Blockchain Education: A Prerequisite for Socio-Economic and Technological Advancement

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Contents

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General Introduction

Blockchain[1] is a foundational and institutional technology[2] that has the potential to redesign socio-economic transactional infrastructure and related organisational and operational models from the bottom up. When using Blockchain, the ownership and exchange of assets and data become both an integral and integrated part of the fabric of the internet without the need for involving trust-building centralised third-parties.

The autonomous, decentralised, trustless and borderless character of the validation process of Blockchain-based transactions in combination with Public-Private-Key-Infrastructure,[3] enables a freely accessible global system of self-custody and -management of assets and data. The concepts of peer-to-peer exchange of asset ownership and self-sovereign identity are examples of the paradigm-shifting capabilities of Blockchain.

The ability to tokenise anything on a Blockchain,[4] from tangible and intangible assets to data, tasks and processes, allows for any type of organisational and operational building-block to exist and move freely within the fabric of the internet. The internet of value[5] was able to become a reality through Blockchain.

Smart contracts, defined here as an asset and transaction related code that is executed by the nodes in a Blockchain network, adds the programmability of assets, data and transactions to the internet and facilitates automation of any type of transaction, process or organisational model.

The decentralisation of asset and data custody as well as the programmability it offers opens up the possibility for innovation in processes, governance and business models.[6] Indeed, new grounds are available for those who use the borderless infrastructure of the internet and create value by combining global direct distribution channels and digital networks with global borderless talent pools and programming of contracts and processes.

The scope and depth of the potential transformation are simultaneously huge and experimental. Indeed, the paradigm shift projected by Blockchain would lead the international socio-economic ecosystem into previously unknown terrain, possibly lending itself to worldwide organisational transformation and innovation.

The importance of understanding and implementing Blockchain should not be underestimated. The transition from a global centralised socio-economic organisational model to a globally decentralised and borderless model invites all socio-economic stakeholders to re-think their participation, roles and processes.[7, 8] The change is

[1] The paper's approach consists in discussing the educational needs for the positioning of an economy and a society in the context of global network effects and permissionless innovation brought about by public permissionless Blockchains. DLT, as being anything that evolves toward that point of global network effects and permissionless innovation, is covered by the term Blockchain.

[2] See e.g. Chris Berg, Sinclair Davidson and Jason Potts, 'Understanding the Blockchain economy: an introduction to institutional cryptoeconomics' (Cheltenham: Edward Elgar Publishing, 2020).

[3] See e.g. A. Narayanan, S. Goldfeder, A. Miller, E. Felten, J. Bonneau, 'Bitcoin and cryptocurrency technologies: a comprehensive introduction' (Princeton, NJ: Princeton University Press, 2016).

[4] See e.g. S. Voshmgir, 'Token economy, how Blockchains and smart contracts revolutionize the economy', (Berlin: BlockchainHub Berlin, 2019).

[5] See e.g. A. Yee, A. Welfare, C. Wyper, D. Schwartz, F. Caccioli, G. Cupi, et al., 'The Internet of Value, A collection of articles from the UCL CBT Research and Industry Associate Community on how Blockchain and DLT are enabling the new Internet of Value', (University College London Centre for Blockchain Technologies), http://blockchain.cs.ucl.ac.uk/wp-content/uploads/2020/07/Complete-Manuscript_v1_early_release.pdf [accessed 17 January 2021].

[6] See e.g. D. Furlonger, C. Uzureau, 'The real business of Blockchain: how leaders can create value in a new digital age', (Boston: Harvard Business School Publishing Corporation, 2019).

[7] See e.g. M. Fenwick, E. Vermeulen, 'Decentralisation is Coming: The Future of Blockchain' (Journal of the British Blockchain Association, 2019), https://jbba.scholasticahq.com/article/10236-decentralisation-is-coming-the-future-of-blockchain [accessed 17 January 2021].

[8] See e.g. M. Anderson, 'Exploring Decentralization: Blockchain Technology and Complex Coordination' (Journal of Design and Science, 2019), https://jods.mitpress.mit.edu/pub/7vxemtm3 [accessed 1 January 2021]

uncomfortable and unsettling, but at the same time, the integration of the socio-economic infrastructure and its functional model in the very fabric of the internet seems to be an inevitable evolution.

This transition will take time. The resistance to change, especially when the legacy setup does not seem dysfunctional, is huge.[9] Indeed, Blockchain not only challenges traditional cognitive collective and individual models but also requires all stakeholders to participate in the immense global coordination and standardisation process that is vital to the realisation of new decentralised models.

The current corporate and institutional adoption of Blockchain[10] solutions can be conceptualised as a logical marriage between the current corporate and institutional/organisational legal setups. Current Blockchain solutions often use the permissioned private version of Blockchain technology to improve and optimise the existing organisational or operational context.

There is, however, a path to maturity that challenges the traditional socio-economic organisational and operational infrastructure and models.[11] The permissionless public version of Blockchain appeals to the decentralisation of traditional models as the open version of Blockchain establishes a global platform for open exchange and innovation which seems to hold a greater potential for novel value creation.

This decentralised approach requires a fundamental change in mindset, moving away from established centralised socio-economic models toward new decentralised organisational models.[12]

The path to maturity requires a long-term educational strategy that accompanies the logical adoption capacity of socio-economic institutions, with the initial insertion of Blockchain into existing operational setups and subsequently the gradual transformation of the socio-economic infrastructure and organisational models to be decentralised.

This position paper proposes a view on Blockchain education that tackles this first phase of Blockchain adoption: the first encounter of the technology with existing socio-economic operational models. In this stage, the objective is to educate first implementers in the ecosystem, providing a basic understanding of the technology and its socio-economic implications.

As will be shown further in this paper, institutions, businesses and classical education providers are considered primary Blockchain implementers and consequently are priority targets for Blockchain education. The proposed curriculum focuses on providing a fundamental understanding of technological principles and socio-economic implications. According to the targets' specific professional specialities, different levels of mastery of the proposed Blockchain curriculum is recommended based on a customised version of Bloom's taxonomy of cognitive educational objectives created specifically for this paper.[13]

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9 See e.g. C. Walsh, P. O'Reilly, R. Gleasure, J. Mcavoy, K. O'Leary, 'Understanding manager resistance to Blockchain systems' (European Management Journal, 2020), https://doi.org/10.1016/j.emj.2020.10.001 [accessed 17 January 2021].

10 See e.g. Deloitte, C-Suite Briefing 5 Blockchain Trends for 2020, Deloitte Ireland LLP, March 2020, https://www2.deloitte.com/content/dam/Deloitte/ie/Documents/Consulting/Blockchain-Trends-2020-report.pdf [accessed 17 January 2021]

11 See e.g. D. Furlonger, C. Uzureau, 'The real business of Blockchain: how leaders can create value in a new digital age' (Boston: Harvard Business School Publishing Corporation, 2019).

12 See e.g. Roman Beck, Christoph Müller-Bloch and John Leslie King, 'Governance in the Blockchain Economy: A Framework and Research Agenda' (Journal of the Association for Information Systems: Vol. 19 : Iss. 10 , Article 1., 2018) https://aisel.aisnet.org/jais/vol19/iss10/1 [accessed 17 January 2021]

13 B. S. Bloom, M. D. Engelhart, E. J. Furst, W. H. Hill, D. R. Krathwohl, 'Taxonomy of educational objectives: the classification of educational goals' (London: Longman, 1956).

Blockchain-Technology and the Importance of Education

Blockchain was introduced in 2009 as a technology that could empower individuals by providing a socio-economic infrastructure of trust. However, Blockchain, like any other type of infrastructure, brings its own set of "relations, processes, and imaginations."[14] Thus, to benefit from it, users of Blockchain technology and stakeholders will need to cross a certain threshold of knowledge to be able to use and profit from it. Here, this threshold of knowledge incorporates all the basic concepts and ontologies needed to understand Blockchain technology and the vocabulary of its governance.

As Blockchain technology expands to more areas of the economy, a new risk emerges: the more successful the technology is, the greater the social field "left behind" the threshold of knowledge needed to understand the ecosystem. To put it bluntly, Blockchain technology development poses the growing risk that the people who were originally supposed to be empowered by the technology might be excluded from a meaningful form of participation in society.

UNESCO has already explored how the Information and communications technologies (ICT[15]) have expanded the original notion of 'digital illiteracy' beyond its actual use to describe the ability to handle computers. A Report from the Institution stated in 2011 that ICT brings a new layer of digital illiteracy that is understood as a "*set of user skills that enable active participation in a society where services and cultural offerings are computer-supported and distributed on the internet*."[16]

In the same vein, in the past few years, UNCTAD has monitored a so-called 'digital divide' that stresses the additional problem of ICT connectivity especially in developing countries. Although connectivity has significantly improved in previous years, there is still a significant divide between internet access levels in developed and developing countries. For instance, in developing countries, only 40 percent of people use the internet, compared with more than 80 percent in developed countries.[17]

If education is not taken seriously by states, international organisations, universities and economic actors, the evolution of Blockchain could introduce a new layer of exclusion beyond the current concepts of 'digital literacy' and the 'digital divide.' Moreover, the ideas, ontologies, and vocabulary that are instrumental in Blockchain technology are not self-evident even for a well-informed digital literate. For example, a critical distinction between permissioned versus permissionless Distributed Ledger Technology systems could be difficult to explain even to highly educated individuals from a developed country that has not been acquainted with Blockchain technology. Thus, if not appropriately addressed, the lack of education around Blockchain infrastructures could pull a vast majority of the global population into a new type of digital exclusion. Consequently, the lack of proper education at different levels could compromise the achievement of several Sustainable Development Goals (SDGs) and undermine human rights as recognised in international treaties.

