to the public in support of our mission. To find out more, please visit www.blockchainresearchinstitute.org.

Blockchain Research Institute, 2019

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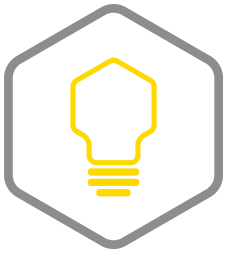

Preface

IBM has been integrally involved with the transformation of education from its earliest days. As the computing revolution took flight in the 1950s, IBM worked closely with education institutions to leverage those new technologies and prepare people with the knowledge needed to be successful in the information technology revolution. IBM's commitment to the application of advanced technologies to revolutionize education continues to this day.

As one of the world's largest employers, we see the potential of blockchain in support of our talent management strategies in preparing current and future employees for the new-collar jobs of the future. IBM's current work in education focuses on the application of artificial intelligence (AI), blockchain, and other advanced technologies to support the mission of educators, education institutions, and companies by creating solutions that enable learners and educators to enjoy the benefits of personalized learning at scale.

Blockchains can empower individuals to design their own pathways over a lifetime of learning and work. Blockchains also introduce trust, transparency, and efficiency into an education system that can be difficult to navigate and use. These benefits are multiplied by the power of blockchain to create secure and connected networks of education institutions, education technology (edtech) companies, and learners. Enabling the secure sharing and exchange of data, in a self-sovereign framework, shifts control of learning to the individual, and away from the institution. This shift offers the potential to transform the education ecosystem fundamentally.

IBM's work in education and blockchain focuses on solving the big problems and being a leader in applying blockchain to transform education. Working with key thought leaders on blockchain is an essential element in achieving IBM's objectives. IBM's own research into the application of blockchain in education is strongly complemented by our collaboration with Don Tapscott and the Blockchain Research Institute. Our combined thinking allows both organizations to offer more profound insights to the emergence of blockchain technology within education.

ALEX KAPLAN
Member
IBM Industry Academy, Education

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Idea in brief

To remain relevant, institutions must begin transforming how they measure, record, and credential student accomplishments, and how they secure these records over time.

» *Self-sovereign identity is becoming a possibility:* The concept of a self-sovereign and inalienable digital identity is critical to society in general and to students in particular. It means that our identities and the data associated with them are neither bestowed nor revocable nor owned by any central administrator (such as a university, an academic testing company, or a licensing agency) and are enforceable in any context—in person and online—anywhere in the world.

» *Students, parents, and employees will begin claiming rights to their learning data:* Education institutions and companies must put ownership of student data into the hands of students (and their parents) and employees. Blockchain enables learners to own and control their own data but not alter their grades or degrees or certifications.[1]

» *Protecting the privacy and cybersecurity of students is paramount:* In recent years, questions of identity, security, and privacy of student data have challenged providers and users of edtech. University systems have been hacked, and their reputations tarnished. Technology companies such as IBM, institutions such as MIT, standards organizations such as IMS Global Learning Consortium, and blockchain education companies such as Learning Machine are at the forefront of preserving these student rights.

» *Microcredentialing of skills and know-how is on the rise:* To remain relevant, education institutions and companies must begin transforming how they measure, record, and credential student accomplishments and mastery of skills, both inside and outside the classroom, and how they secure these records over time. Mass adoption of blockchain as the trust anchor of one truth for credentials flips the power relationship between the educator and the students. Individuals become their own lifelong registrar and academic and career advisor and can share their skills broadly.

» *Educators who want to attract students will continue to change their pedagogy:* Newer models of collaborative teaching and learning—where students create and share their knowledge worldwide—are driving the customization of educational content and environments to fit the needs and abilities of each student.

» *New funding models are emerging through blockchain:* In addition to lower administrative costs and risks, distributed ledger technology enables alternative ways to pay for education, such that more people from a diversity of locations and backgrounds can participate without burdening families with student debt.

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Learners everywhere are curating their own education, and employers are encouraging them to do so.

» *The meta-university is in the making:* More people around the world are learning from TED Talks, incorporating MIT's open courseware in their syllabi, participating in free massive open online courses (MOOCs), and receiving industry-recognized certifications for their participation and completion in these learning activities. Employers are investing more aggressively in reskilling their employees for new-collar jobs and focusing more on skills than degrees. In other words, learners everywhere are curating their own education, and employers are encouraging them to do so.[2]

Introduction to student self-sovereignty

Blockchain technology provides a secure and innovative means of realizing the concept of the self-sovereignty, referring to an individual's supreme authority over and complete ownership of that individual's personhood. The self-sovereign identity springs from our inalienable right to claim our selves and determine who we are in the world. Until now, we have relied on governments to secure that right and enforce that authority.[3]

With distributed ledgers, we will soon be able to establish and administer our own digital identities and easily so. A prominent solution to empower digital identities is emerging from the Sovrin Alliance, in collaboration with such companies as Cisco, IBM, T-Mobile, and others:

> *The Sovrin Network is a new standard for digital identity—designed to bring the trust, personal control, and ease of use of analog IDs—like driver's licenses and ID cards—to the Internet. [The Sovrin Alliance wants] to give people, organizations, and things the freedom to collect and carry their own lifelong verifiable digital credentials.*[4]

Blockchain technology provides a secure and innovative means of realizing the concept of the self-sovereignty.

In this context, *self-sovereign* means that "individual identity holder[s] can access, use, and share their credentials on the Sovrin Network whenever and however they please."[5] Through such solutions, the parents of a newborn or possibly the doulas, midwives, or obstetricians who assisted in the birth of a child, can initiate a digital identity for the child on the blockchain, an identity owned by the child and administered by the parents or guardians until the child is ready to assume administrative rights.

Until that point of transfer, parents can pick and choose how much of their child's identity to reveal—such as inherent data (age, DNA, birth date, birth place), assigned data (name), and selected data (gender)—and whether others can view or contribute to data related to the health, religious instruction, or academic achievement of the child. They may choose to anonymize their child's data for usage in research, in exchange for a fee that would accrue to pay for that child's healthcare or education.

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From pre-kindergarten onward, both traditional and nontraditional institutions of learning will associate each student's grades, test scores, and skill mastery to that student's digital identity and transfer rights to those data to the student, parents, or employer as appropriate. As it develops, the digital identity will encompass all aspects of an individual's knowledge and learning such as extra-curricular activities and awards as well as abilities to collaborate in groups or to lead teams. Those who want to pursue education and career advancement will have not just a multidimensional portfolio of data about what they know and have to offer but also an account for funding their pursuits.

We see the possibility of making better matches between students and teachers through online education platforms, and between job seekers and employers through trusted skills marketplaces.

As digital identities using blockchain become more robust and widely adopted, and education—like the workplace—becomes increasingly digital and virtual, we see the possibility of making better matches between students and teachers through online education platforms, and between job seekers and employers through trusted skills marketplaces. Giving students greater freedom to focus on content creation, learning will become a social experience, one in which to practice teamwork and collaboration.[6] Internships, part-time jobs, and skill building assignments will become indistinguishable, as students will be able to apply each newly learned skill immediately in the job market.

Blockchain also has the capacity to change relationships among colleges, universities, employers, and their relationships to society. As we delve deeper into blockchain and education, we look into how distributed ledger technology supports institutional and corporate learning and secures the academic records of refugees, immigrants, and students in emerging economies.

With portable identities comes the need for interoperable standards and data governance policies in the blockchain space. Educators, parents, and employers should lead the conversations about standards setting and governance. The current mishmash of identifications—with each jurisdiction, each institution, each skill certification, and each test administrator issuing its own type of student ID and skill or course schema—thwarts the individual's understanding, collection, use, and analysis of all the data associated with that individual's identity.

With portable identities comes the need for interoperable standards and data governance policies in the blockchain space.

Blockchains and their successors as well as the identities preserved on them will go through a period of divergence and convergence. As more blockchains are built for different spheres of our lives—as medical patients, voting citizens, bank balance holders, lifelong learners, home owners, social security beneficiaries, and consumers of food, insurance, and transportation—the more identifiers (that is, the more account numbers) we will be asked to manage in order to participate. Simultaneously, the breaking down of these siloes on the blockchain will ensure an aggregation of these disparate flows of data.

While all these data and metadata become more portable and interoperable, blockchain's value of trust will increase in importance.

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It strengthens the aggregation and preservation of a person's data over time and the verifiability of identity system-wide, and allows for secure sharing of that data, all to the benefit of that person.

What is the blockchain revolution?

With the current Internet of information, we rely on powerful intermediaries such as governments, banks, and digital platforms to protect and transmit things of value.

Today's Internet is great for communicating and collaborating in the classroom, but it was built for moving and storing information rather than protecting student and teacher rights and preserving value of quality content. It has done little to change how we manage academic institutions, recognize and codify skills and talent, help people manage their own pathways, fund education, or help employers manage the talent pipeline.

When professors exchange student information (e.g., e-mail, lecture notes, presentations, or an audio recording of a lecture), they are not sending the original, but merely a copy. Although it is acceptable (and indeed advantageous) for students to share lecture notes and presentation files, it shocks the ordinary senses for students to plagiarize their classmate's homework or take tests online for their classmates. When companies issue digital badges to their employees, and those employees post them to LinkedIn, it makes us wince to see other people copy those badge images to their own LinkedIn profile and present them as authentic. Thus, with the current Internet of information, we continue to rely on powerful intermediaries such as governments, banks, and digital platforms (e.g., Amazon, eBay, Airbnb, and colleges and universities) to protect and transmit things of value. These third parties do the work of establishing our identity and vouching for our trustworthiness, and they acquire and transfer assets as well as settle transactions.

Even though these intermediaries may seem to work to our satisfaction, they have vulnerabilities and shortcomings that can hurt our data and us. They use hackable, centralized servers. They take a piece of the value pie for performing a service, such as 10 percent to send money internationally. They capture our data, not just preventing us from using it for our own benefit but often undermining our privacy. The intermediaries can be unreliable and slow.

Using the highest level of cryptography, digital assets are distributed across a global ledger.

Most problematically, they exclude two billion people who don't have enough money to justify a bank account, let alone an education. Those two billion people can't capture the benefits of the digital age.

With blockchain technology, digital assets—everything from money, stocks, bonds, and intellectual property to music, art, loyalty points, student records, and credentials—are not stored in a central place. They are distributed across a global ledger, using the highest level of cryptography. Transactions are posted globally across millions of computers.

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The Bitcoin blockchain is the most high-profile example of the technology's potential. Another massively adopted blockchain is Ethereum, which enables programmers to create smart contracts.

Around the world is a group of people called *miners* who have massive computing power at their fingertips—10 to 100 times bigger than all of Google worldwide. Every 10 minutes, much like the heartbeat of a network, these miners assemble all transactions from the previous 10 minutes into a block. Then they compete to solve a tough mathematical problem; whoever solves the problem gets to validate the block and receives some digital currency as a reward. In the case of the Bitcoin blockchain, the winner gets bitcoin. Next, that block is linked to the previous block and to the block before that, to create a chain of blocks. Every block is time-stamped, as with a digital waxed seal.

So if someone wanted to hack a block and, say, send the same bitcoin to several people, he'd have to hack that block plus all the preceding blocks, through the entire history of that bitcoin on the blockchain—not just on one computer but across millions of computers, simultaneously, all using the highest levels of encryption. Tough to do—and infinitely more secure than the computer systems that we use today.

The Bitcoin blockchain is the most high-profile example of the technology's potential. Another massively adopted blockchain is Ethereum, which was developed by 22-year-old Canadian Vitalik Buterin. Ethereum has some extraordinary capabilities and tools. For example, it enables programmers to build smart contracts, which are agreements translated into lines of computer code that handle the enforcement, management, performance, and payments of contracts between people. There are projects on the Ethereum blockchain to create a replacement for the stock market and a new model of democracy, where politicians are accountable to citizens.

