Generation Blockchain Audit & Framework.

Educational model of Blockchain teaching for students of economics and management

"…European Union has an excellent opportunity to become the global leader in the field of DLT and to be a credible actor in shaping its development and markets globally, in collaboration with our international partners."

Resolution of European Parliament, 2018

POLAND, 2022

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GLOSSARY OF TERMS AND ACRONYMS

Ant Blockchain – an aggregating technology platform for Blockchain-based solutions.
Big Data – extensive and complex data sets.
Bitcoin – the first cryptocurrency introduced in 2009.
Blockcerts – digital certificate issued by an organization and owned by an individual, expressed in this format and notarized in the blockchain.
Corda – an open source platform that allows building interoperable Blockchain networks.
Crowdfunding – social funding.
DAC (Decentralized Autonomous Corporations) – a type of DAO – a community operating under rules coded as smart contracts.
DAO (Decentralized Autonomous Organizations) – decentralized and independent entity, run by the community according to an accepted set of rules, based on Blockchain.
DeFi (Decentralized Finance) – collective term for Blockchain-based decentralized financial services.
Distributed networks – distributed computing network system in which program components and data are located in multiple locations.
DLT (Distributed Ledger Technology) – decentralized database technology supporting distributed recording of encrypted information.
edX – a digital training platform.
EEA (Enterprise Ethereum Alliance) – distributed community in the form of an organization promoting open source Enterprise Ethereum and Mainnet Ethereum technology.
Ethereum – digital currency that is also a multi-functional and multi-service Blockchain-based platform.
GPU (Graphics Processing Unit) – responsible for the digital rendering in a computer system.
Halving – an economic model for managing multiple cryptocurrencies.
Hashing – an implementation technique for hash tables, guaranteeing a constant search.
Hyperledger – an open source project supporting and improving Blockchain initiatives.
Hyperledger Fabric – a modular Blockchain structure that is the de facto standard for corporate platforms based on the technology.
ICO (Initial Coin Offering) – a form of crowdfunding to raise startup capital for startups and projects, using cryptocurrencies.
ICT (Information and Communication Technologies) – a family of technologies that process, collect and transmit information in electronic form.
IoT (Internet of Things) – a network of devices that can autonomously communicate with each other and exchange data.
NFT (Non-Fungible Token) – a unique digital value.
peer-to-peer (P2P) – a computer network in which all devices are equal in hierarchy.

Satoshi Nakamoto – a nickname used by the person/group of people/institution that created the Bitcoin cryptocurrency.
Smart contract – a digital contract secured and authenticated by Blockchain.
Space10 – an innovation and new technology laboratory created by Ikea.
Token – a set of rules encoded in a smart contract.
Tokenization – a type of project/business/company digitization based on Blockchain and involving giving a specific value to a token or cryptocurrency dimension.
TracrTM – a dedicated aggregation platform based on distributed system.
Quorum – an open source platform for business solutions running on Blockchain.
Udemy – a digital training platform.

Elaborated based on: [1].

INTRODUCTION

The usefulness of Blockchain technology due to its many advantages, in the form of off-the-shelf solutions, is conquering many sectors of the economy, such as finance, insurance, retail, industry, healthcare, logistics or public administration. All reports and publications on the subject agree on the possibility of significantly increasing efficiency in almost every area of human life and economic processes. From the technical point of view, Blockchain is relatively young, but its development continues to gain acceleration as favorable regulatory conditions and supportive policies have emerged in addition to economic stimulation. Every month, new applications and projects are being developed that break the barriers of scalability and performance, while surprisingly reducing the cost of deployment and operation. Blockchain is under continuous evolution and we have not yet fully explored the limits of its applications. The markets are certainly in a pre-consolidation stage currently, but the first initiatives to merge private platforms with public networks are already emerging. These processes should not be held back, but rather the emphasis should be on stimulating experimentation and innovative attempts, including in the area of system integration and migration [2].

The 21st century has seen the emergence of many new tools and solutions from the ICT area but with interdisciplinary aspects. These can include: Big Data, IoT or artificial intelligence. However, none of them has as much development potential in the context of the next decade as Blockchain.[3][4] New technologies have always been in the area of interest of educators and educationalists. This is because they have enabled them to improve the educational process, provide new opportunities to convey knowledge, simplify and facilitate organized tasks, and have also been a new area of knowledge that can be used to familiarize pupils or students with.

The main aim of this paper is to introduce readers to the opportunities brought by the implementation of Blockchain technology into the teaching area. The benefits can be enormous and affect teachers, academic and research institutions and facilities, students and, as a result, the entire local society. Consideration of this topic led to the identification of many scientific problems such as: how to teach students of economics and management about advanced information technology? How much should they know about the technical aspect and how much about the implications and economic effects associated with Blockchain? Should such topics be taught in courses or in universities? How long should the study last and what exactly is involved? Should there be prerequisites, and if so, what kind of prerequisites, etc.?

In order to meet the undoubted challenge of developing an innovative teaching model and to clarify the many uncertainties surrounding the subject matter, an international quantitative survey, secondary research, an in-depth literature analysis and a review of good practices and experiences were conducted. After statistical analysis, the results were presented in a number of charts and graphs. Advanced analytical methods were also used. Repeated references were made to actual implementations and examples of Blockchain implementations. The counterpoint of these activities was the development of a strategy to convey extensive and technically difficult knowledge to non-engineering students in a way that will be accessible, achievable, substantively valuable, interesting and a viable entry capital in the difficult job market.