[14] Benedict Kingsbury, 'Infrastructure and Infrareg: On Rousing the International Law "Wizards of Is"', (2019) 8(2) Cambridge International Law Journal, p. 179.

[15] Information Technology (IT) can be defined as exchanging information and using the exchanged information to perform a function correctly without changing the content of the data, allowing communication between the data and/or unrestricted data exchange.

[16] Andrea Karpati, 'Digital Literacy in Education' (UNESCO Institute for Information Technologies in Education; Moscow: 2011), p. 2

[17] Torbjörn Fredriksson, 'Information Economy Report 2017: Digitalization, Trade and Development', UNCTAD (Geneva: 2017), p. 17

The first step forward is to clarify the threshold of knowledge that an individual or a collective needs to acquire to participate in an informed manner inside a Blockchain infrastructure. Consequently, the current paper does not seek to provide a comprehensive 'gold standard' for Blockchain education; it instead moves in the direction of providing a reference point in the global debate on Blockchain education, providing specific targets and priorities.

Chapter 1.
The Current Status Quo of Digital Transformation

Science is a system that prizes doubt, and in science, error leads to progress in knowledge. In science, one works with testable hypotheses. Science is the fundament of our understanding: disruption, digital change and progress demand explanations. This paper aims to deliver inspiration on how to implement science and expert knowledge about Blockchain Technology into an educational system for a better understanding.

To begin this paper, definitions of key terms are first needed to reach a common understanding among readers. First, we distinguish between digitisation and digitalisation.

Digitisation is the process of converting information from a physical/analogue format into a digital one. To that end, analogue information is converted into digital bits of 1s and 0s that represent the original meaning.[18] Digitalisation, on the other hand, means to leverage digitisation to improve business processes and help bring changes in businesses and markets.[19]

Tanda notes, "*Digitalisation has become a key issue for intermediaries and incumbents, too, if they are to be able to cope with competition not only from FinTechs and BigTechs but also from larger incumbents and new entrants.*"[20]

Incumbent firms are aware of the challenges of digitalisation and respond by adopting a number of strategies. Blockchain technology is a facet within the broad categories encompassing new technologies. Thirteen years after the release of Satoshi Nakamoto's White Paper[21] about the digital currency Bitcoin, Blockchain has become a technology with an increasingly apparent impact.

In summation, a digital process is a process that is based on something (maybe artificial) that transforms former analogue data into digits for the purpose of using, reading and interpreting this given data. An IT infrastructure is required for this process. According to the ITIL Foundation Course Glossary, IT Infrastructure can be termed as "All of the hardware, software, networks, facilities, etc., that are required to develop, test, deliver, monitor, control or support IT services. The term IT Infrastructure includes all of the Information Technology but not the associated People, Processes and documentation."[22]

Within the last decade, there has been a rapid development in both IT infrastructure as well as in "new technologies". The development, however, seems to be more classified as an evolution rather than a revolution. To help conceptualise this type of development, the following figure shows the evolution of the number of transistors on a chip:

18 T. Ritter, C. L. Pedersen, 'Digitization capability and digitalization of business models in business-to-business firms: Past, present, and future', Industrial Marketing Management, Vol. 86, April 2020, pp. 180–190, https://doi.org/10.1016/j.indmarman.2019.11.019.

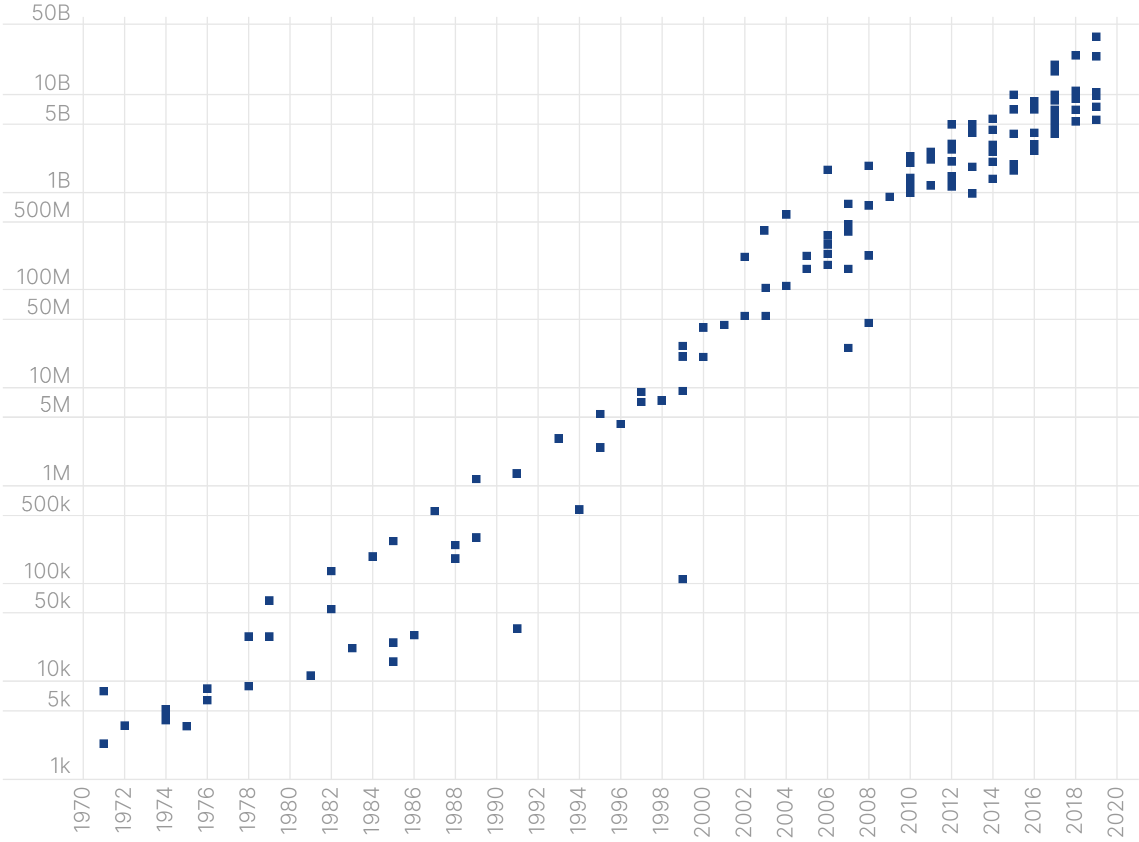
19 Dobrica Savić, 'From Digitization, through Digitalization, to Digital Transformation' (2019), 43/2019, pp. 36–39.

20 A. Tanda, C. M. Schena, 'Bank Strategies in the Light of the Digitalisation of Financial Activities', FinTech, BigTech and Banks; Palgrave Macmillan Studies in Banking and Financial Institutions. Palgrave Pivot, Cham, 2019. https://doi.org/10.1007/978-3-030-22426-4_4.

21 S. Nakamoto, 'Bitcoin: A Peer-to-Peer Electronical Cash System' (2008), https://bitcoin.org/bitcoin.pdf [accessed 2 January 2021].

22 https://itil.it.utah.edu/downloads/ITILV3_Glossary.pdf [accessed 3 January 2021].

Figure 1. Moore's Law: The number of transistors on microchips doubles every two years



Data source: Wikipedia, OurWorldInData.org. Licensed under CC-BY by the authors Hannah Ritchie and Max Roser

According to Moore's Law, the number of transistors in a dense integrated circuit is doubling about every two years.[23] Like a clock of the modern world, Moore's prediction has set the pace for innovations and technical developments for over 50 years.

Chip capacities have doubled every two years while prices have fallen by almost the same amount; a similar pattern will also be visible in Blockchain technology adoption. Currently, the development and implementation of Blockchain solutions seem too complex and expensive, but as more applications enter the market, implementation will become easier and prices will fall.[24] This tendency will be fostered by Blockchain technology that acts as a link to the other technologies that are increasingly coming into focus. Therefore, the debate on this technology must be stimulated at a macro and micro level, i.e. at the level of the state, administrations and companies, in order to wisely exploit its potential.

The World Economic Forum declared that the events of 2020 have forever changed the trajectory of technology and its role in society.[25] In order to analyse the validity of this statement for the case mentioned in this report, we first need to understand the current conditions and (digital) environment. The Digital Economy and Society Index (DESI-Index) from 2020,[26] presents the digital competitiveness between the EU Member States in five different areas.