New blockchains are emerging all the time that enable different and powerful changes to the status quo. For example, in December 2015, the Linux Foundation launched Hyperledger with support from big industry players like IBM, Intel, and SAP Ariba:[7]

> *The Hyperledger Project is a collaborative effort to focus on an open platform that will satisfy a variety of use cases across multiple industries to streamline business processes. Peer to peer in nature, distributed ledger technology is shared, transparent, and decentralized. … By creating a cross-industry open standard for distributed ledgers, virtually any digital exchange with value, such as [credentials] can securely and cost-effectively be tracked and traded.*[8]

For education, issuers of credentials need to control those credentials over the credential's lifespan.

In addition, industries can explore the use of permissioned or closed ledger blockchains to strengthen the governance structures of blockchain networks. For education, issuers of credentials need to control those credentials over the credential's lifespan. A credential issued for a veterinarian or accountant requires periodic renewal, and the issuer requires the ability to manage that credential, ensuring it is always correct and valid. In addition, all credential-issuing bodies have an interest in assuring that all issuers to the blockchain are legitimate credentialing entities and that no one can write fraudulent

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credentials to the blockchain. Permissioned blockchains provide the technical ability to address these requirements and when combined with strong governance structures are ideal for education.

Studying alone by varunkul01 (Varun Kulkarni), 2016, used under Pixabay license, accessed 15 April 2019.

Blockchain, identity, and student records

Today's society—or at least today's employers, including governments—values academic credentials as exemplars of mastery of skills. As long as students are willing to pay more for recognized and highly ranked brand names on their diplomas rather than pursue alternatives, then the well-known college or university will remain a gatekeeper to opportunity.

Today's society values academic credentials. As such, well-known colleges and universities remain gatekeepers to opportunity.

The credentials and even the prestige of education institutions are rooted in the perceived effectiveness of the learning institution. Increasingly, employees are evaluating companies on their ability to provide high quality learning experiences. If colleges, universities, and employers come to be seen as places where learning is inferior to other models or, worse, as places where learning is restricted and stifled, then the role of the campus experience, the desirability of the job, and the value of the credential itself will be undermined. Attending the wrong college or picking the wrong employer is too costly.

So what counts as a credential? What counts as a quality postsecondary credential? Who defines quality and how? What counts as an education institution? All of these questions become more relevant in the education space as blockchain takes over.

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"Today you need an organization with endowed rights to provide you with an identity," said Carlos Moreira of WISeKey.[9] This process of identity usually begins with a birth certificate issued by the state, with information from a licensed medical professional. From that day forward, human beings generate personal data through every stage of life. All of this will be in analog form, usually handwritten. Blockchain can be programmed to record virtually everything of value and importance to a person's life. This is a huge opportunity, and it presents three primary challenges.

Blockchain can be programmed to record virtually everything of value and importance to a person's life.

The three challenges: Privacy, validity, and time

Privacy

The first challenge is to maintain the privacy and security of individuals' data. In 2013, the Education Advisory Board (EAB) in Washington DC published a list of 157 strategies for collecting data about students and alumni for colleges and universities to exploit in fundraising efforts, and institutions have become good at doing so.[10]

When it comes to protecting students' data, however, colleges and universities are as vulnerable as any other large organization. For example:

- The University of California–Berkeley, Ohio State University, the University of Wisconsin–Milwaukee, and Kirkwood Community College have been hacked in recent years.
- Yale University accidentally published confidential information online.
- Indiana University hosted private data on an unprotected site.
- The University of Utah Hospitals and Clinics, Stanford University, and the University of Miami stored data on laptops or data tapes that were later stolen.[11]

The blockchain protects data by using *public key infrastructure* (PKI) for establishing a secure platform. PKI is an advanced form of asymmetric cryptography. Users get two keys that don't perform the same function: one is for encryption and the other for decryption—hence, they are asymmetric.

Hyperledger Fabric, a fast emerging blockchain, lends itself well to education, allowing two parties anywhere in the world to share official academic records securely.

The Bitcoin blockchain is now the largest civilian deployment of PKI in the world, second overall to the US Department of Defense's common access system.[12] Hyperledger Fabric, a fast emerging blockchain, lends itself well to education. Sony Global Education has adapted this technology to secure educational record integrity, allowing two parties anywhere in the world to share official academic records securely.[13] Without the exact two keys, a hacker cannot access the data.

Validity

The second challenge to address is validity. At a time when information is abundant, fleeting, and mutable, employers place

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more importance on verifying job prospects' claims. CareerBuilder reported in 2014 that 57 percent of job applicants had been caught embellishing their skills set, 33 percent had lied about their academic degree, and 31.1 percent of employers had either rescinded a job offer or fired an employee for falsely representing their credentials.[14] Unsurprisingly, therefore, employers want to see official education transcripts.

At a time when information is abundant, fleeting, and mutable, employers place a lot of importance on verifying job prospects' claims.

However, universities often charge transaction fees to provide transcripts, and transcript issuance is growing. Sixty-two percent have seen an increase in the number of official transcripts issued by their institution in the last five years at an average cost to students between $5.00 and $9.99.[15] A blockchain credential solution could make the transfer of such information quickly, comparatively cost-free, and completely trusted. If such a system were adopted widely, imagine how it could benefit, say, refugees who are seeking to continue their education or find a job in a new country. Or imagine a process where a university could pro-actively offer admission to a high school student in an underserved community based upon that student's trusted portfolio of education and credentials.

Time

The third challenge to address is time. In the United States, only 25 percent of students attend college full-time at residential campuses. The rest are juggling work and family. These part-time students take twice as long to graduate, and only one-quarter of them actually earn a degree.[16]

Open Badges, Blockchain Certificates, and Learning is Earning 2026 are some of the initiatives exploring ways to credential students for everything they learn, no matter the setting.[17] Even the US Department of Education has been moving forward with its Educational Quality through Innovation Partnerships (EQUIP) pilot program, announced in 2015. The pilot is to allow, for the first time, federal aid to low-income students who enroll in non-traditional training such as coding boot camps. Its goal is "to provide faster, less expensive pathways to credentials of value."[18]

Education funding for blockchain credentialing start-ups has also increased. These start-ups offer an alternative credential platform or product, and raised venture capital in 2016:

- Degreed ($24.5 million)—investors include Jump Capital, Signal Peak, Rethink Education, Deborah Quazzo, and GSV Acceleration[19]

- Credly ($2.5 million)—investors include University Ventures, New Markets Venture Partners, Lumina Foundation Venture Fund, City & Guilds Group, and Lion Brothers Company

Related investments in MOOCs and coding boot camps, both of which offer certificates, will also serve as alternative forms of credentials. Acquisitions for credentialing start-ups in 2016 included Digitalme

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Firms that focus on credentialing are looking to aggregate both volume and scale.

and Makewaves, acquired by City & Guilds, and LinkedIn acquired by Microsoft.[20] Also, firms that focus on credentialing are looking to aggregate both volume and scale, as evidenced by Credly's acquisition of Acclaim from Pearson in 2018.[21]

Growing Up Digital underscored the importance of knowledge sharing. This includes the deployment, creation, protection, and management of knowledge for the Net Generation (N-Gens) entering the workforce.[22] Aligned with this, the United Kingdom proposed changes to its university education system in *Success as a Knowledge Economy*.[23] IBM was an early innovator, creating a digital badge program for its employees in 2015.

As of 2018, the program has more than 350,000 badge earners, and one million badges have been issued.[24] In this manner, IBM is acting as an academic institution. We could see companies such as

Table 1: Ten most popular MOOCs that started in April 2019

According to Class Central, only six percent of MOOCs are self-paced; the rest have specific start and end dates. Unfortunately, over half of these have no scheduled start dates. Class Central created a MOOC tracking tool for students to keep on top of course status.

Course title	Platform	Supplier
Agile for Project Control	University System of Maryland	edX
Computer Science: Programming with Purpose	Princeton University	Coursera
Innovation and Emerging Technology: Be Disruptive	Macquarie University	Coursera
Weight Management: Beyond Balancing Calories	Emory University	Coursera
Computers, Waves, Simulations: A Practical Introduction to Numerical Methods using Python	Ludwig-Maximilians-Universität München	Coursera
Mathematical Game Theory	Saint Petersburg State University	Coursera
Time Value of Money	University of Michigan	Coursera
A Scientific Approach to Innovation Management	Università Bocconi	Coursera
An Introduction to Computer Networking for Teachers	Raspberry Pi Foundation	FutureLearn
Introduction to Nursing: The Role of Nurses Around the World	King's College London	FutureLearn

Source of data: Dhawal Shah, "Ten Most Popular MOOCs Starting in April 2019," Class Central, 20 March 2019. See also Class Central's MOOC Tracker.

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Google, Facebook, and Microsoft's LinkedIn with SlideShare setting up their own academic institutions capable of awarding degrees and continuing education credits in the United Kingdom.[25]

If a student learns a new skill, collaborates to finish a task, or manages others at work, then those skills and experience could go on the learning transcript, too. The MIT Media Lab has started hashing digital certificates onto the blockchain to denote membership and to reward community members for their valuable contributions to the lab's work.[26] IBM and Northeastern University have entered into a partnership where IBM employees, customers, and members of the public can now use IBM-issued badge credentials toward completion of a Northeastern professional master's degree. This partnership recognizes that learning can occur everywhere and that skill mastery should be transferable from work to university.[27]

Stackable credentials are becoming more commonplace, with more academic institutions and companies exploring them.

Competency profiles, a global positioning of sorts for human capital development, and competency marketplaces are increasingly part of the post-secondary landscape and will ultimately transform education and talent management.[28] Students are getting not just grades but credentials that they can put on their résumés.[29] These credentials, available on the blockchain, become digital assets that the student can share or withhold at their will. This sharing will help employers to find the right skill mix of talent for available jobs and reach out directly to the student. In essence, *the job will find the student*, inverting the relationship between the job seeker and employer.

Such *stackable credentials*—academic credits that fit together into a degree even though they come from different sources or skill badges that fit together into a certification—are becoming more commonplace, with more academic institutions and companies exploring them.[30] Budgeting time and finances, especially for working students who are dedicated but may be able to take only one course per term, is one benefit of stackable credentials.[31] Another is giving employees a clear pathway to the skills required for maintaining certifications or moving into new jobs. Traditional educators and new organizations are attracted to the opportunity.

With blockchain technology, the job will find the student, *inverting the relationship between the job seeker and employer.*

According to Iris Palmer, senior policy analyst for education at the New America Foundation, human resource professionals need to keep on top of the skills and competencies that their organizations need. They can then collaborate with learning institutions to design sets of credentials—like Lego sets—that, when assembled, result in diplomas of value, no matter where the learning bricks originate. Students would assemble these credentials on the blockchain.[32]

Likewise, institutions can identity the sets of courses and certifications that are in demand because students can immediately apply what they've learned in the job market. These courses are ideal components of an assembled degree. Finally, for the model to work, HR professionals may need to serve as educational advisors and help employees to identify appropriate sequences of credentials that will stack up to what the company needs.

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Organizations such as IMS Global Learning Consortium are exploring the concepts of personalized pathways, supported by blockchain data, that point students to learning and career opportunities.

Organizations such as IMS Global Learning Consortium are exploring the concepts of personalized pathways, supported by blockchain data, that point students to learning and career opportunities. These pathways are tailored to each student according to the knowledge and skills they have acquired. IMS Global Learning Consortium has introduced its Comprehensive Learning Record, which it describes as a "next-generation digital transcript," and its Open Pathways for Learning, which it defines as "portable data objects" beyond badges.[33] With such high fidelity personalized learning pathways, students have the information and control they need to make academic and professional decisions.

Privacy and cybersecurity in edtech

In such a "world ledger" of education transactions, what happens to privacy and cybersecurity?[34] Cable Green, director of Open Education for Creative Commons, agrees that privacy and cybersecurity span all sectors of society, including education.