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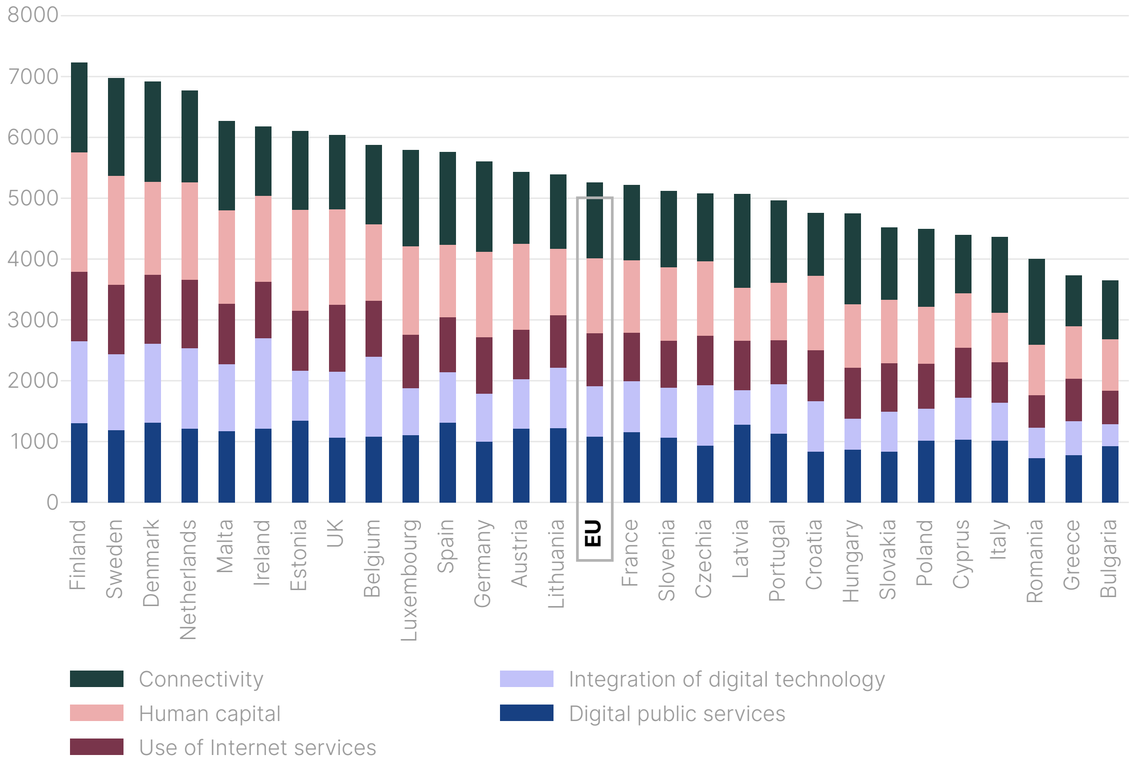
[23] G. Moore, 'Cramming more components onto integrated circuits', intel.com, Electronics Magazine (1965).

[24] Even today a Blockchain implementation can be cheap if open source is used. We can say that the technology, despite the mentioned circumstances (costly and complex) is used in various industries and sectors. But as long as we have no mass market for applications and a lack of understanding the concept only experts are able to use this technology favourably.

[25] https://www.weforum.org/platforms/shaping-the-future-of-the-internet-of-things-and-urban-transformation [accessed 14 January 2021].

[26] https://ec.europa.eu/digital-single-market/en/digital-economy-and-society-index-desi [accessed 13 January 2021].

Figure 2: Digital Economy and Society Index 2020 (EU Commission)



European Commission, Digital Scoreboard

Even though the report shows that all member countries improved their digital performance, we can see that on average broadband connectivity is rated approximately 53% but in looking at 5G pioneers and readiness, only 17 member states have assigned spectrum in the 5G band.[27] This can be seen as a blockade to the adoption of new technologies like Blockchain. For example, when we look into the Internet of Things (IoT) Industry, data exchanges in an IoT environment create values while discovering, sorting and finding advantages in using different data. Blockchain technology supports this approach but also requires a solid infrastructure. If the bandwidth is too poor, neither IoT nor Blockchain technology can reach their full potential.

Maturity levels of digital transformation remain perceived as quite low because the transformation process is too often a siloed and/or ad-hoc project. At the core of the development issue lies a lack of detailed understanding of the link between processes in different company departments. Departments may still have an adequate overview of their own processes, but this often is lacking where another, different department is involved. For example, a marketing department is well informed about their own processes, but lacks an understanding of how processes are carried out in the procurement department. Therefore, understanding and recognising the urgency to achieve interoperable transformation across different sectors and business processes will help to manage all phases of the transformation process.

To cope with all of the requirements related to the integration of knowledge and understanding how to use technology to improve a company's performance, we recommend establishing a framework for supporting the change. In this chapter, we will only look at the digital transformation and industry 4.0 from a holistic point of view. But even from this holistic perspective, it is clear that all business processes are becoming

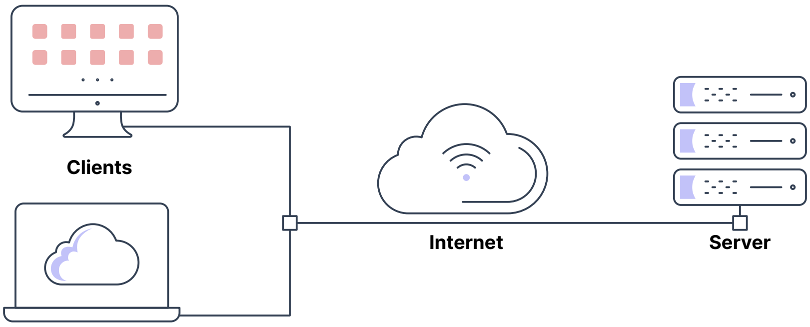
[27] DESI2020 Thematic chapters — Full European Analysis, p. 11.

more and more knowledge-intensive relative to embedded technology. It should also be noted that process optimisation and synchronisation between different parties rely on data generated by operations and/or new services.

Brief Evolution of IT Infrastructure in the Last Decade

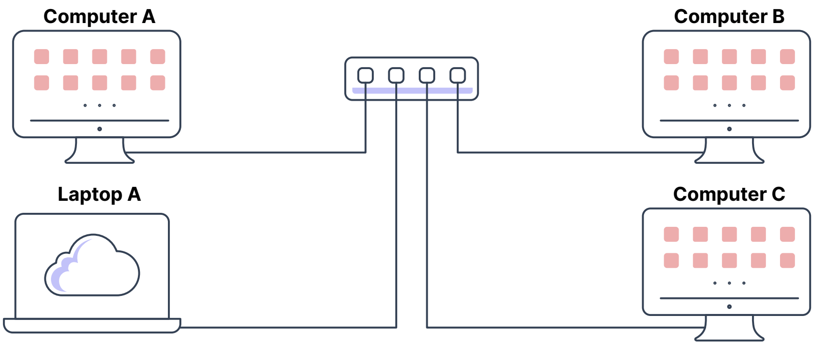
Currently, we are in the client-server-era that started in the early 1980s. It started with a network in which the server (service provider) is a computer that provides resources and functions to the workstations of the individual users at a central location. The client then makes use of these services.[28]

Figure 3: Client-Server-Model[29]



In contrast, a so-called Peer-to-Peer-Network is a network that in principle consists of workstation computers with equal rights. Therefore, each user is able to distribute resources from their own computer to others in the network so that all computers in this network provide server services to a certain extent.[30]

Figure 4: Peer-to-Peer-Network[31]



In a Peer-to-Peer-Network there is no centralised management or security because each computer in the network has a management function.

Definition of a Digitalisation Process

To use the earlier definition, we always speak of digitalisation as improved business processes and holistic changes in the company that are implemented using IT solutions.

[28] Sascha Kersken, 'IT-Handbuch für Fachinformatiker, Der Ausbildungsbegleiter', 9. (Aktualisierte und erweiterte Auflage; Bonn: Rheinwerk Verlag, 2019), p. 203.

[29] https://sites.google.com/site/alcbusinessintelligence/home/client-server-model [accessed 14 January 2021].

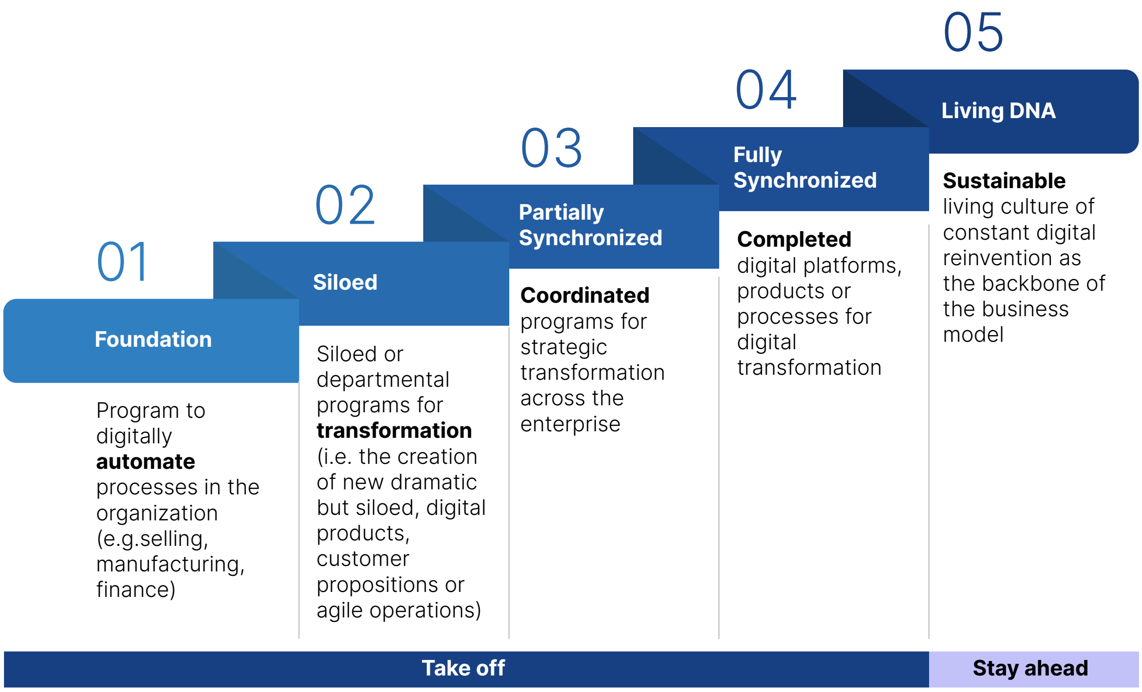
[30] The Peer-to-Peer Network approach was first time recognizable in the late 1960 and gained popularity with the release of Napster in 1990. This advanced Peer-to-Peer Network allowed the sharing of files worldwide.

[31] https://www.onlinecomputertips.com/support-categories/networking/673-peer-to-peer-vs-client-server-networks [accessed 14 January 2021].

This incorporates the integration of digital solutions into all areas of the organisation and changes the way companies are operating.

According to Tony Saldanha, author of "Why Digital Transformations Fail", the spectrum of a successful digital transformation can be divided into five key stages.

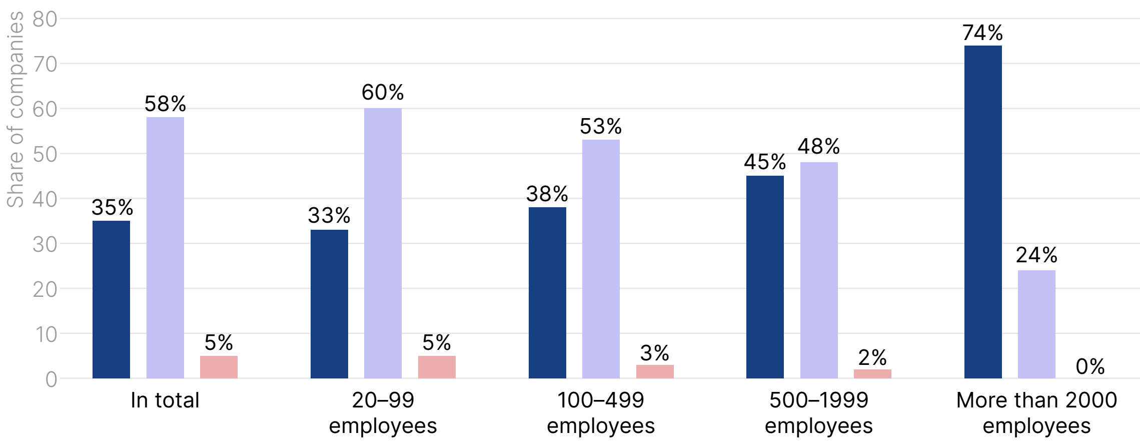
Figure 5: 5-Stage model for successful digital transformation by Tony Saldanha



Based on the five stages included in Figure 5, Saldanha describes the spectrum of digital transformation ranging from "simple digital automation" to new business models. Stages one and two describe the environments most companies find themselves in in 2020/2021.

Figure No. 6 shows the digital transformation assessment of German companies in 2018. It can be seen that only large companies with more than 2000 employees consider themselves digitalisation frontrunners.

Figure 6: Status Quo of Companies in terms of the digital transformation



(Source: Bitkom and Statista)

The majority of companies see themselves as late digitalisation adopters. We conclude that most companies meet the criteria for stage one or two of the Five-Stage Model by Tony Saldanha. To remain competitive, however, companies of all sizes have to understand the speed with which digitalisation is introduced. Hesitation means falling behind the competition.

Assessment tools have been developed both by academia and firms to provide analytical frameworks that support companies in executing a self-assessment of their digitalisation conditions. The authors of this report want to encourage company-management to use these analytical frameworks and identify the digitalisation gaps and the lack of understanding of digitalisation technology, including Blockchain technology.

Internal Processes

To understand whether it makes sense to implement a Blockchain-based solution in the company, it is of utmost importance to figure out which company processes are slow and inefficient and why. On top of that, it is crucial to ascertain whether a Blockchain solution is a feasible option in the given scenario. The digitalisation of these processes can help a company to reveal its own potential and opportunity for business growth. However, the mere order by management to eliminate inefficient processes through automated and digitalised processes will not be sufficient to gain acceptance at all levels of the company. Resistance to change is often high unless benefits of transformation are clearly communicated.

A company's self-evaluation should include the following indications:

- Is a sponsor available?
- Is internal Blockchain knowledge available?
- What degree of digitalization-maturity internal processes find themselves in (see also the five stages from Saldanha)?
- How much staff capacity is available?

The sponsorship could come from someone inside of the company who is in a position to guide and influence the progress of a mentee or a group. Many larger organisations offer sponsorship programs for their employees – this now can be used to help and guide people while adopting Blockchain technology.

Management should determine whether knowledge about Blockchain technology already exists in the company. To what extent does this knowledge exist? Are initial steps already being carried out in the company to gain a technical understanding? How can this primarily technically-oriented knowledge also be used for other status groups within the company?

Are there enough employees to deal with new technologies in addition to the normal day-to-day business?

All these considerations involve change that will likely cause anxiety among many employees. Often, digital transformation is associated with job cuts. To prevent this, we recommend a framework based on Kotter's action plan for change, described below:

#1 — Create a sense of urgency for adopting new technologies,

#2 — Adapt the company's own vision and mission statement to the company's own digital transformation,

#3 — Create a guiding coalition in the company (and industry) to nominate sponsors and partners,

#4 — Communicate the need for the digital transformation,

#5 — Identify the risks (economic, culture, financial, technical, etc.),

#6 — Find partners, network and platforms to empower broad-based action,

#7 — Anchor new approaches in the corporate culture,

#8 — Understand how the implementation of new technologies within the business processes provides value to the company's customer.[32]

Since successful digitalisation is a joint project that will only succeed if a constructive and targeted debate and cross-sector collaborations are present, we advocate an emphasis on promoting an understanding of the high-speed nature of digital transformation.

Recommendations for Action

Strengthening companies: Digitalisation shortens development cycles and generates an extremely high speed of innovation. To achieve this, the traditional regulatory approach of European economic policy must be supplemented with a digital-industrial policy targeting coherent data strategy and cooperation for the further development of key technologies. The goal must be to strengthen the companies themselves, because as companies grow stronger, they require reduced protection by the state.

Connecting the digital economy: Innovation and differentiation can be leveraged in the digital economy by the "economies of networks."[33] Digital economy is a connective, economic activity that operates in a digital environment (i.e., more than purchasing goods via the internet). While calibrating the right level of openness to be connected in the digital economy via platforms, INATBA and the Education Working Group help to support education for and between companies in the lead industries with classic industry players, digital companies, SMEs and start-ups to understand the DLT / Blockchain Technology and how to use it while improving existing processes.

Promoting Interoperability

Since there is no such thing as one centralised Blockchain, the question naturally arises as to the ability to ensure connectivity between Blockchain networks. PWC says "In its simplest form, interoperability can be defined as different Blockchain protocols and applications communicating and exchanging information and value, the objective of which is to make information usable in a frictionless way."[34]

A four-level distinction is made:

Organizational Level: Organisational interoperability refers to the coordination of processes that lead to data exchange, whereby the questions of "why" and "when" must be clarified above all.[35]

[32] John P. Kotter, 'Leading Change, Wie Sie Ihr Unternehmen in acht Schritten erfolgreich ändern' (München: Vahlen Verlag, 2011), p. 35–136, https://doi.org/10.15358/9783800646159.

[33] C. Shapiro, H. R. Varian, 'Information Rules, A Strategic Guide to the Network Economy' (Harvard: Harvard Business Review Press, 1999), p. 173.

[34] https://www.pwc.com/m1/en/services/assurance/risk-assurance/digital-and-technology-risk/accelerating-blockchain/overcoming-interoperability-collaboration-challenges.html [accessed 26 January 2021].

[35] Brasoveanu / Dotlacil, 2020, Computational Cognitive Modeling and Linguistic Theory, p. 161, https://doi.org/10.1007/978-3-030-31846-8

Semantic Level: Semantic Interoperability: the aim of this interoperability level is to establish a common understanding of the information units among the systems involved without creating misunderstandings.[36]

Syntactic Level: Syntactic operability pertains to the subject of syntactics or syntax, the relationship between the signs of a language system, i.e., the rules of a language established by convention according to which individual signs can be combined to form valid expressions and sentences.[37]

Technical Level: Technical interoperability aims to be able to exchange data between two systems like a bus system (USB,..); serial and parallel connections can be found on this level, as well as protocols e.g. of the OSI stack such as TCP/IP, FTP, NFS, HTTP, etc. Interoperability between these systems at a technical level is not pervasive. Setting principles, standards and guidelines for a common transfer mechanism, developing standardized metadata (data about data) and using a common language are all required to achieve technical interoperability.[38]

All four levels have to be taken into account when looking at interoperability as a whole. It is easy to see the challenges the Blockchain industry and broader community are facing. Various Blockchain architectures with different providers initially pursue their own vision, just as most Blockchain solutions begin their productive existence disjointed and separate. Thus, depending on the direction of use, there are

- Oracle-enabled blockchains that simply integrate external data sources,
- Blockchain solutions for establishing identity and authentication, or general-purpose Blockchains, and
- General-purpose Blockchain solutions with a focus on smart contracts, etc.

Even if interoperability is still in its infancy, the interlocking of different Blockchain protocols will boost the digital economy. In order to transfer value, exchange data securely and without tampering and carry out transactions, blockchains must communicate with each other without barriers. In this way, synergies can be created and the wasting of resources due to multiple activities on different Blockchain systems can be avoided.