When Sony announced its plans for a blockchain-based assessment platform, Sony Global Education President Masaaki Isozu told *Education Week*,

> *We want to keep lifelong learning records … securely in the cloud forever. While these records are usually held privately, we want to make it possible for students and educators to securely share verified, trustworthy information with others. Trading these records securely would be an all-new service in the education sector.*[35]

Isozu recognizes the threat of permanent records where data that may not be accurate cannot be changed or removed, and acknowledges all sorts of problems for education. So, do we desire unalterable academic records?

Veronica Diaz, director of EDUCAUSE's online programs, sees an increasing discussion of privacy and cybersecurity around data ownership in the education space. She said academic institutions might be able to collect more than mere academic records, aggregating lifestyle choices, food and dining preferences, living situations, and day-to-day purchases. When asked what student information may be tracked by universities, Brenda Leong, senior counsel and director of strategy of the Future of Privacy Forum has responded, "All of it."[36] Organizations use such information to recognize patterns, develop student profiles, make correlations, and more.

Kim Hamilton Duffy, chief technology officer of Learning Machine, emphasizes that privacy and security are core in designing an education claims system.[37] Duffy is a co-chair of the W3C Credentials Community Group, which develops and prototypes approaches that enable individuals' privacy, for example, by allowing individuals control over which information they choose to reveal; ensuring claims

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are structured, transmitted, and stored in a secure manner; and avoiding privacy violations through correlation of claims.[38]

In addition to the Sovrin Alliance's efforts is Blockcerts, an open standard released by the MIT Media Lab and Learning Machine for notarizing academic records on the blockchain.[39] These technologies create a new infrastructure of trust that replaces the need to request records from a central authority.

Blockcerts technology establishes a new infrastructure of trust that replaces the need to request records from a central authority.

To avoid dependency on issuers for verifying academic credentials over time, Natalie Smolenski, vice president of business development and anthropologist at Learning Machine, stresses the importance of self-sovereign identities. Digital self-sovereignty means that individuals have administrative control over their own data. Self-sovereign digital identities represent one of the most exciting promises of blockchain technology, but they are not guaranteed; they must be architected at both the blockchain protocol and the application layers.

Another challenge that blockchain can solve is the loss of credentials. Students invest time and money to build skills and earn credentials, but employers and other entities require proof of that investment. However, schools can shutter their doors, people can be displaced without proof of identity or credentials, or credentials can be permanently lost. Self-sovereign identity combined with digital credentials stored securely on a blockchain would assure that each person would have lifelong and global access to proof of the credentials earned.

For this reason, technology firms are designing solutions for digital self-sovereignty around credentials. The goal is to enable recipients around the world to store and share their records freely in a private portfolio of achievement.[40] No one but the recipient has access to this portfolio, unless the recipient has granted others permission to access, and using it does not require an account with any software provider. The blockchain-based learning records stored in the wallet do not depend on any vendor or institution to act as a custodian or verifier of those credentials on the recipients' behalf—allowing recipients to share credentials with whomever they choose.

Blockcerts Wallet is a free, open source app that allows recipients around the world to store and share their records in a private portfolio of achievement.

Credentials anchored on the blockchain are instantly verifiable by employers, governments, or schools with the click of a button. Issuers can either build their own applications for issuing credentials to the blockchain (using the free, open-source reference libraries) or buy solutions from a variety of such providers as IBM, Learning Machines, Fujitsu/Sony, Aversafe, Gradbase, and others.[41]

Central New Mexico Community College issued its first learner-owned digital records to the blockchain in 2018 using the Learning Machine issuing system. The college is continuing its blockchain journey by working with IBM to create a learning credential network for sharing credentials among institutions and employers.[42] In addition to working with MIT, Learning Machine has worked with the University of Melbourne in Australia to issue teaching certificates and the

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Federation of State Medical Boards for undergraduate and graduate medical records. Learning Machine is also conducting a nationwide pilot with the Ministry of Education and Employment in the Republic of Malta to issue certifications with the Institute for Tourism, Malta College for Arts, Science, and Technology, and the National Commission for Further and Higher Education.[43]

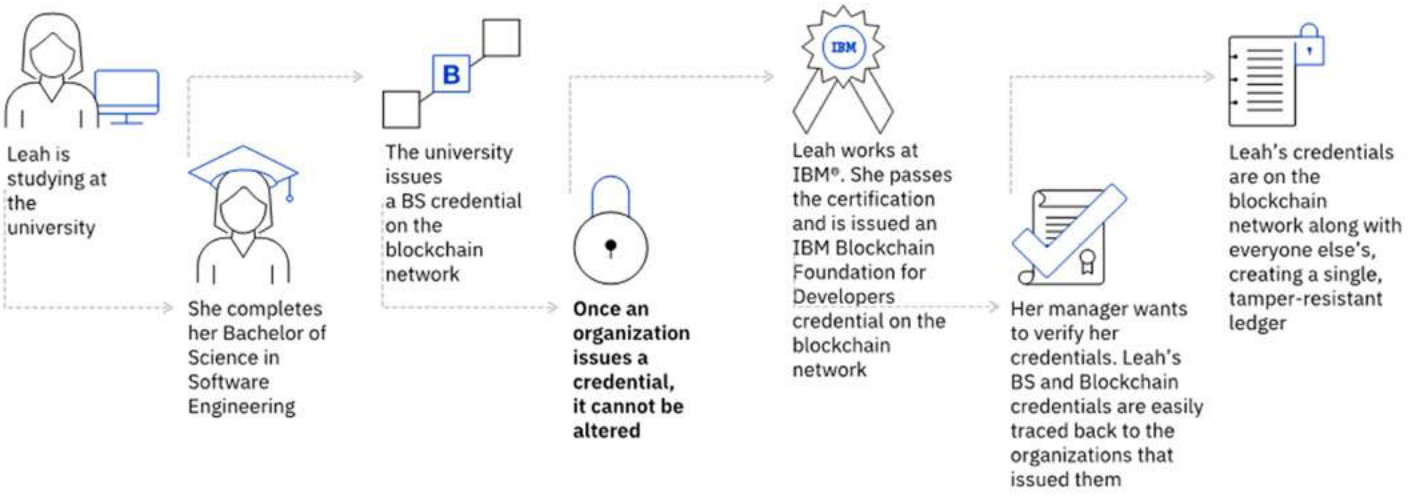
Students could catalog the assets they have created, and provide select universities access to these e-portfolios during the college application process.

Noan Fesnoux, an innovative teacher at Green School Bali, believes blockchain provides a powerful means for securing an e-portfolio in secondary education.[44] Students could catalog the assets they have created, regardless of whether these artifacts, and provide select universities access to these e-portfolios during the college application process. Students would have control over their e-portfolios, while teachers would associate standards and skill mastery to each asset as an independent verification of the educational value that the asset represents.

Along with Sarah Williamson, Amelia Vance, educational policy counsel for the Future of Privacy Forum, wrote on law enforcement access to student data.[45] This body of work belongs to FERPA|Sherpa, the leading resource for information about education privacy issues.[46] It provides a guide on how schools and service providers need to review "information they collect to align the amount and types of data to the programs and services they provide."[47] They do a cost-benefit analysis on what information schools should collect, and the potential opportunity cost of deleting data they are not legally permitted to collect. The document also mentions consulting with a lawyer before engaging in data collection.

Most importantly, FERPA "requires states to provide equal access to public education for undocumented children, and schools cannot use any information collected about race, ethnicity, national origin,

Figure 1: How digital credentials work



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or English proficiency to discriminate against students."[48] Only under court order, subpoena, or valid warrant may schools disclose certain information collected under FERPA. If schools don't have legal obligations to collect information such as the student's immigration status, then they shouldn't collect it.[49]

With blockchains on the rise with immutable, unalterable student records and metadata, only time will tell how these laws and recommendations will affect students' ability to engage in registrarship. The questions become, "What about parents and guardians? How cyber-prepared are they collectively?"[50] What percentage of parents are having important conversations about dealing with cyberbullies, maintaining privacy, using mobile devices, apps, and the Internet safely, and managing money and other cryptoassets (such as academic data) in a cryptovalue world?

Education providers, including employers, who embrace new models of learning will become more effective and more desirable places to study and work.

As more schools, universities, and employers use information beyond grades and assessments for predictive decision-making, student privacy is increasingly vulnerable to invasion. Stopping this intrusion is what blockchain seeks to achieve.

Education providers that embrace the new models become more effective learning environments and more desirable places. Computer-based learning, for instance, can free up intellectual capital—on the part of both professors and students—for more on-campus time for thinking, inquiring, and challenging each other, rather than just absorbing information.

Blockchain and the new pedagogy

We need to reinvent the model of pedagogy in education. Far too many school systems and big universities still use the broadcast model of learning, in which the teacher is the broadcaster and the student is the supposedly willing recipient. It is a one-way message. It goes like this: "I'm a professor, and I have knowledge. Get ready; here it comes. Your goal is to take this information into your short-term memory so that you can recall it to me when I test you."

To remain relevant, professors will have to start listening to and conversing with their students.

It is true that colleges, universities, and companies—and many of their professors and instructors—are trying to update this broadcast model through essays, hands-on labs, work experiences, and even seminar discussions. However, the lecture remains dominant overall. The professors who remain relevant will have to abandon the traditional professing and start listening to and conversing with the students. To begin, students could achieve the mastery of knowledge (anything where there is a right or wrong answer) by working with interactive, self-paced computer learning programs outside the classroom, freeing students and faculty alike to spend class time on what matters: discussion, debate, and group projects.

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We also need to be clear on the purpose of education. It's not about skills and, to a certain extent, it's not even about knowledge. What counts these days is the capacity to learn throughout life; to research, analyze, synthesize, contextualize, and critically evaluate information; to apply research in solving problems; and to collaborate and communicate.

The purpose of education is less about skills and knowledge per se and more about a person's capacity to learn throughout life.

University lecture by nikolayhg (Nikolay Georgiev), 2013, used under Pixabay license, accessed 15 April 2019.

Models that balance independence and interdependence

In 2011, the technology entrepreneur and investor Peter Thiel launched his two-year-fellowship program for "young people who want to build new things."[51] Thiel's target audience is students who "skip or [drop] out of college to receive a $100,000 grant and support from the Thiel Foundation's network of founders, investors, and scientists." Students learn by working on something they care about, such as clean water. Thus far, Thiel Fellows have started more than 60 companies with a combined value of $1.1 billion. Blockchains provide a platform for students in such collaboration, not just tracking people's individual contributions but also rewarding them for results.

A good model for classroom collaboration is Consensus Systems (ConsenSys), one of the first Ethereum software-development companies. It is breaking new ground in management science along the lines of *holacracy*, a collaborative rather than hierarchical process for defining and aligning the work to be done. Among those holacratic tenets are "dynamic roles rather than traditional job descriptions;

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distributed, not delegated, authority; transparent rules rather than office politics; and rapid reiterations rather than big reorganizations," all of which describe how blockchain technologies work.[52]

Holacracy is a collaborative rather than hierarchical process for defining and aligning the work to be done. The goal is to achieve a balance between independence and interdependence among participants.

ConsenSys differs not only from the typical classroom but also from the typical online course, in the ways it is structured, how it creates value, and how it manages itself. For the most part, members of ConsenSys choose two to five projects to work on. No top-down assignments, and no boss. Everyone owns a piece of every project directly or indirectly; the Ethereum platform issues tokens that members can exchange for ether and then convert into any other currency.

The goal is to achieve a balance between independence and interdependence. For the classroom, the watchwords are agility, openness, and consensus: identify what needs to be learned, distribute the load among the students eager and able to do it, agree on their roles, responsibilities, and rewards, and then codify these rights in smart contracts. Teachers and students alike need training to participate in such a system.