[36] Brasoveanu / Dotlacil, 2020, Computational Cognitive Modeling and Linguistic Theory, p. 171, https://doi.org/10.1007/978-3-030-31846-8

[37] Kremar, 2005, S. 16

[38] EPAN, 2004, European Public Administration Network, eGovernment Working Group: Key Principles of an Interoperability Architecture. Brussels, p. 11

Chapter 2.
Beyond Initial Adopters: Educational Needs

The evolution of Blockchain technology and its implementation are strictly connected to the identity of the adopters and how they envision current and future applications. Therefore, educating the appropriate audience not only represents an opportunity for the growth of Blockchain and DLT applications but needs to be at the core of the adoption strategy.

Defining who to train, avoiding leaving anyone behind, is a turning point that needs to be addressed. The opportunities introduced by cutting-edge technology creates challenges for both traditional educational institutions that need to update their *curricula*, as well as companies and market players who need to train their internal teams and decision-makers.

In addition, institutional decision-makers who bring together national, supranational, and international visions need to fully understand the value and the potential of the technology to have the ability to translate it into concrete actions.

It is a complex undertaking to cluster and prioritise educational target audiences, but it is a necessary effort that will foster new employment opportunities and technological advancement.

The three main categories we propose as priority educational target audiences are institutions, businesses and classical education organisations, each one with specific tiers and content to be delivered (see Chapter 3 for further details). The following Matrix specifies the specific priorities for the targeted audiences. The Matrix will be discussed in further detail in Chapter 3.

Institutions

Blockchain infrastructures represent a challenge for state-based (public) institutions and organisations that make policy decisions related to the exercise of their regulatory power. Thus, a particular topic for the analysis is to define what are the concepts and skills that ought to be part of an institution-oriented curriculum.

There are two main factors that need to be considered to develop an educational curriculum within this category. First, the institutions included in this category have some connection with the state, which implies that they are subject to specific public authority legitimation patterns. Second, institutions, even national ones, could be an essential part of a broader global governance structure. In this regard, institutions are expected to develop a stable regulatory environment where the synergy between Blockchain infrastructures and different social fields could occur. This subsection explains these two characteristics in creating an educational curriculum compatible with institutional needs at the national, transnational and international levels.

First, institutions of any kind shared a common ground regarding the legitimation or justification of their existence on democratic principles. In other words, institutions are created and held accountable under the frame of a democratic process. The latter is true, whether this process arises within a state or from several states' consent in the case of international organisations. In this regard, the decisions made by institution officials should be oriented to the fulfillment of the mandate of a broader social field that goes beyond the ecosystem of Blockchain technology.

An adequate education curriculum should provide background on Blockchain technology and skills needed to comprehensively understand the different taxonomies of Blockchain infrastructures: the broad spectrum between the categories of public permissionless and private permissioned DLTs. Only more in-depth knowledge of the technology's socio-economical transactional features would allow an institution to assess the impact of related decisions within its constituencies.

In this regard, the skills and socio-economical transactional knowledge that could be transferred in an education curriculum should allow an individual working for an institution to understand and follow the work undertaken by different standardisation communities (e.g., ISO, IEEE, ITU, etc.), specifically in lexicological standards for Blockchain technology. If an individual can discern the different semantic production of the standard-setting bodies, it implies that they possess knowledge of the necessary ontologies that define meaning within Blockchain infrastructures.

Second, institutional actions and decisions—even those with an effect strictly inside one state—impact the global governance of Blockchain infrastructures. Any institutions' regulatory presence could influence how Blockchain systems' interoperability unfolds within two or more jurisdictions. Moreover, the implementation of Blockchain infrastructures usually implies the exchange of information with different methods taking place in different regulatory settings.

Consequently, the development of an education curriculum needs to include, in addition to the background of the Blockchain technology and its socio-economical features, an additional layer of technical skills that could allow decision-makers inside institutions to assess the interoperability challenges that arise from the implementation of the technology.

This technical layer should be adequate for institutions to process the more sophisticated and technical suggestions that experts in the field could provide. In other words, the technical skills needed for institutional personnel should be of an adequate level to understand the interoperability challenges that could affect Blockchain technology's regional or global governance.

Business

Education of professionals represents a key element for analysis. From key decision-makers to active implementers, managers and board members, all need to be aware of how DLT works and how it benefits the organisation.

Having a clear understanding of the processes behind the technology allows corporate players to avoid potential risks. Each business process brings risks and opportunities in itself; both aspects could benefit from Blockchain and DLT applications but need to be carefully drafted. Specific problems require specific solutions, and specific solutions require specific technologies. Corporate decision-makers need to be aware of this need for customisation.

Prioritising training represents an additional asset to deliver corporate education in the most effective manner. C-Level officers working in IT and innovation-related positions, followed by CTOs, CIOs and CROs are the first who need to have a clear understanding of the application of the technology within their industries. Training becomes synergic with their expertise and fosters new innovative approaches that may bring new business opportunities and reduce risks.

Once the technology-involved C-levels are trained, the focus moves to top executives and board members who are involved in the organisation's decision-making processes. Specific consideration should also be given to shareholders.

Once the managerial level education is completed, it is crucial to move forward with the training of directors and managers as these individuals are responsible for project management and delivery and winning new deals. Their knowledge and understanding of Blockchain and DLT can be a game-changing asset in addressing new business challenges and solving complex problems.

Businesses may evolve and grow thanks to the technological advancements brought by the new decentralised approaches, however, it is imperative to first invest in high-level training and education to foster fitting models of applications.

Classical Education

The evolution of classical educational institutions, from high school to universities and Vocational and training organisations (VETs), is often discussed while addressing emerging technologies. The ideal process and speed of evolving the curricula to scale-up knowledge and enlarge employment opportunities is a complex discussion, but a necessary one. Decentralised technologies are changing the way society and business work. There is, therefore, a need to expand the topics tackled by traditional academia in their educational approach.

Many organisations have already started this process and a great number of new educational players have emerged that provide new methodologies and support to traditional education.

While considering initial targets, business schools, law schools, public administration faculties, journalism schools, and the whole STEM ecosystem, including science and engineering, information and communications technology are of particular interest.[39]

According to the Danish Technological Institute, in association with Technopolis Limited Danish Technological Institute 3s Unternehmensberatung GmbH and ICF Consulting Services, "CEDEFOP projects that employment in STEM occupations in the EU will increase by 12.1% by 2025: a much higher rate than the projected 3.8% increase for other occupations in the EU."[40]

The Blockchain and DLT industry represents a notorious application of the skills acquired during STEM studies; being able to embed related content during the academic years constitutes an added value to the curricula.

[39] European Center for the development of vocational training, based on the International Standard Classification of Occupations (ISCO-08).

[40] Danish Technological Institute in association with Technopolis Limited Danish Technological Institute 3s Unternehmensberatung GmbH ICF Consulting Services, 'Does the EU need more STEM Graduates?', Final Report (München: Vahlen Verlag, 2015), p. 3–8.

The same curricula-expansion-approach concerns law, business, public administration, and journalism departments as traditional professions and approaches to business should be aware of how Blockchain and DLT are shaping the market and economy.

Although the aforementioned faculties are already seeing a comprehensive approach toward technology introduced, other sectors need to be approached as well, including philosophy, ethics and sociology. The way society may evolve based on the decentralised ecosystem has to be considered in addressing critical issues in societal, ethical and philosophical contexts.

Finally, considerations have to be given to the field of studies concerning semantics, language and interpretations, as only by finding a common linguistic ground, we are able to effectively transfer technological advancement to society.

Chapter 3.
A Blockchain Curriculum Proposition

Introduction

Blockchain has the potential to transform the economy and society through increased data transparency, traceability and security in addition to abating costs across various industries. There is no industry today that has not explored the opportunities integrating Blockchain technology affords. Nevertheless, the general public still lacks an understanding of how this technology works and the value it adds. Simultaneously, and possibly as a consequence, the industry suffers from a lack of skilled Blockchain professionals. The information asymmetry permeating the sector stifles Blockchain usage, preventing the possibility of reaching mass-adoption, whilst it is precisely the systemic adoption by the general public that enhances the value that single individuals could realise.

The Working Group believes that every citizen should have access to a curriculum that would enable them to gain "Blockchain literacy". For Europe to fully exploit the opportunities that this technology enables, its adoption must be fast and coordinated among all actors along the value chain.[41]

The existence of a shared foundational Blockchain curriculum would, on the one hand, facilitate adoption, and on the other hand, solve the problem of inadequate skilled Blockchain professionals currently facing the industry. Such a curriculum would develop a pool of workers possessing the critical competencies needed to drive innovation.

Even though every citizen should have some Blockchain knowledge, clearly there is no one-size-fits-all solution and no single learning path for all stakeholders. However, everyone should start from the same foundational knowledge in order to later—or complementarity—deepen their knowledge on those aspects of Blockchain which are most relevant to their industry, area of expertise or chosen specialisation, and develop basic or in-depth technical skills.

The Working Group has defined a comprehensive curriculum building on these foundations.

The list of curriculum subjects proposed in this document is non-exhaustive and it is not meant to be as such. We acknowledge that technologies are subject to rapid change and that a new attitude is needed for continuous learning and mastering skills that will enable Europeans to be prepared for not-yet-arrived jobs of the future. That being said, the list of subjects that we propose could certainly help in identifying the minimum "Blockchain literacy" level needed across all defined target groups.

Curriculum Structuring

Curriculum Topical Categories

The curriculum proposition has been structured around three topical categories covering:

- Blockchain Background,
- Blockchain as a Technology Stack,
- Blockchain as a Socio-Economic Transactional Infrastructure.

[41] J. Atherton, A. Bratanova, Markey–Towler, 'Who is the Blockchain Employee? Exploring Skills in Demand using Observations from the Australian Labour Market and Behavioural Institutional Cryptoeconomics', 20 June 2020, DO-10.31585/jbba-3-2-(4).

The structuring around three curriculum categories has been inspired by a holistic view of Blockchain. The first category focuses on understanding the existing traditional socio-economic transactional context as well as the technological primitives that preceded the invention of Blockchain. The second category sheds light on Blockchain as a technology, its infrastructure, consensus protocols and programming. The third category concentrates on the impact of Blockchain on innovation, business, society, economy and law.

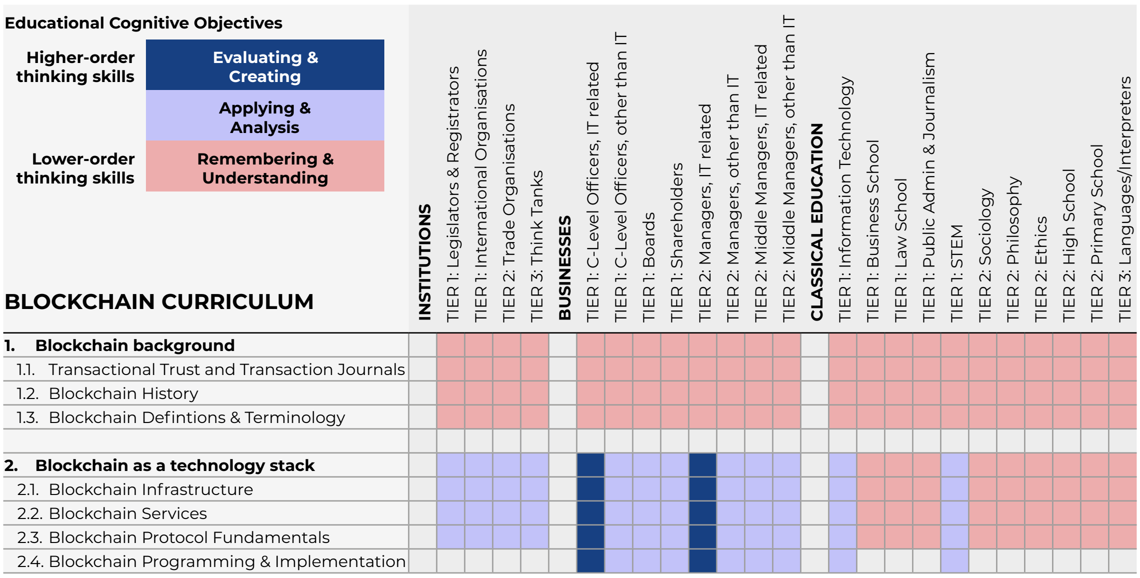
Educational Cognitive Objectives

Each educational prioritised target group, as described in Chapter 2, needs a different level of educational intensity and depth for different topics. To indicate this requirement, three levels of educational objectives have been defined by customising Bloom's Taxonomy of Cognitive Educational Objectives.[42] In order to enhance the readability of the mapping of topics and target groups, Bloom's six cognitive categories have been grouped into three categories with the following definitions:[43]

	COGNITIVE OBJECTIVES	DEFINITION
Higher-order thinking skills	**Evaluating & Creating**	Examine information and make judgments & Use information to create something new
	Applying & Analysis	Use information in a new (but similar) situation & Take apart the known and identify relationships
Lower-order thinking skills	**Remembering & Understanding**	Recall specific facts & Grasp meaning of instructional materials

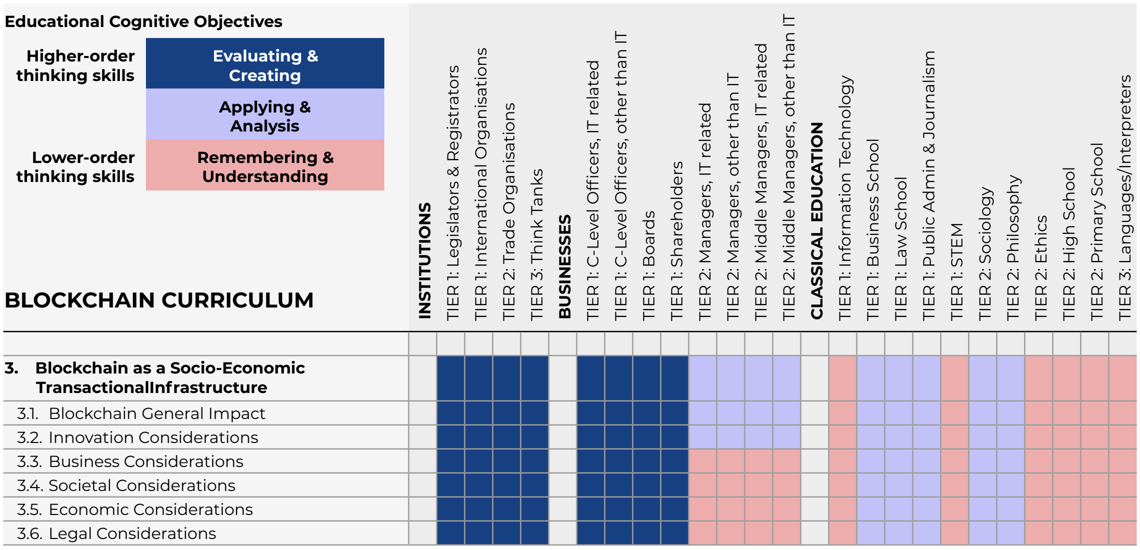
Curriculum Matrix

The following high-level matrix makes specific recommendations in terms of the required mastery levels and cognitive objectives for each curriculum-topic/educational-target pair.



[42] B. S. Bloom, M. D. Engelhart, E. J. Furst, W. H. Hill, D. R. Krathwohl, 'Taxonomy of educational objectives: the classification of educational goals' (London: Longman, 1956).

[43] See Annexe for the customisation of Bloom's Taxonomy.



The matrix shows that all target groups are indistinguishably recommended to acquire a basic understanding of the "Blockchain Background" and its sub-categories.

The second curriculum category, "Blockchain as a technology stack", is recommended to be understood by all target groups at different degrees of cognitive mastery, except for its sub-category "Blockchain Programming & Implementation." Only the Business target group and the Tier 1 IT and STEM students are recommended to master "Blockchain Programming & Implementation." Within the Business target group, the Tier 1 IT-related C-level Officers and Tier 2 IT-related Managers are recommended to reach the highest cognitive educational objective in order to be able to evaluate, create and participate in the modeling and design of the currently unknown terrain of Blockchain and its decentralisation.

The third curriculum category "Blockchain as a Socio-Economic Transactional Infrastructure" is recommended to be understood by all target groups. The recommended levels of understanding and mastery are the highest for the Institutions and all their tiers as well as for the Businesses-Tier-1 target-sub-groups. Indeed, as decision-makers and systemic implementers, the Institutions and Businesses Tier 1 target groups are the stakeholders that should be capable of evaluating, creating and participating in the modeling and designing of the Blockchain future.

Detailed Description of Curriculum

Blockchain Background

Transactional Trust and Transaction Journals

In order to grasp the significance of transactional trust and transaction journals, each individual studying Blockchain is recommended to understand their fundamental function in our current socio-economic functioning and organisation, their historical emergence and evolution, their current infrastructural and organisational socio-economic setup and their influence on business models and processes.

The historical emergence, importance and role of trusted third parties in the verification, validation and maintenance of trust and transaction journals is an essential area of understanding as an introduction to the functional similarity in Blockchain. The functional similarity between trusted third parties and Blockchain protocols as institutions ensuring the verification, validation and maintenance of transaction journals should also be acknowledged.

Students should also understand how the infrastructure and protection mechanisms of transaction journals maintained by traditional third parties compare to the infrastructure and protection mechanisms of transaction journals maintained by Blockchain protocols. The fundamental shift from a traditional setup with siloed, isolated transaction journals and multiple scattered, to-be-reconciled data sources, toward a pre-audited single data source accessible to all participants, should be understood by all students.

Blockchain History

Satoshi Nakamoto's invention of Bitcoin[44] was the culmination of decades of research and entrepreneurial endeavours. Nakamoto created a solution to the double-spending problem through a brilliant combination of existing IT primitives and integration of lessons from previously failed projects.

Understanding the principles of the individual computer-scientific elements and the tentative previous solutions as well as the reasons for their failures in the quest of creating a peer-to-peer electronic cash system, is essential in grasping the reasons for the success and also the limitations of the solution invented by Nakamoto.

The history of Blockchain covers also the post-invention evolution of Bitcoin. Blockchain is since its implementation through Bitcoin the subject of a history of community philosophical disagreements and forks, of technological evolution and quests for solutions to problems, of institutional positioning and legislative or regulatory interventions. In order for students to understand where Blockchain stands today, it is essential for them to learn the history of the technology since its inception in October 2008.

Blockchain as a Technology Stack

Each person studying Blockchain technology should have at least a foundational understanding of both the technology stack[45] on which Blockchain operate and the technology layers that support Blockchain services and applications. In this chapter, we try to summarise its basic components.

Blockchain Infrastructure

The Blockchain protocol operates on the Internet, which is its foundational technology layer. It is a network of networks of globally interconnected devices that works on top of the Internet Protocol Suite (TCP/IP) which determines how data should be packetised, addressed, sent, routed and received.