The Holberton School in San Francisco is dedicated to software engineering. It offers project-based education as an alternative to college courses. Holberton has already used blockchain to store and deliver its issued certificates, as a measure to stop fake certification. It uses encryption and two-factor authentication to create the certificate, sign-off on it, and place it into the blockchain. The school still gives students paper copies, but a system-created decentralized clearing number allows authentication by employers.[53]

Newer and trendier platforms are coming up. In October 2017, Steve Wozniak, co-founder of Apple, announced that he would start Woz U—initially as an online learning platform focused on both students and companies—to be available on iTunes.[54] He hired Chris Coleman, former CEO of Coder Camps, to be president of Woz U and is partnering with the Art Institutes to design and deliver technology boot camps on some two dozen campuses across the country to prepare students for careers in software development.[55]

Alternative education: Conditional training and the token economy

Conditional training and reinforcements recorded on blockchain technology will change the marketplace for education technology. Going forward, a key step in modern education will be issuing tokens as rewards.[56]

Noan Fesnoux, green studies teacher at Green School Bali, has used bitcoin, dogecoin, and the blockchain to teach students as young as ten years old about environmental sustainability.[57] He believes that blockchain technology would be an immensely useful tool in rethinking college internships. For example, Green School is continuously pairing up students with mentors who are professionals

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in their field. Through the blockchain, mentors could validate and reinforce learning as well as recommend students for other opportunities based on their set of skills. Students could collect their records of experience, which would have immense value in applying for apprenticeships or other internships.

Within an educational setting, a token economy is a system for providing positive reinforcement to children for completing tasks or behaving in desired ways.

Huge strides are being made in the blockchain and specialized areas of education such as refugee academic reintegration and special education. Within an educational setting, a token economy is a system for providing positive reinforcement to children for completing tasks or behaving in desired ways.[58] In special education such as for autism, students can be helped to learn and complete tasks by using tokens as rewards on the blockchain.

The United Nations is creating global IDs for refugees with the help of Microsoft and Accenture.[59] These include micro-learning opportunities and at-home degrees that may be accessible and viewable by academic institutions in the host country. This approach contributes to a smoother transition of refugees in the new country and allows them to study and gain employment with less difficulty than would otherwise be the case.

Lifelong learning and new collar jobs

Another area in dire need is preparing the workforce for the future. Currently, continuing professional development (CPD) is difficult to deliver, often fragmented, poorly tracked, and misaligned with jobs of the future.

With blockchain, we are able to incorporate CPD data from conference attendance, courses, internships, work experience, and other kinds of alternative learning. We can also use that information to create high fidelity pathways aligning our experiences and skills with opportunities of the future, and the proper path for employees to follow to be prepared. Teachers, HR managers, employees, and other professionals could get inputs from trusted providers and thus be incentivized to take on more CPD, if those experiences and learning opportunities are securely stored in a reputable system.

With blockchain, we can use continuing professional development data from a variety of sources to create high fidelity learning pathways that align our skills and experience with career opportunities.

The University of Nicosia (UNIC) is the first accredited university in the world to accept bitcoin payments and launch a master of science degree in digital currency. The first course in the degree is a free MOOC.[60] UNIC is a member of the Blockchain Education Network, a group of prestigious universities around the world coordinating their student-led activities on blockchain research and experimentation.[61] UNIC has established relations with MIT (Digital Currency Initiative at the MIT Media Lab) on Blockcerts and the BSafe.network.[62]

In collaboration with Global Training, UNIC has launched a blockchain training series, which brings together some of the world's foremost academic and business experts to build the largest portfolio of CPD courses on blockchains to date.[63] UNIC also collaborates with

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Adroit Lawyers, Australia's leading legal experts in the technology, on course delivery and consulting.[64] Finally, UNIC has formed relationships with such organizations as Accenture, the Association of Financial Professionals (AFP-USA), Boston University, George Mason University, Imperial College London, and University College London.[65]

Cyprus, in collaboration with the University of Nicosia, is taking into account blockchain's unique characteristics to design, develop, and deploy its customized Smart Specialization Strategy (S3Cy):[66]

> *S3Cy approaches research, technological development, and innovation as a set of tools for the amplification and enhancement of the efforts initiated for overcoming the current economic crisis and as an important diachronic agent for the restructuring and post-evolution of the Cyprus economy and society.*[67]

Blockchain has great potential to transform corporate learning through conditional token reinforcements.

Cyprus aims to promote competitive infrastructure and strong edu-econo links in the European Union. While collaborating with the University of Nicosia, the government of Cyprus is cultivating relationships with business, research, policy, and education communities:

> *With global recognition, it is developing the Centre of Excellence to further drive its policies. It aims at the formation of a three-dimensional ecosystem of stakeholders (researchers, businesses, and the Cypriot state) that will gather in and around the CoE to actively pursue knowledge creation, exchange, and commercialization.*[68]

Blockchain has great potential to transform corporate learning through conditional token reinforcements and learning pathways aligned to jobs of the future. At present, companies deliver huge amounts of training to their employees, but storing records of achievement is not easy. Oftentimes, that training is not directly aligned with emerging skills requirements.

Current learning and talent management system technologies like sharable content object reference model (SCORM) are arcane, inefficient, and siloed. They employ existing legacy systems without any interconnection among nodes.

Even vocational education such as apprenticeships and learning by doing can be credited on the blockchain.

With blockchain, the platform for corporate learning could include interconnected and transparent systems where all forms of education are effectively captured. Even vocational education such as apprenticeships, learning by doing, and job assignments could be credited on the blockchain. These learning inputs could then be combined to provide employees with pathways that align to future jobs.

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Education finance: Funding academic success

A member of the Class of 2016 racked up an average debt of $37,172. It's no wonder that the cost of a college education was such a hot issue in the 2016 US presidential election.

Many educators dislike the idea of education as big business, but that's how companies such as Pearson and McGraw-Hill make their profits. They provide classroom content, supplemental teacher training, classroom and school administration systems, and testing content, test-taking platforms, and scoring. All of this can lead to credentials, not just of high school diplomas and college entrance, but also of individual licensures and professional certifications. These companies have considerable budgets for lobbying federal and state legislators and boards of education.

Let's look at the numbers in the United States. From 1995 to 2015, the average tuition and fees at private colleges and universities increased 179 percent. Tuition and fees for out-of-state students at public universities jumped 226 percent, and in-state tuition and fees 296 percent.[69] Approximately 44 million Americans owe a total of $1.3 trillion in student loans. A member of the Class of 2016 racked up an average debt of $37,172.[70] It's no wonder that the cost of a college education was such a hot issue in the 2016 US presidential election.

Melanie Swan is looking to the blockchain to tackle student debt head-on. She is the founder of the Institute for Blockchain Studies. She has been working on MOOC accreditation and "pay for success" models on the blockchain. The blockchain provides three elements toward this goal: a trustable proof-of-truth mechanism to confirm that the students who signed up for Coursera classes actually completed them, took the tests, and mastered the material; a payment mechanism; and smart contracts that could constitute learning plans.

With $1.3 trillion in student loans outstanding, blockchain could help lenders better manage their portfolio of student debt risk. If universities recorded semester grades to a blockchain, then it could alert students that their grades may jeopardize their ability to pay off loans. The university could mobilize to support the student, and the lender would have incentive to assist the student in getting back on track. The blockchain could provide the type of trusted insight to that student's ability to pay loans, so that the lender could take action early, when it counts.

Consider smart contracts for coding skills. "Why don't we target financial aid toward personal development?" Swan said.[71] It works like the micro-funding organization Kiva, but for coding classes rather than for entrepreneurial start-ups. Everything would be extremely transparent, and students would be accountable for their progress. Donors—such as companies that need specific skills—could sponsor individual students, put money toward learning goals, and pay out according to achievement.

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"Teach it forward" schemes are envisioned in which students can pay down their student loans by teaching other students what they just learned or by applying this new knowledge immediately in the job market.

Let's say we wanted to support a female student who lives in Nigeria and is going through IBM's Deep Learning certification for artificial intelligence.[72] Every week this student would need to provide proof of completion of a development module. Perhaps this is all automated through an online test where the blockchain confirms the student's identity and records progress before disbursing the next week's funding—into what we could call the student's "smart wallet for education"—so that she could continue paying for college courses without interference.[73] We could accomplish this goal without a not-for-profit or government agency with administrative costs and the power to change funding. "Money toward a girl's education couldn't be diverted to her brother's schooling," Swan said.

The visionaries behind the Learning is Earning initiative, such as Jane McGonigal in partnership with the Institute for the Future and the ACT Foundation, envision "teach it forward" schemes in which students can pay down their student loans by teaching other students what they just learned or by applying this new knowledge immediately in the job market.[74] They needn't wait for a degree to begin earning money. Employers—or other students or professors—will be able to query the blockchain for people with the particular combination of skills and knowledge needed immediately on the job or in the classroom.

In other words, the blockchain will help employers match projects with the proven capabilities of students available for project work.

Table 2: Coursera's most popular courses in 2018

Thinking and learning in both machine and human systems topped the global list of Coursera's offerings in 2018, rating 4.9 and 4.8 out of five stars.

Course	Supplier	Rating
Machine learning	Stanford University	4.9
Learning How to Learn	McMaster University and University of California San Diego	4.8
The Science of Well-Being	Yale University	4.9
Bitcoin and Cryptocurrency Technologies	Princeton University	4.7
Algorithms, Part I	Princeton University	4.9
English for Career Development	University of Pennsylvania	4.8
Financial Markets	Yale University	4.8
Introduction to Psychology	University of Toronto	4.9
How to Write a Thesis	National Autonomous University of Mexico	4.8
Chinese for Beginners	Peking University	4.7

Source of data: Nikhil Sinha, "End of the Year Round-Up 2018," Coursera blog, 12 Dec. 2018, and "2018's Most Popular Courses," Coursera.org, n.d.

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Students will be able to link these earnings with a particular learning experience or skill so that they can calculate the precise value of each element of their training and development.

Likewise, human resources personnel will be able to calculate the return on their training and development investments. Employers may even be willing to pay for a student's entire education in exchange for a cut of the student's future earnings. Academic publishers may be willing to pay for some of these tracking data to improve their learning modules for all types of learners, as they won't have access to it otherwise on the blockchain.[75]

To reduce the operational costs, Imran Khan, a business development manager at Microsoft, sees experimentation across such functions as procurement on the blockchain.[76] Today, most schools rely on an archaic system of publishing requests for proposals. In the request-for-proposals process, users may be able to manipulate the system and steer contracts to favored suppliers. Through smart contracts running on a blockchain, chief procurement officers could screen for suppliers who meet specific criteria and then negotiate better terms and procure products and services without bias.

The blockchain and the meta-university

The phrase "ivory tower" usually carries pejorative connotations. From the 19th century, people have used it to designate a world or atmosphere in which intellectuals engage in pursuits that are disconnected from the practical concerns of everyday life. For cynics, it connotes a willful separation from the everyday world; esoteric, over-specialized, or even useless research; and academic elitism, if not outright condescension.

If we imagine a moat around the ivory tower, then we extend the metaphor to indicate how these institutions have come to operate as largely autonomous islands of scholarship that have thus far failed to use the Internet to bridge the gaps among professors, students, and organizations of theory and practice. That is jaw-dropping in a time of unprecedented connectivity.

Innovators have an enormous opportunity to create unparalleled learning experiences for students and employees by enabling them to customize their learning pathways.

The blockchain will enable the 21st century institution of education to disaggregate into a network and an ecosystem—not a tower. Indeed, innovators have an enormous opportunity to create an unparalleled educational experience for students globally by assembling the world's best learning materials online and enabling students to customize their learning paths with support from a network of instructors and educational facilitators, some of whom may be local and others around the globe. To make this work for students, colleges and universities will require deep structural changes, and educators will need to embrace partnerships.

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The meta-university is "a transcendent, accessible, empowering, dynamic, communally constructed framework of open materials and platforms on which much of higher education worldwide can be constructed or enhanced."

CHARLES M. VEST
President EmerItus
Massachusetts Institute of Technology

In 2006, MIT President Emeritus Chuck Vest offered a tantalizing vision of what he called the meta-university. In the open-access movement, he saw "a transcendent, accessible, empowering, dynamic, communally constructed framework of open materials and platforms on which much of higher education worldwide can be constructed or enhanced."[77] The web would provide the communication infrastructure, and a global open-access library of course materials would provide much of the knowledge and information infrastructure.

Library by ElasticComputeFarm, 2015, used under Pixabay license, accessed 15 April 2019.

Dr. Vest argued that a noble and global endeavor of this scale would speed the propagation of high-quality education and give teachers and students everywhere the ability to access and share teaching materials, scholarly publications, and scientific works in progress and to participate in real-time science experiments.

However, without a means of associating students' identities with their achievements, recording and credentialing these achievements over time, rewarding constructive and collaborative behavior in the community, and otherwise holding participants accountable for deliverables, this Internet-only meta-university would still fall short of traditional education. An average of only 15 percent of students who sign up for MOOCs complete them; free MOOCs are still considered supplemental to tuition-based online courses from traditional colleges and universities.[78]

The blockchain provides a rich, secure, and transparent platform on which to create such a global network for learning.[79] We envision three stages.

» The first stage is content exchange. Professors and teachers share ideas and upload their teaching materials to the Internet for others to use freely.

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- The second stage is content co-innovation, where educators collaborate across institutional and disciplinary boundaries to create new teaching materials using wikis and other tools.

- By stage three, the educational institution has become a node in the global network of faculty, students, and institutions learning collaboratively (but still maintains its identity, campus, and brand).

Leading scholars know that higher education institutions and their faculties cannot continue to operate as islands, constantly reinventing the lecture.

The global network for lifelong learning is not a pipe dream. Leading scholars know that educational institutions and their faculties cannot continue to operate as islands, constantly reinventing the lecture.

Stage 1: Content exchange

The lowest level of collaborative knowledge production is already well underway. Prior to the Internet, educational material was considered a proprietary asset and part of the institution's competitive advantage in the global market for students. Today, many post-secondary institutions post their educational materials online, putting this material into the public domain.

MIT pioneered the concept, and today nearly 250 institutions all over the world have joined MIT's OpenCourseWare initiative, which is now the Open Education Consortium.[80] MIT's site receives over a million unique visitors each month, and over two million views of videos on its YouTube channel, with 1.7 million subscribers; users come from around the globe, with more than half from outside of North America.[81] OpenCourseWare helps solve the problem of educators working in isolation and provides a wealth of materials that others can use and even build on.

OpenCourseWare helps solve the problem of educators working in isolation and provides a wealth of materials that others can use and even build on.

This goes beyond just textbooks. It also includes material such as lecture notes, assignments, exams, videos, and podcasts. Professors and students will need better tools for gauging the quality and suitability of various assets. Using capabilities such as smart contracts, blockchains provide a means of tracking and rewarding each party's contributions. Users can do more than "like," "upvote," or share a piece of content; they can send its creator some tokens of value. These tokens might be used, say, to support research assistance or grant writing, or serve to meter the value of the content.

This will give an incentive to members of the worldwide academic community to contribute their intellectual property, know-how, and insights. They will do this not just to improve education but also to enhance their own reputations and even to receive material or financial benefit. Newcomers will be able to see not only the most used but also the most valued content relevant to their studies.

Stage 2: Content co-innovation

The next level in collaborative knowledge creation goes beyond discussing and sharing ideas to the actual co-creation of content.

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The next level in collaborative knowledge creation goes beyond discussing and sharing ideas to the actual co-creation of content.

Just as Wikipedia's distributed editors collaborate to create, refine, and expand the online encyclopedia's entries, professors could also co-innovate new teaching material, publish this newly synthesized content, and share in the recognition and rewards.

A case in point is Wikiversity, a project of the Wikimedia Foundation. Rather than offer a set menu of courses and materials, Wikiversity participants propose what they want to learn and the Wikiversity community collaborates, in multiple languages, to develop learning activities and projects to accommodate those goals. Introducing a token system on a platform like Wikiversity could dramatically encourage collaborative behavior. This is what blockchain can help to make happen. It enables the community to identify valuable projects, assemble teams of collaborators, and fund each phase of development, rewarding collaborators according to their contributions.

Under such a system, for example, psychology professors would work together to design the "perfect course" that pools the knowledge of the psychology world's leading thinkers. Obviously, there wouldn't be unanimity on all of the content. There are various perspectives, schools of thought, and teaching techniques. But, as in Wikipedia, the professors could work globally to create core, generally agreed-upon modules, and then subnetworks of like-minded teachers could develop ancillary elements. For the ultimate course, the teachers would need more than course materials—they would need course software allowing students to interact with the content, supporting small-group discussions, enabling testing and scoring, and issuing badges for completion.

Table 3: MIT OpenCourseWare's top courses visited, March 2019

Course number	Course title	Level
6.00	Introduction to Computer Science and Programming	Undergraduate
6.0001	Introduction to Computer Science and Programming in Python	Undergraduate
6.0002	Introduction to Computational Thinking and Data Science	Undergraduate
6.006	Introduction to Algorithms	Undergraduate
6.034	Artificial Intelligence	Undergraduate
6.041	Probabilistic Systems Analysis and Applied Probability	Undergraduate
6.042J	Mathematics for Computer Science	Undergraduate
6.046J	Design and Analysis of Algorithms	Undergraduate
8.01SC	Classical Mechanics	Undergraduate
8.04	Quantum Physics I	Undergraduate

Source of data: "Most Visited Courses," MIT OpenCourseWare, as of 5 April 2019.

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If thousands of people can develop Linux, the most widely used computer operating system in the world, they can certainly develop the tools for a psychology course. Indeed, many well-known open-source software projects are already under way in the academic community. One of the most popular is Sakai.[82] Built by educators for educators, Sakai facilitates collaboration in and across courses, research, projects, administrative processes, and multidisciplinary and multi-institution efforts. Creation of the software itself is a product of co-innovation. In turn, the product helps users co-innovate content that educators can teach to students. We need more projects like this.

Used properly, blockchain platforms could support collaboration among students or employees as they co-create knowledge and co-develop skills.

Used properly, blockchain platforms could also support such collaboration directly with students. Rather than simply receiving the professor's knowledge, the students could co-create knowledge with light supervision—one of the most effective methods of learning—and get credit for their co-creation.

Stage 3: Global network

The upshot could be a disaggregation of institutions of learning. The digital world, which has trained young minds to inquire and collaborate, is challenging not only the lecture-driven classroom but also the very notion of a walled-in institution that excludes large numbers of people. Why not allow brilliant ninth-graders to take first-year college math, without abandoning the social life of their high school? Why use the concept of grades and grade matriculation at all? Why not encourage a foreign student majoring in math to take a high school English course? Why is the college or university the unit of measurement when it comes to branding a degree? In fact, in a networked world, why should students have to assign their "enrollment" to a given institution, akin to declaring loyalty to some feudal fiefdom?

In this global network for learning, a student or an employee draws experience from a dozen institutions and a dozen employers, while the blockchain tracks the student's or employee's path and progress.

In this vision of a global network for learning, a student receives a custom learning experience from a dozen institutions and a dozen employers, while the blockchain serves to track the student's path and progress. The student enrolls in his or her primary college and is assigned an artificially intelligent knowledge facilitator, an agent that works with the student to customize a learning experience, the journey, and outcomes based upon the proven paths of millions of similar students. The student might enroll in the primary college in Oregon, and the AI knowledge facilitator would recommend registering for a behavioral psychology course from Stanford University, a medieval history course from Cambridge, and an AI course from IBM. For these students, the collective syllabi of the world form their menu for education, and the knowledge of millions of other students' pathways informs their unique journeys.

Yet the opportunity goes beyond simply mixing and matching courses. Next-generation faculty and AI agents will create a context whereby students from around the world can participate in online discussions, forums, and wikis to discover, learn, and produce knowledge as a community of learners who are engaged directly in addressing some of the world's most pressing problems.

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For today's knowledge workers, remaining truly competitive in fast-moving fields of research and innovation means constantly retraining and retooling in a modern, dynamic, and technology-focused environment.

The blockchain harmonizes and aggregates the records of various institutions for each skill learned and each module completed, steadily building each individual student's list of achievements, while AI agents and machine learning harvest those experiences to improve the outcomes for everyone.

Of course, such open platforms could provide a means to address the needs of all learners, not just traditional college-age students. For today's knowledge workers, remaining truly competitive in fast-moving fields of research and innovation means constantly retraining and retooling to begin or continue their working lives in a modern, dynamic, and technology-focused environment. The cost of building new continuing education programs from scratch could be prohibitively high, but innovative models of collaborative education, the use of artificial intelligence and machine learning, and lower walls between formal academia and alternative education providers could bring greater efficiency, creativity, and credentialing to lifelong learning initiatives.[83]

Indeed, why not allow companies and governments to participate in this global network for learning? Platform developers could use fees collected from commercial users to subsidize ongoing development.

Imagine Wikipedia or Khan Academy, academic journals, Open Educational Resources (OER), and even research bodies issuing proof of learning from their systems. Current systems (OpenAthens, Shibboleth) use centralized ledgers and are dysfunctional. Blockchain can provide a more robust authentication infrastructure and enhanced learning experience with small transaction models such as Experience API (xAPI) or IMS Caliper to gather evidence from micro-learning experiences.[84] It is open source, the natural successor to SCORM, and preserves data in learning record stores.

Students by StockSnap, 2015, used under Pixabay license, accessed 15 April 2019.

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Another possibility is an educational blockchain that educators, students, and employers could use to house students' and employees' learning records. With student, parent, or employee consent (and in exchange for some benefit), institutions and companies could share data with different audiences and license data within the blockchain education community. Individuals could choose to share their credentials on a public facing version of the blockchain and allow prospective employers and others to search for and identify students with the skills needed for jobs.

"There is a compelling industry-wide need to unlock the value of each person's credentials and transform them into transactable digital asset."

MICHAEL KING
Vice President and General Manager
IBM Global Education Industry

IBM's learning credential network initiative is researching both the technical and the governance strategies required to create a global blockchain that pursues these objectives. "There is a compelling industry-wide need to unlock the value of each person's credentials and transform them into transactable digital assets," said Michael King, vice president and general manager, IBM Global Education Industry.[85]

Blockchain standards creation

An ongoing issue with blockchain has been "a lack of certain standardization that allows for it to be scalable and universalized."[86] With identities pervading all areas of our lives, it is currently difficult to express machine-readable personal information, let alone credentials, verified by intermediaries and third parties on the web.[87]

Several problems within education identity and credentialing show how students are not easily able to "change their service provider without losing their digital identity."[88] In turn, this leads to problems like "vendor lock-in, identity fragility, reduced competition in the marketplace, and reduced privacy for all stakeholders."[89] Mainly, the lack of interoperable standards "capable of expressing and transmitting rich verifiable claims cutting across siloed identities" is a major problem.[90]

Global initiatives

With the rise of e-Estonia and Bitnation borderless governance, virtual nations are giving rise to borderless education. Not confined to any particular nation-state or academic institution, blockchain will allow premier learning institutions to accept and incorporate classes, credits, and grades worldwide without restrictions of nation-states and governments.[91]

What is changing in the blockchain space is how these kinds of data, or *verifiable claims*, are being incorporated into standards. In 2016, the International Organization for Standardization (ISO) established a special committee to develop blockchain standards.[92] Although education is missing, education data standards are needed for the following:

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- Establishing consensus on consistent terminology
- Ensuring interoperability between multiple implementations
- Addressing security, privacy, and data governance concerns
- Fostering trust, including managing end-user identity
- Facilitating implementation of provenance tracking[93]

The lack of interoperable standards "capable of expressing and transmitting rich verifiable claims cutting across siloed identities" is a major problem.