Blockchain operates via a peer-to-peer network of computing devices (the nodes) that executes the protocol by performing transactions based on a cryptographic consensus algorithm on identical copies of the distributed ledger.

The protocol builds an open, shared and trusted public ledger of transactions without any single entity in control. The recorded transactions cannot be modified and can be inspected by anyone. The protocol provides enough economic incentives, in the form

[44] S. Nakamoto, 'Bitcoin: A Peer-to-Peer Electronical Cash System' (2008), *op. cit*.

[45] There are various classifications of Blockchain technology stack: https://www2.deloitte.com/content/dam/Deloitte/in/Documents/industries/in-convergence-blockchain-tech-stack-noexp.pdf; https://101blockchains.com/web-3-0-blockchain-technology-stack/#prettyPhoto.

of tokens, to the owners and operators of the computers, the miners, to sustain the transaction-execution in the distributed ledger.

Nodes are fundamental components of the Blockchain infrastructure. Without nodes, information would not be accessible as they store the blocks of data composing the Blockchain. Every node on a Blockchain is interconnected to the others in order to constantly exchange the latest data. A full node contains a full copy of the transaction history of the Blockchain.

Mining is the mechanism that allows the Blockchain to be decentralised. It consists of the process of validating transactions and recording them in blocks in the global ledger. Miners have to run a full node. When a miner tries to add a new block to the chain, it broadcasts it to all the nodes on the network, who can accept or reject it, depending on the block's legitimacy. When nodes accept a block, they store the new one on top of the ones already present.

At the heart of the Blockchain infrastructures, there are Virtual Machines, computational engines that interpret bytecode-compiled programming languages, that have the capacity to abstract the entire network and make it function as one supercomputer that solves various computational tasks.[46] A Virtual Machine's job is to update the state of the system by computing valid state transitions as a result of code execution.[47]

Blockchain Services

It is important to learn the key services[48] that Blockchain offers and leverages to enable application operations as well as connection to other technologies.

One of the most important tools is undoubtedly the wallet, which is to be considered a constituent element of the Blockchain. It is a device, program or service which contains pairs of public and private cryptographic keys and can be used to safely store, send and receive any type of cryptocurrencies to track ownership of digital assets. There are mainly two types of wallets: hot wallets and cold wallets. A hot wallet is any digital wallet that is connected to or at any point that interacts with a peer-to-peer network. To essentialise this to one word, hot wallets are 'online'. A cold wallet is 'offline'; you are the only owner of your keys, and the only way for an attacker to steal your cold wallet is by physically stealing your device. Wallets can interact with smart contracts. A smart contract is a computer protocol intended to digitally facilitate, verify, or enforce the negotiation or performance of a contract, consequently enabling trusted transactions without the intervention of third parties.

An oracle is a way for smart contracts to interact with external data. In fact, it is a bridge between off-chain and on-chain events. We include them under the section "Blockchain Services", however, it has to be noted that while wallets or Digital Identity (DID) are indeed Blockchain-enabled services, oracles are instead services that blockchains need in order to interact with external events.

From a technical point of view, in order to exploit the great potential of this technology, it is necessary to know the main programming language for Blockchain solutions:

[46] A. Tara, K. Ivkushkin, A. Butean, H. Turesson, 'The Evolution of Blockchain Virtual Machine Architecture Towards an Enterprise Usage Perspective', Silhavy R. (eds) Software Engineering Methods in Intelligent Algorithms. CSOC 2019. Advances in Intelligent Systems and Computing, Vol. 984. Springer, Cham, (2019), https://doi.org/10.1007/978-3-030-19807-7_36.

[47] Andreas M. Antonopoulos, Gavin Wood, 'Mastering Ethereum' (O'Reilly Media, 2018).

[48] We attempt to describe in this section what most Blockchain technology stack classifications include under "services layer", however, since this term is open to various uses, we believe some clarification is needed. Wallet and Digital Identity are certainly services that the Blockchain offers. Nonetheless, the former is a constituent element of the Blockchain, while the Digital Identity is a derivative element. Smart-contracts are also constituent elements. Oracles are not services that the Blockchain provides to users, instead they are services that the Blockchain uses.

Solidity, born for smart-contract writing. Knowledge of other programming languages such as Javascript, Python, C++ and Golang are useful additions to the curriculum.

Digital Identity is a crucial part of online life. Personal data should be safely protected, and Blockchain can offer the best solution for securing and managing that process. The fundamental security component of Blockchain systems is cryptography. When you use cryptography to store digital identity data, only the owner possessing the private key can access the data. In simple words, no one but the identity owner can see and manage data. In fact, Decentralised Identity is a way of replacing common identifiers, such as your email address or username, with a personal identity rooted in Blockchain technology that participates in an interconnected decentralised network of identities. This is where the concept of "self-sovereign identity" comes in: people can store their identity on a personal device and provide it when required without having to rely on a central database.

Blockchain Protocol Fundamentals

A Blockchain is a set of technical specifications that are based on cryptography and game theory. These specifications include data structures, processes and protocols. We can list the essential components that must be understood by Blockchain students:[49]

- A peer-to-peer (P2P) network connecting participants and propagating transactions and blocks of verified transactions, based on a standardised 'gossip' protocol;
- Messages, in the form of transactions, representing state transitions;
- A set of consensus rules, governing what constitutes a transaction and what makes for a valid state transition;
- A state machine that processes transactions according to the consensus rules;
- A chain of cryptographically secured blocks that acts as a journal of all the verified and accepted state transitions (the transaction ledger);
- A consensus algorithm that decentralises control over the blockchain by forcing participants to cooperate in the enforcement of the consensus rules;
- A game-theoretically sound incentivisation scheme (e.g., proof-of-work costs plus block rewards) to economically secure the state machine in an open environment;
- One or more open source software implementations of the above ('clients').

For each of the components listed, each blockchain has adopted different choices. A technical blockchain curriculum should include knowledge of the most established blockchain choices.

A technical profile in the field of Blockchain must include some basic elements of cryptography: hash functions, symmetric and asymmetric cryptography, digital signatures, digital timestamps and commitment schemes. Even if not directly related to a protocol, cryptography topics such as homomorphic encryption, zero-knowledge proofs, secure multi-party computation and secret sharing should be included in this knowledge body.

In terms of what secures the ledger, Bitcoin and Ethereum have adopted the Proof of Work, which forces miners to spend energy to produce a block. To solve problems related to scalability and consumption of resources, other blockchains have introduced the Proof of Stake, which is based on a deposit that the miner places as collateral. Others have used the Proof of Authority, where miners use their reputation as a guarantee

[49] Andreas M. Antonopoulos, Gavin Wood, Mastering Ethereum, *op. cit.*

to operate correctly. These mechanisms are complemented by consensus protocols that establish proper cooperation between miners. Some establish how to properly grow the blockchain in a cooperative environment (Bitcoin used the Ghost protocol, later amended by Ethereum) others employ voting schemes such as Authority Round or Clique (the latter is used by Quorum). Some other blockchains have adopted other algorithms from the world of distributed systems such as Byzantine Fault Tolerance and Raft.

A technical profile should include knowledge of how a Blockchain client or software implementation that enables a user to take part in the network is organised, understanding the difference between an archival client, normal client and light client, and having knowledge of the alignment needs of the client connecting to the network.

With a view on designing Blockchain-based systems, it is necessary to understand the Scalability, Security and Decentralisation Trilemma. It is necessary to be clear about scalability limits and all the solutions that have been proposed over time: side and chain level 2, payment channels, state channels and solutions based on zero-knowledge proof.

Additionally, students should master:

- Blockchain interoperability, bridging solutions between chains, centralised and decentralised, based on secure enclave or cryptographic evidence,
- the differences between public and private chains, between permissioned and permissionless chains and their design advantages and disadvantages,
- the attack and sabotage schemes that public blockchains can face.

Blockchain Programming and Technical Implementation

Bitcoin introduced a very limited possibility of programming (scripting). Ethereum soon after introduced full programmability (its language is Turing complete[50]) by building an open and decentralised computer made secure by cryptography and consensus protocols.

As mentioned previously, Ethereum introduced an abstract machine (Ethereum Virtual Machine) which is defined through the specification of machine instructions (low level), syntax and execution semantics. On an abstract machine, high-level languages are defined, close to the human way of thinking, as well as software capable of translating these languages into the instructions of the abstract machine. Ethereum has at least two languages that can be used, and each blockchain equipped with a smart-contract has chosen its own, either by adopting one already widespread in the field of computer science or by deriving one from those already known and providing it with idiomatic expressions necessary for areas of the Blockchain.

A technical profile should include knowledge or understanding of at least the most used languages and micro-patterns typical of Blockchain decentralised applications, for example: tokens.

Micro-patterns are the basic elements on which decentralised applications (dApps) are built: applications that aim to be resistant to censorship or external manipulation, impossible to stop and trustless.

In addition to the patterns and micro-patterns mentioned above, the programmer should know a series of anti-patterns or programming schemes to be avoided, as they

[50] "Turing Completeness" refers to any device or system which could in theory calculate and solve any reasonable computational problem, assuming enough memory is available.

lend themselves to attacks aimed at tampering with the functioning of the code or stealing funds.

Blockchain as a Socio-Economic Transactional Infrastructure

Blockchain General Impact

Blockchain proposes paradigm-shifting settings that require participants to rethink and fundamentally redesign their participation and role in the socio-economic setting. The foundational nature of Blockchain within all fields of society and economy means understanding in all its aspects is a necessity for all stakeholders.