Within the World Wide Web Consortium (W3C), the verifiable claims working group expresses, exchanges, and makes "verifying claims easier and more secure on the Web."[94] Its charter "focuses on use cases for education."[95] The verifiable claims task force is a "neutral group to discuss use cases (such as enrollment) and the problem area in general. The group is documenting and analyzing concerns raised in various fora around the value-add that W3C could provide to verifiable claims that are user-centric."[96]

Education stakeholder initiatives

Kim Hamilton Duffy of Learning Machine and Blockcerts has worked toward establishing blockchain standards in the education space.[97] Within the Credentials Community Group, she is working with other scholars and implementers to develop open standards for verification of blockchain-based claims, as well as ensuring educational claims are maximally usable for the recipient by following open, standard formats.[98] IMS Global Learning Consortium is leading efforts around open badges, which it defines as follows:

> *Open badges are information-rich visual records of verifiable achievements earned by recipients. … The open badges contain detailed metadata about achievements such as who earned it, who issued it, the criteria required, and in many cases, even the evidence and demonstrations of the relevant skills. The data [are] all inside![99]*

The education ecosystem desperately needs cross-industry interoperability standards, so that students have a greater say in how their data are collected, used, and managed.

Stakeholders from all facets such as the "W3C, IETF, IMS Global Learning Consortium, claims issuers, identity providers, claims consumers, the Credentials CG, the general public, and a variety of other organizations and individuals that have shown interest in the space" are actively providing input to make strong claims.[100]

> *The Force of the Web Payments Interest Group have extensively researched the problem and proposed an architecture and specification to enable the interoperable expression, exchange, and verification of claims. The narrow scope of work in the draft Verifiable Claims Working Group Charter proposes that the first step toward broad interoperability is standardizing a data model and syntaxes for the expression and verification of verifiable claims.[101]*

A push toward cross-industry interoperability specification is the norm for working groups. The education ecosystem desperately

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needs this, so that students have a greater say in how their data are served, provided, and managed; and data about the meaning of credentials are uniform and sharable.

Imran Khan of Microsoft believes that open data will shift the paradigm of higher education and research.[102] He points to Doc.ai—the AI for artificial intelligence—a blockchain research start-up that is looking to connect patients and scientists so that the former can share their medical data securely and privately through the blockchain, and the latter can improve their research outcomes, ideally leading to better predictive models and truly precision medicine.[103]

Graduate students could set up a worldwide study of what Doc.ai calls *omics* data such as genomic, phenomic, microbiomic, and so on. Let's say a student wanted to study the effects of Omega 3 on Alzheimer patients. The student could deploy a survey on a secure blockchain that would incentivize patients to participate.

Incentives to change

Although all this innovation is good, what are the drivers of implementation? Why should professors adopt a new model of pedagogy? The US publishing industry provides much of the classroom curriculum, administrative and engagement platforms, and the testing programs for credentialing at all levels of academic achievement. An academic or an administrator might say, "Let the publishers rethink the student experience. Why should I bother? I have enough on my plate."

The education sector has few incentives to change—except that the new model of lifelong learning is in the best interest of learners.

The education sector has few incentives to change—except that the new model of lifelong learning is in the best interest of learners. Faculty and administrators alike should consider what has happened to other cultural institutions that have resisted change. Encyclopedias, newspapers, record labels, religious organizations, school systems, colleges, and universities have a lot in common:

- They are all in the business of producing and delivering content that connects with an audience.
- They all recruit, manage, and compensate capable producers and performers.
- They all offer proprietary products—"experiences," they would argue.
- They take legal action against those who infringe their intellectual property.
- Because they create unique value, their customers pay them, and they have revenue.
- All of these businesses are possible because of scarcity—in quality news, information, knowledge, learning, art.

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Today the businesses of encyclopedias, newspapers, and record labels are in various stages of collapse. Because of the Internet, they've lost their monopolies on the creation and curation of quality content. The digital age brought abundance, mass participation, new delivery channels, and new business models. The Internet erased their once-unassailable attributes faster than we can transfer bitcoin from one wallet to another. In each sector, only two or three global behemoths remain.

The digital age brought abundance, mass participation, new delivery channels, and new business models.

Conclusion and recommendations

Colleges and universities have not yet lost their monopoly on academic credentialing and educational brands. But, soon, one of the blockchain-based innovators will demonstrate that its approach to learning will pay off more quickly, that employers issue and value its credentials as much if not more, and that it can deliver real value to the great many students and employees who can't afford college tuition or whose cognitive or social abilities don't "fit" traditional pedagogy or whose jobs don't allow them the freedom to learn outside their workplace. When that happens, then rest assured: students will demand more for their money than what they are receiving from traditional educational institutions. How can administrators, educators, alumni, and companies collaborate to reimagine the experience?

Prepare students for digital citizenship. While blockchain education is booming, we need to embed digital citizenship needs into curricula of schools and universities and open it up to communities. Courses teaching students (and parents) and employees how to be good digital citizens should incorporate elements of responsible use of technology, ethical online time, dealing with cyberbullying, accountability for a truthful online reflection of their skills, and data management surrounding blockchain technology.[104] Future teachers and parents need guidance on how to raise a digital child effectively, including setting personal rules and policies around the Internet and blockchain.[105] Future employees and hiring managers need comparable guidance for projects and workplace settings as well.

Start talking with all stakeholders about data sovereignty. Once the technology for self-sovereign identities is ready for mainstream adoption, we will likely have initial custody over our digital IDs and data. Blockchain will accrue, integrate, and synthesize our educational records from different portals into one place for us to determine whether, how, and with whom to share it. We will also have that responsibility for our children until they are of an age (and potentially of a disposition) to manage it themselves.

Offer significantly more collaborative activities. As more academic information is digitized, and alternative forms of education become normalized, security notions in transparency and openness grow in importance. Soon students will be rewarded for their efforts, while focusing on work, and will be able to engage in more collaborative activities throughout their lifelong learning process.

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As more academic information is digitized, and alternative forms of education become normalized, security notions in transparency and openness grow in importance.

Learn how to work with large scale anonymized data. At present, every industry—be it education, finance, or healthcare—creates "costly, inefficient, proprietary" data solutions that prevent people from managing their digital identities cohesively.[106] These "proprietary industry-specific solutions for verifiable claims … often fail to scale outside of a particular industry" or jurisdiction.[107] So neither the individual nor the institution gets full benefits from the system. Blockchain removes barriers to scale and geography so that educators and employers can access and analyze (with individuals' permission) massive amounts of educational or other types of data in their scientific research as well as in their administrative, academic, managerial, or professional roles.

Rethink the boundaries of the institution—again. Education works best when it works for all types of teaching and learning and every type of student. Blockchain is an engine of inclusion. It will provide a secure and transparent platform on which to create a global network for lifelong learning. Let's use it to think outside the ivory tower, offer a greater diversity of teaching and learning opportunities, consider ever smaller units and different types of knowledge to credential. Let's use credentials to improve access to jobs and education, enable employers to find people with skills that meet their requirements, and reconsider different types of entry requirements and funding arrangements for students who perform poorly in standardized testing environments or who lack funding for full tuition.

Learning pathways work best when they accommodate all types of learning styles and teaching and training methods.

Study rows at library of La Trobe by andrew_t8 (Andrew Tan), 2016, used under Pixabay license, accessed 15 April 2019.

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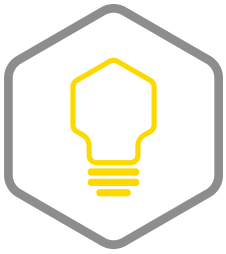

About the authors

Don Tapscott

Don Tapscott, executive chairman of the Blockchain Research Institute, is one of the world's leading authorities on the impact of technology on business and society. He has authored 16 books, including *Wikinomics: How Mass Collaboration Changes Everything*, which has been translated into over 25 languages. Don's most recent and ambitious book—*Blockchain Revolution: How the Technology Behind Bitcoin and Other Cryptocurrencies Is Changing the World*—was co-authored with his son, Alex Tapscott, a globally recognized investor, advisor, and speaker on blockchain technology and cryptocurrencies. According to Harvard Business School's Clayton Christensen, it is "*the* book, literally, on how to survive and thrive in this next wave of technology-driven disruption." The paperback version of the book, updated with new material covering recent developments in the blockchain industry, was published in June 2018.

In 2017, Don and Alex co-founded the Blockchain Research Institute. Its 100+ projects are the definitive investigation into blockchain strategy, use cases, implementation challenges, and organizational transformations. Don is a member of the Order of Canada and is ranked the second most influential management thinker and the top digital thinker in the world by Thinkers50. He is an adjunct professor at INSEAD and chancellor of Trent University in Ontario. It is hard to imagine anyone who has been more prolific, profound, and influential in explaining today's technological revolutions and their impact on the world.

Alex Kaplan

Alex Kaplan, worldwide leader IBM blockchain in education and member IBM Industry Academy, is a leading authority on the application of advanced technologies in education.[108] He is a leader of IBM's work on how artificial intelligence, blockchain, analytics, and other advanced technologies, which are essential tools facilitating personalized and lifelong learning at scale. Alex's work focuses on the intersection of technology and business processes, and he identifies solutions that can improve the user experience and reduce inefficiencies. His work also encompasses talent management, assessments, digital badging, learning progression paths, learner aligned smart content, and conversational agents in support of learning.

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Alex has led technology solutions initiatives that change the teaching and learning paradigm. He has served in various roles in the education technology industry, including CEO, education industry strategist and researcher, leader of sales and professional services organizations, and leader of product development teams. Alex is a board member of IMS Global Learning Consortium and has shared responsibility for IBM's global strategy for education. Alex has worked with leading firms in the field, including IBM, Apple, Pearson, Workday, and Sesame Workshop, and numerous K12 districts, universities, and state boards of education. He has contributed to sessions on advanced technologies in education at Harvard University, Columbia University, IMS Global, the Getty Foundation, IBM Research, and others.

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Alex also extends his thanks to Michael King for his insights into the roles of advanced technology in education and how IBM can use its resources to transform education. Mike is IBM's vice president and general manager for the global education industry. His work with education institutions around the world has provided a deep grounding in how IBM's approach to blockchain in education should evolve.

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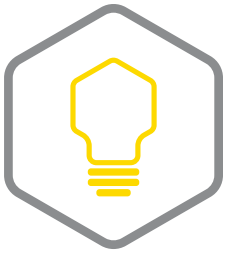

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Co-founded in 2017 by Don and Alex Tapscott, the Blockchain Research Institute is a knowledge network organized to help realize the new promise of the digital economy. It builds on their yearlong investigation of distributed ledger technology, which culminated in the publication of their critically acclaimed book, Blockchain Revolution (Portfolio Penguin).

Our syndicated research program, which is funded by major corporations and government agencies, aims to fill a large gap in the global understanding of blockchain technology and its strategic implications for business, government, and society.

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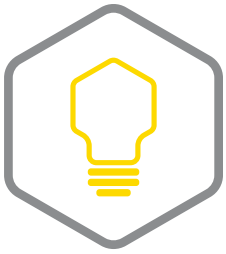

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Notes

1. Don Tapscott, *Growing Up Digital: The Rise of the Net Generation* (New York: McGraw-Hill, 1998).
2. Chris Jagers, "Do you have any examples of blockchain applications in education?" Q&A online platform, Quora, 11 Oct. 2016. www.quora.com/Do-you-have-any-examples-of-blockchain-applications-in-education?, accessed 4 March 2018. Chris Jagers is CEO of Learning Machine.
3. Doc Searls, "Sovereign-Source vs. Administrative Identity," ProjectVRM, 25 March 2012. blogs.harvard.edu/vrm/2012/03/25/sovereign-source-vs-administrative-identity, accessed 21 Feb. 2018.
4. "The Sovrin Solution," *Sovrin.org*, Sovrin Foundation, n.d. sovrin.org, accessed 5 April 2019.
5. "The Sovrin Solution." See also "Sovrin: A Protocol and Token for Self-Sovereign Identity and Decentralized Trust," White Paper V1.0, Phil Windley and Drummond Reed, eds., Sovrin Foundation, Jan. 2018. sovrin.org/wp-content/uploads/2018/03/Sovrin-Protocol-and-Token-White-Paper.pdf, accessed 5 April 2019.
6. Tapscott, *Growing Up Digital: The Rise of the Net Generation.*
7. "Linux Foundation Unites Industry Leaders to Advance Blockchain Technology," Press Release, Linux Foundation, 17 Dec. 2015. www.linuxfoundation.org/press-release/2015/12/linux-foundation-unites-industry-leaders-to-advance-blockchain-technology, accessed 5 April 2019.
8. "Linux Foundation's Hyperledger Project Announces 30 Founding Members and Code Proposals to Advance Blockchain Technology," *Hyperledger*, Linux Foundation, 9 Feb. 2016. www.hyperledger.org/announcements/2016/02/09/linux-foundations-hyperledger-project-announces-30-founding-members-and-code-proposals-to-advance-blockchain-technology, accessed 5 April 2019.
9. Carlos Creus Moreira, interviewed by Don Tapscott, 3 Sept. 2015. Moreira is founder, chair, and CEO of WISeKey.
10. EAB, "Strategies for Alumni and Student Data Collection," 5 Sept. 2013. www.eab.com/research-and-insights/advancement-forum/resources/posters/strategies-for-alumni-and-student-data-collection, accessed 19 Dec. 2017.
11. "World's Biggest Data Breaches," *Information Is Beautiful*, David McCandless, updated 3 April 2018. informationisbeautiful.net/visualizations/worlds-biggest-data-breaches-hacks, accessed 4 March 2018.
12. Andreas M. Antonopoulos, interviewed by Don Tapscott, 20 July 2015. Antonopoulos is the author of *Mastering Bitcoi*n (2014), *The Internet of Money* (2016), and with co-author Gavin Wood, *Mastering Ethereum* (2017).
13. Sony Global Education, "Sony Global Education Develops Technology Using Blockchain for Open Sharing of Academic Proficiency and Progress Records," News Release, Sony Corporation, 22 Feb. 2016. www.sony.net/SonyInfo/News/Press/201602/16-0222E/index.html, accessed 4 March 2018. "Creating a Trusted Experience with Blockchain," *SonyGED.com*, Sony Global Education, Inc., 2017. blockchain.sonyged.com; and Asha McLean, "Fujitsu and Sony Think Blockchain Is the Best Way to Store Education Records," *ZDNet*, CBS Interactive, 27 Feb. 2019. www.zdnet.com/article/fujitsu-and-sony-think-blockchain-is-the-best-way-to-store-education-records, both accessed 5 April 2019.
14. CareerBuilder, "Fifty-eight Percent of Employers Have Caught a Lie on a Resume, According to a New CareerBuilder Survey," News Release, CareerBuilder, LLC, 7 Aug. 2014. www.careerbuilder.com/share/aboutus/pressreleasesdetail.aspx?sd=8%2F7%2F2014&id=pr837&ed=12%2F31%2F2014, accessed 4 March 2018. "ITCC Employer Survey Results Summary Results," IT Certification Council, May 2016, p. 14. www.itcertcouncil.org/employers, accessed 5 April 2019. See also Dawn Papandrea, "The Biggest Resume Lies to Avoid," Monster, Monster Worldwide, n.d. www.monster.com/career-advice/article/the-truth-about-resume-lies-hot-jobs, accessed 23 April 2018.
15. "Official Transcript Types, Cost and Volume: Results of the AACRAO May 2018 60-Second Survey," dir. Wendy Kilgore, American Association of Collegiate Registrars and Admissions Officers, Hobsons and National Student Clearinghouse, 17 May 2018. www.aacrao.org/docs/default-source/research-docs/aacrao-may-2018-transcript-cost-type-and-volume.pdf?sfvrsn=1d4aeaf2_2, accessed 11 April 2019.
16. Complete College America, "Time is the Enemy," Lumina Foundation et al., Sept. 2011. www.luminafoundation.org/files/resources/time-is-the-enemy.pdf, accessed 23 April 2018.

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17. Open Badges, n.d. openbadges.org; Blockcerts, n.d. www.blockcerts.org; and Learning is Earning 2026, Institute for the Future, n.d. www.learningisearning2026.org, all accessed 23 April 2018.

18. Ryan Craig, "Why Free Bootcamps + Inexpensive Bachelor's Degrees Make Sense," *EdSurge*, EdSurge Inc., 28 Sept. 2016. www.edsurge.com/news/2016-09-28-why-free-bootcamps-inexpensive-bachelor-s-degrees-make-sense, accessed 23 April 2018.

19. GSV Acceleration, "Venture Capital to Transform Education and Talent," GSV Asset Management LLC, n.d. gsvacceleration.com, accessed 26 April 2018.

20. Audrey Watters, "Who's Funding 'Credentialing' Start-ups?" *Hack Education*, 14 Dec. 2016. funding.hackeducation.com/2016/12/14/credentials, accessed 19 Dec. 2017.

21. "Industry Leaders Combine to Create Global Platform for Digital Credentials," Press Release, *Credly.com*, Credly and Pearson, 12 April 2018. credly.com/releases/180412/Credly-Acclaim, accessed 5 April 2019.

22. Tapscott, *Growing Up Digital: The Rise of the Net Generation*.

23. Secretary of State for Business, Innovation and Skills, "Success as a Knowledge Economy: Teaching Excellence, Social Mobility and Student Choice," Department of Business and Innovation Skills, May 2016. www.timeshighereducation.com/sites/default/files/breaking_news_files/higher-education-white-paper-success-as-a-knowledge-economy.pdf, accessed 19 Dec. 2017.

24. Credly, "IBM Case Study: Executive Summary," *Credly Resources*, Credly, Inc., n.d. resources.credly.com/ibm-case-study-executive-summary, accessed 5 April 2019.

25. Ben Woods, "Facebook and Google could be allowed to award university degrees," *The Next Web*, The Next Web BV, 16 May 2016. thenextweb.com/uk/2016/05/16/facebook-google-allowed-award-university-degrees-uk, accessed 19 Dec. 2017.

26. Philipp Schmidt, "Certificates, Reputation, and the Blockchain," MIT Media Lab, *Medium*, A Medium Company, 27 Oct. 2015. medium.com/mit-media-lab/certificates-reputation-and-the-blockchain-aee03622426f, accessed 19 Dec. 2017.

27. David Leaser, "Northeastern University + IBM: Turning Digital Badges into Academic Credentials Will Create Opportunities and Better College Graduates," *IBM Training and Skills Blog*, IBM Corporation, 19 Feb. 2019. www.ibm.com/blogs/ibm-training/northeastern-university-ibm-turning-digital-badges-academic-credentials-will-create-opportunities-better-college-graduates, accessed 15 April 2019.

28. MIT Registrar's Office, "Transcripts"; Ryan Craig, "The technology of higher education," *TechCrunch*, Oath Tech Network, 28 June 2016. techcrunch.com/2016/06/28/the-technology-of-higher-education, accessed 19 Dec. 2017.

29. "Dialog Session Blockchain Enhanced Student Services," YouTube video, Blockchain-in-Education Conference, 5 Sept. 2017, uploaded 18 Sept. 2017. www.bcined2017.nl/dialog-session-blockchain-enhanced-student-services, accessed 19 Dec. 2017.

30. Corinne Ruff, "More Colleges Turn to 'Stackable' Degrees as Entries to Graduate Programs," *The Chronicle of Higher Education*, The Chronicle of Higher Education, 30 March 2016. www.chronicle.com/article/More-Colleges-Turn-to/235886, accessed 19 Dec. 2017.

31. Holly Moore, "The Potential for Stackable Credentials: From 30,000 Feet," *The EvoLLLution*, The EvoLLLution, 26 May 2016. evolllution.com/programming/credentials/the-potential-for-stackable-credentials-from-30000-feet, accessed 19 Dec. 2017.

32. Iris Palmer, "Five Things to Remember When Building Stackable Credentials," *The EvoLLLution*, Destiny Solutions, 2 July 2015. evolllution.com/opinions/remember-building-stackable-credentials, accessed 23 April 2018.

33. "Advancing Digital Credentials and Competency-Based Learning," *IMSGlobal.org*, IMS Global Learning Consortium, n.d. www.imsglobal.org/initiative/advancing-digital-credentials-and-competency-based-learning; and "Beyond Badges: Open Pathways for Learning," *EdTech Revolution Leaders*, *IMSGlobal.org*, IMS Global Learning Consortium, Feb. 2018. www.imsglobal.org/concentric-sky-open-pathways, both accessed 5 April 2019.

34. Tapscott, *Growing up Digital: The Rise of the Net Generation*.

35. Sean Cavanagh, "Would 'Blockchain' Tech Work for K-12 Schools?" *Education Week*, Editorial Projects in Education, 15 March 2016. www.edweek.org/ew/articles/2016/03/16/would-blockchain-tech-work-for-k-12-schools.html, accessed 4 March 2018.

36. Brenda Leong, interviewed by Reshma Kamath, 19 Nov. 2017.

37. Kim Hamilton Duffy, interviewed by Reshma Kamath, 15 Nov. 2017.

38. Kim Hamilton Duffy, "W3C Credentials Community Group Charter," World Wide Web Consortium, 19 Oct. 2017. www.w3.org/community/credentials/charter, accessed 23 April 2018.

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39. Kim Hamilton Duffy, "The Time for Self-Sovereign Identity is Now," *Learning Machine Blog*, Medium, 7 Nov. 2017. medium.com/learning-machine-blog/the-time-for-self-sovereign-identity-is-now-222aab97041b, accessed 19 Dec. 2017.

40. Blockcerts, "Own and Share Your Achievements," n.d. www.blockcerts.org, accessed 23 April 2018.

41. Asha McLean, "Fujitsu and Sony Think Blockchain Is the Best Way to Store Education Records," *ZDNet*, CBS Interactive, 27 Feb. 2019. www.zdnet.com/article/fujitsu-and-sony-think-blockchain-is-the-best-way-to-store-education-records; and Sead Fadilpasic, "10 Best Projects Implementing Blockchain in the Educational Field," Token Investor Online, 4 Dec. 2018. tokeninvestoronline.com/10-best-projects-implementing-blockchain-in-the-educational-field, both accessed 5 April 2019.

42. Hallie Busta, "Innovator of the Year: Central New Mexico Community College," *Education Dive*, Industry Dive Inc., 3 Dec. 2018. www.educationdive.com/news/innovator-of-the-year-central-new-mexico-community-college/542143, accessed 5 April 2019.

43. Ministry for Education and Employment, "Press Release Issued by the Ministry for Education and Employment," Press Release, Reference No. PR170153, GOV.MT, Government of Malta, 24 Jan. 2017. www.gov.mt/en/Government/Press%20Releases/Pages/2017/January/24/PR170153.aspx; Megan Frydel, "Malta Launched Education Blockchain Certification," *Medium*, A Medium Company, 25 Sept. 2017. medium.com/bite-my-coin/malta-launched-education-blockchain-certification-7d9a98a8787a, both accessed 23 April 2018.

44. Elsa Weill, e-mail to Hilary Carter, 19 March 2018.

45. Mia Little and Amelia Vance, "Law Enforcement Access to Student Records: What Is the Law?" Ferpa|Sherpa, Future of Privacy Forum, 25 Sept. 2017. ferpasherpa.org/law-enforcement-access-to-student-records, 19 Dec. 2017.