The change in mindset that Blockchain proposes is profound. The transition from a socio-economic setting in which third parties take care of the management of assets and data, to a novel context with self-custody and self-management, empowers individuals and institutions but requires also a much higher degree of self-responsibility and socio-economic awareness.

Innovation Considerations

The Blockchain technology and organisational platform come with an overhaul of the existing infrastructural and organisational structures. The integration of tokenisation, identity, trustless transactions and automated processes in the fabric of the internet enables a rethinking of the basic socio-economic interactions.

Blockchain features like transparency, immediacy, immutability, peer-to-peer interactivity, programmability, pre-auditing and network robustness, open up the possibility to revisit transactional procedures and foster innovation.

Each individual studying Blockchain as a socio-economic transactional platform has to understand the possibility to re-imagine and rebuild the way we interact in society and economy by combining the fundamental elements of the traditional transactional setup with the new features that Blockchain proposes.

Business Considerations

Blockchain puts an ocean of unknowns in front of businesses of all kinds. At the same time, it is these businesses that shape the Blockchain integrations of today and tomorrow. The vast majority of strategic, organisational and operational questions that arise currently remain largely unanswered and need highly skilled evaluative and creative thinking skills.

The path toward adoption will be long and accompanied by uncertainty. With the existing traditional business setting aligned to centralised operational, organisational and business models, the potential transition toward a decentralised paradigm will be uncomfortable and met with resistance. Nevertheless, businesses will have to make strategic decisions on its impact and potential for new ways of creating value.

Businesses are recommended to master the principles and consequences of the potential tokenisation and decentralisation of tasks and business processes. Business-related Blockchain students should master the fundamental capabilities of Blockchain and be able to evaluate the impact on existing business models and design and implement new ones. The decentralisation of governance through Blockchain should be understood as a potentially game changing decisional basis for businesses.[51]

[51] See e.g. D. Furlonger, C. Uzureau, 'The real business of Blockchain: how leaders can create value in a new digital age' (Boston: Harvard Business School Publishing Corporation, 2019).

Business-related Blockchain students are recommended to master the different types of public, private, permissioned and permissionless Blockchains and understand their short-term and long-term value. Students are recommended to master the strategic business analysis of different types of platforms and their short and long-term business impact.

Societal Considerations

Blockchain comes with a paradigm-shifting set of capabilities that empowers citizens. Blockchain students are recommended to understand the impact of Blockchain in the public sphere. Not only does Blockchain propose itself as a trusted tool for more direct and immediate participation in democratic life, the irrefutable character of Blockchain also puts the accountability of public services on the direct availability of citizens.

Students are recommended to grasp the change in mindset that Blockchain can bring about. Indeed, self-custody and -management of one's identity and data, the use of Blockchain as a self-management platform for asset custody and property transactions and Blockchain's function as a public source for accountability, all contribute to a transfer of control away from institutional players toward the participants in a distributed decentralised system. Blockchain students should understand the effect that the empowerment of the individual can have on creativity, cooperation, civic awareness, participation and self-determination.

Economic Considerations

Many questions remain unanswered when considering the economic impact of Blockchain. In order to cope with these unknowns, decision-makers and first implementers should be able to analyse, evaluate and be creative with a wide range of topics that links Blockchain to micro- and macro-economic issues.

The following is a non-exhaustive list of topics for which Blockchain students should acquire a thorough understanding in order to be able to participate in the global analysis, debate and decision-making processes:

- Impact of disintermediation and open public permissionless Blockchains on market accessibility, product and price discovery and information asymmetry;
- Impact of cryptocurrencies and frictionless payment systems on macro-economic efficiency;
- Impact of Blockchain on the decentralisation of finance and its impact on monetary parameters;
- Impact of the programmability of monetary models into cryptocurrency protocols;
- Impact of tokenisation and token-programmability on micro- and macro-economic performance;
- Impact of self-custody, self-management of tokens and its frictionless peer-to-peer transfer between individuals, institutions and machines;
- Impact of Blockchain and decentralised organisations on the *raison d'être* of the firm;[52]
- Impact of the integration of economic models into the value of a token and align the objectives and interests of all stakeholders.

[52] See e.g. R. Coase (n.d.), 'The nature of the firm', The Economic Nature of the Firm, p. 79–95, https://doi.org/10.1017/cbo9780511817410.009.

Legal Considerations

Blockchain and its decentralisation imposes a change in the fundamental design of our socio-economic apparatus. The organisational consequences are huge and require a re-thinking of all socio-economic aspects and their transition from a centralised model towards a decentralised one.

Legislation and regulation are not exempt from this sizable task of re-designing and integrating the principles of decentralisation. The road will be long and cumbersome as the existing legislation lacks any accommodating approach that supports fundamental integration of decentralisation into the socio-economic fabric.

Blockchain students should be aware of the centralisation principles in existing legislation that are incompatible with the decentralised setup of public permissionless Blockchains. The following is a non-exhaustive list of issues that decision makers and first implementers should master in order to be able to navigate the complex terrain of Blockchain legal compliance:

- Relativity of transaction finality,
- Liability and the borderless nature of Blockchain,
- Data and privacy related issues and the immutability of Blockchain,
- Anonymity/pseudonymity,
- Regulatory action and decentralisation,
- Self-sovereignty.

Conclusions

This paper represents the combined effort of several professionals acting within the Blockchain educational space and market for several years.

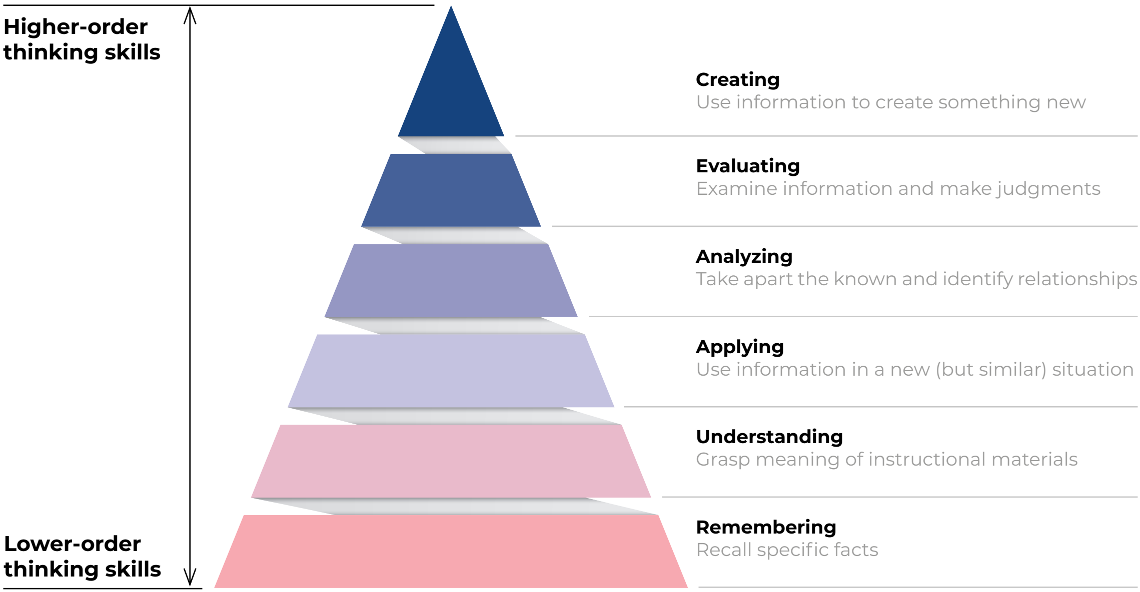
One of INATBA's key goals is to bring Blockchain technology to the next stage of development. Education constitutes a fundamental building block in this process and is essential to unlocking the potential of the technology. Completing the long-life-learning journey of managers and decision-makers with the Blockchain topic will not only support the implementation of Blockchain across industries but also enable the construction of a more interoperable ecosystem.

Training current and future stakeholders to understand, challenge and work in decentralised environments will help close the skills gap and create new employment opportunities. Additionally, ensuring a deep understanding of Blockchain among lawmakers and international organisations is needed in order to ensure a relevant evolution of the regulatory approach.

This position paper began with a description of the current state of the digitalisation of industries, continued with identifying the target groups that are most urgently in need of Blockchain education and finally defined a proposition of the basics that every Blockchain curriculum needs to integrate in order to be considered relevant.

The output presented here is intended to be distributed, challenged and bettered with the sole purpose of uplifting the way Blockchain education is designed and delivered in public and private institutions. The Education Working Group of INATBA looks forward to discussing our work with internal and external stakeholders who may find interest in our work and wish to engage further.

ANNEXE: Customisation of Bloom's Taxonomy of Cognitive Educational Objectives



Source: https://citt.ufl.edu/resources/the-learning-process/designing-the-learning-experience/blooms-taxonomy.
Original version in: Benjamin Samuel Bloom, Taxonomy of Educational Objectives (Longman, 1979).

Customised version: Adapted & reduced version for the purpose of readability of the curriculum matric

	COGNITIVE OBJECTIVES	DEFINITION
Higher-order thinking skills	**Evaluating & Creating**	Examine information and make judgments & Use information to create something new
	Applying & Analysis	Use information in a new (but similar) situation & Take apart the known and identify relationships
Lower-order thinking skills	**Remembering & Understanding**	Recall specific facts & Grasp meaning of instructional materials

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