46. Named after the core federal law that governs education privacy, FERPA|Sherpa provides students, parents, schools, edtech companies, and policymakers with easy access to the resources, best practices, and guidelines that are essential to understanding the complex privacy issues arising at the intersection of kids, schools, and technology.

47. Amelia Vance and Sarah Williamson, "Law Enforcement Access to Student Records: A Guide for School Administrators & Ed Tech Service Providers," Future of Privacy Forum, Sept. 2017. fpf.org/wp-content/uploads/2017/09/Law-Enforcement-Access-to-Data-Final.pdf, accessed 19 Dec. 2017.

48. Vance and Williamson, "Law Enforcement Access to Student Records."

49. Vance and Williamson, "Law Enforcement Access to Student Records."

50. Tapscott, *Growing Up Digital: The Rise of the Net Generation*.

51. "About the Fellowship," The Thiel Fellowship, n.d. thielfellowship.org/about, accessed 3 March 2018.

52. Joseph Lubin, interviewed by Don and Alex Tapscott, 13 July 2015. Lubin is the founder and CEO of ConsenSys, an Ethereum development studio.

53. Holberton School, "Holberton School to Authenticate Its Academic Certificates with the Bitcoin Blockchain," News Release, *Market Wired*, West Corporation, 21 Oct. 2015. www.marketwired.com/press-release/holberton-school-authenticate-its-academic-certificates-with-bitcoin-blockchain-2065768.htm, accessed 23 April 2018.

54. Jordan Crook, "Steve Wozniak announces tech education platform Woz U," *TechCrunch*, Oath Tech Network, 13 Oct. 2017. techcrunch.com/2017/10/13/steve-wozniak-announces-tech-education-platform-woz-u; Coder for Rent LLC, "Woz U," App Preview, Apple Store, Apple Inc., n.d. itunes.apple.com/us/app/woz-u/id1247575927?mt=8, both accessed 19 Dec. 2017.

55. Angela Gonzales, "The Art Institutes partners with Woz U for technology curriculum," *Phoenix Business Journal*, American City Business Journals, 16 March 2018. www.bizjournals.com/phoenix/news/2018/03/16/the-art-institutes-partners-with-woz-u-for.html; The Art Institutes, "Our Campuses," n.d. www.artinstitutes.edu/our-campuses, both accessed 23 April 2018.

56. Gavin Cosgrave, "Token Economy," Educate Autism, n.d. www.educateautism.com/token-economy.html, accessed 19 Dec. 2017.

57. Elsa Weill, e-mail to Hilary Carter, 19 March 2018.

58. Cosgrave, "Token Economy."

59. Jeff John Roberts, "Microsoft and Accenture Unveil Global ID System for Refugees," *Fortune*, Time Inc., 19 June 2017. fortune.com/2017/06/19/id2020-blockchain-microsoft, accessed 4 March 2018.

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60. University of Nicosia, "Unconventional Linkages: Blockchains and S3Cy," *Research Matters Blog*, no. 06, 22 Dec. 2016. www.unic.ac.cy/blog/research-matters-issue-06/unconventional-linkages-blockchains-and-s3cy, accessed 19 Dec. 2017.

61. Blockchain Education Network, n.d. www.blockchainedu.org. It issues a regular free newsletter on advances in the space.

62. University of Nicosia, "Unconventional Linkages: Blockchains and S3Cy."

63. Globaltraining, "Blockchain Training Series," n.d. globaltraining.org/blockchain-training-series, accessed 4 March 2018.

64. Adroit Lawyers, n.d. www.adroitlawyers.com.au, accessed 4 March 2018.

65. University of Nicosia, "Unconventional Linkages: Blockchains and S3Cy."

66. Nicosia, "Smart Specialization Strategy for Cyprus," May 2014. s3platform.jrc.ec.europa.eu/documents/20182/89368/S3CY_Executive+Summary_EN.pdf/4af4bbe0-85ce-4be7-8b55-b7eb7b27ebd6, accessed 19 Dec. 2017.

67. University of Nicosia, "Unconventional Linkages: Blockchains and S3Cy."

68. University of Nicosia, "Unconventional Linkages: Blockchains and S3Cy."

69. Briana Boyington, "See 20 Years of Tuition Growth at National Universities," *US News and World Report*, US News and World Report LP, 20 Sept. 2017. www.usnews.com/education/best-colleges/paying-for-college/articles/2017-09-20/see-20-years-of-tuition-growth-at-national-universities, accessed 4 March 2018.

70. "A Look at the Shocking Student Loan Debt Statistics for 2018," Student Loan Hero, updated 24 Jan. 2018. studentloanhero.com/student-loan-debt-statistics, accessed 23 April 2018.

71. Melanie Swan, interviewed by Don Tapscott and Kirsten Sandberg, 14 Sept. 2015.

72. "Developer Guides," Google LLC, developer.android.com/training, accessed 19 Dec. 2017.

73. Sony Global, "Sony Global Education Develops Technology Using Blockchain."

74. Jane McGonigal, "How to Think (and Learn) Like a Futurist," SXSW EDU Keynote Address, SXSW LLC, 9 March 2016. www.youtube.com/watch?v=CKvMmtclUBA, accessed 4 March 2018. See also ACT Center for Equity in Learning, n.d. equityinlearning.act.org; Institute for the Future, n.d. www.iftf.org/home, both accessed 23 April 2018.

75. Learning is Earning 2026.

76. Imran Khan, e-mail to Reshma Kamath, 22 Dec. 2017.

77. Charles Vest, "Open Content and the Emerging Global Meta-University," *EDUCAUSE Review* 41, no. 3 (May/June 2006): 18-30. EDUCAUSE, er.educause.edu/articles/2006/1/open-content-and-the-emerging-global-metauniversity, accessed 4 March 2018.

78. Katy Jordan, "MOOC Completion Rates: The Data," MOOC Project, 12 June 2015. www.katyjordan.com/MOOCproject.html; "State of the MOOC 2016: A Year of Massive Landscape Change for Massive Open Online Courses," *Online Course Report*, OnlineCourseReport.com, 2016. www.onlinecoursereport.com/state-of-the-mooc-2016-a-year-of-massive-landscape-change-for-massive-open-online-courses, both accessed 24 Jan. 2017.

79. The term *global network for higher learning* was first developed by Don Tapscott and Anthony D. Williams in their book *Macrowikinomics: New Solutions for a Connected Planet* (New York: Portfolio Penguin, 2010). See also Don Tapscott and Anthony D. Williams, "Innovating the 21st-Century University: It's Time!" *EDUCAUSE Review* 45, no. 1 (Jan.–Feb. 2010): 16-29. EDUCAUSE, er.educause.edu/articles/2010/2/innovating-the-21stcentury-university-its-time, accessed 23 April 2018.

80. MIT Office of Digital Learning, "About OpenCourseWare: Milestones," *MIT OpenCourseWare*, Massachusetts Institute of Technology, 2018. ocw.mit.edu/about/milestones; and "OEC Members," Open Education Consortium, as of 5 April 2019. www.oeconsortium.org/members, both accessed 5 April 2019.

81. MIT Office of Digital Learning, "Site Statistics," *MIT OpenCourseWare*, Massachusetts Institute of Technology, 2019. ocw.mit.edu/about/site-statistics; and "Dashboard Report: September 2018," *MIT OpenCourseWare*, MIT, 16 Oct. 2018. ocw.mit.edu/about/site-statistics/monthly-reports/MITOCW_DB_2018_09_v1.pdf, both accessed 5 April 2019.

82. Sakai, Apereo Foundation 2014, n.d. sakaiproject.org, accessed 19 Dec. 2017.

83. "EU 2020: Why Skills Are Key for Europe's Future," *EURACTIV*, EURACTIV.COM Ltd., 8 Dec. 2009. www.euractiv.com/section/social-europe-jobs/opinion/eu-2020-why-skills-are-key-for-europe-s-future, accessed 19 Dec. 2017.

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84. Viktor Haag, Mary Millar, et al., "IMS Caliper Analytics Best Practice Guide," V1.0, *IMS Caliper Analytics*, IMS Global Learning Consortium, 10 Oct. 2015, rev. 12 April 2019. www.imsglobal.org/caliper/caliperv1p0/ims-caliper-analytics-best-practice-guide, accessed 15 April 2019.

85. Michael King, conversation with Alex Kaplan, 10 April 2019.

86. Paul Rosenzweig, "Blockchain Standards," *Lawfare*, The Lawfare Institute, 19 Aug. 2017. www.lawfareblog.com/blockchain-standards, accessed 23 April 2018.

87. "Tracking Preference Expression (DNT)," ed. Roy T. Fielding, Editor's Draft, W3C, 31 Oct. 2011. www.w3.org/2011/tracking-protection/drafts/tracking-dnt-20111031.html, accessed 19 Dec. 2017.

88. Verifiable Claims Task Force, "[EDITOR'S DRAFT] Verifiable Claims Working Group Primer," W3C Society and Technology domain, Web Payments Interest Group, n.d. w3c.github.io/webpayments-ig/VCTF/primer, accessed 19 Dec. 2017.

89. Verifiable Claims Task Force, "[EDITOR'S DRAFT] Verifiable Claims Working Group Primer."

90. Verifiable Claims Task Force, "[EDITOR'S DRAFT] Verifiable Claims Working Group Primer."

91. Shermin Voshmgir, "Citizen Chain," *Medium*, A Medium Company, 26 April 2016. medium.com/blockchain-hub/citizen-chain-1c219d9a06e5, accessed 19 Dec. 2017.

92. "ISO/TC 307 Blockchain and distributed ledger technologies," International Organization for Standardization, n.d. www.iso.org/committee/6266604.html, accessed 19 Dec. 2017.

93. Advait Deshpande, Katherine Stewart, Louise Lepetit, and Salil Gunashekar, "Understanding the landscape of Distributed Ledger Technologies/Blockchain: Challenges, opportunities, and the prospects for standards," RAND Europe, RAND Corporation, 2017. www.rand.org/pubs/research_reports/RR2223.html, accessed 19 Dec. 2017.

94. Boyington, "See 20 Years of Tuition Growth at National Universities."

95. Boyington, "See 20 Years of Tuition Growth at National Universities."

96. Boyington, "See 20 Years of Tuition Growth at National Universities."

97. Kim Hamilton Duffy, interviewed by Reshma Kamath.

98. Verifiable Claims Task Force, "[EDITOR'S DRAFT] Verifiable Claims Working Group Primer."

99. "Open Badges 2.0 (OBv2)," *IMSGlobal.org*, IMS Global Learning Consortium, n.d. www.imsglobal.org/activity/digital-badges, accessed 5 April 2019.

100. Verifiable Claims Task Force, "[EDITOR'S DRAFT] Verifiable Claims Working Group Primer."

101. Verifiable Claims Task Force, "[EDITOR'S DRAFT] Verifiable Claims Working Group Primer."

102. Imran Khan, e-mail to Reshma Kamath, 22 Dec. 2017.

103. "Our mission is to decentralize precision medicine with AI," Doc.ai, n.d. doc.ai/about, accessed 25 April 2018.

104. Jamie Loizzo and Peggy Ertmer, "10 tips for using social tools with students," International Society for Technology in Education, 2 Jan. 2015. www.iste.org/explore/articleDetail?articleid=248, accessed 4 March 2018.

105. Mike Ribble, "Digital Citizenship Today," *Digital Citizenship*, GoDaddy, 2017. www.digitalcitizenship.net, accessed 19 Dec. 2017; "Digital Citizenship," *Common Sense Education*, Common Sense Media, n.d. www.commonsense.org/education/digital-citizenship, accessed 4 March 2018.

106. Verifiable Claims Task Force, "[EDITOR'S DRAFT] Verifiable Claims Working Group Primer."

107. Sony Global, "Sony Global Education Develops Technology Using Blockchain."

108. Alex Kaplan can be reached through LinkedIn, www.linkedin.com/in/alexkaplanibm.

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