I. BLOCKCHAIN. CHALLENGES, TRENDS AND DISRUPTIVE POTENTIAL

Blockchain technology remains nascent with innovators continually developing and discovering new application areas. This pace of innovation is accelerating, creating challenges for individuals, companies, governments, and regulators to understand what is unfolding and how to determine their respective positions: What does blockchain imply (vision)? Where will blockchain cause disruption (use cases); How will blockchain technology be implemented (infrastructure)?

Scaling. Designing a blockchain requires trading-off decentralization, security, and scalability considerations. Blockchains have (historically) optimized for two of these at the cost of the third. This is known as the blockchain trilemma [5]. Bitcoin, for example, is widely regarded as highly decentralized and very secure but has low transaction speeds, approximately 4,6 / second, which limits scaling. Solana, on the other hand, has a theoretical throughput of 65,000 transactions per second but has had to compromise on decentralization to achieve this. One of enduring challenges is how to scale a Blockchain – that is, make faster – without compromising decentralization or security principles.

Layer 1 solutions:

- Layer 1 refers to native Blockchain protocols like Bitcoin, Litecoin, and Ethereum. Solutions on this layer seek to improve the speed of the network directly and are referred to as 'on-chain' scaling. Examples include consensus protocol improvements (e.g., moving from proof-of-work to proof-of-stake), and sharding [6] which breaks transactions into smaller datasets called "shards" which are processed in by the network in parallel.
- Projects exploring the potential of sharding include: Ethereum [7], NEAR [8], Polkadot [9], and Zilliqa [10].

Layer 2 solutions:

- Layer 2 solutions refer to a secondary protocol or framework built on top of an existing Blockchain. Layer 2 solutions – referred to as 'off-chain' scaling – provide vastly greater transaction speeds that those offered by the major cryptocurrency networks such as Bitcoin and Ethereum. Layer 2 protocols process Blockchain transactions independent of the layer 1 (main chain) using, for example, state channels or sidechains. These off-chain transactions may be later reported or batched together before being submitted to the main chain. In this manner, scaling is achieved in Layer 2, while the security and decentralization properties of Layer 1 are still leveraged.

- Projects offering Layer 2 scaling solutions include: the Bitcoin Lightning Network [11] and the Ethereum Plasma [12]. Other notable Layer 2 scaling solutions are Optimism [13], Immutable-X [14], Polygon [15], and Arbitrum [16].

Interoperability. The rapid development of blockchain technology has resulted in a growing number and variety of networks where differences in their application area, consensus model, smart contract use, and other capabilities have resulted in assets and data being 'locked' within specific networks. Interoperability refers to the ability of different blockchain networks to interact, integrate, exchange and leverage data between one another, facilitating the seamless flow of unique types of digital assets between the networks' respective blockchains without the need for a third party.

Parachains:

- Parachains are custom, project-specific blockchains that are integrated within the Polkadot [9] and Kusama [17] networks. Parachains are highly customizable and can be adapted for any number of use cases. Parachains feed into the main blockchain, called the Relay Chain. Polkadot and Kasama permit both information and tokens to be transferred on them. Unlike Ethereum, where decentralized applications are created within the limits set by its blockchain, Polkadot and Kusama allow developers to create their own independent blockchains. with custom parameters such as block times, transaction fees, governance mechanisms and mining rewards.
- Projects include: Moonriver [18] and Karura [19].

Bridges and atomic swaps:

- Cross-chain bridges enable a digital asset owned by a party to be locked on one chain while an identical asset is "minted" (i.e. created) on another chain and sent to an address owned by the original owner. Atomic swaps, on the other hand, enable users to exchange tokens from different blockchain networks in a decentralized manner (i.e. peer-to-peer). Both are automatically enabled using smart contracts which are fundamental to facilitating seamless cross-chain value transfers.
- Projects include: Avalanche [20], Solana [21], Fantom ([22], Polygon [15] Arbitrum [23], and Optimism which are all EVM (Ethereum Virtual Machine) compatible. Other non-EVM solutions include Cosmos [24] and Polkadot [9].

Energy consumption. The mining and validation activities of, for example, the Bitcoin and Ethereum Blockchain networks are highly energy intensive. Bitcoin energy consumption alone is expected to exceed 200 terawatt-hours in 2022 [25]. Most of the Bitcoin's energy consumption is related to mining activities using a highly inefficient proof-of-work consensus model. In contrast, Bitcoin's energy consumption related to transaction validation is more modest.

In analyzing the energy consumption of Bitcoin, it is important to recognize that consumption is not equivalent to carbon emissions [25]. Energy consumption is calculated by looking at hashrate (i.e., the total combined computational power required to mine Bitcoin and validate transactions on the network). Carbon emissions are more challenging to determine as miners are reluctant to share operational details [26]. A report by the CoinShares Research suggests that 73% of Bitcoin's energy consumption was carbon neutral in 2019, largely because Bitcoin miners and validators can be located anywhere in the world enabling them to establish operations close to renewable sources and to benefit from oversupply that would otherwise be wasted such as peak hydro-electric power that – in the wet-season – significantly exceeds local demand [27].

Energy sources:

- Blockchain's collective energy and carbon footprint continues to receive attention as part of broader initiatives by governments around the world to regulate this emerging space. There are a range of scenarios for miners to reduce both energy consumption and their carbon emissions that include solar- and wind-powered mining, hydro-powered mining, mining pools, and use of waste energy conversion from other industries.
- Projects include: A Texas-based collaboration between Blockstream [28], The Block [29] and Tesla [30] using solar power and battery storage technology in crypto mining operations. Genesis Digital Assets [31] will deploy a 100-megawatt mining facility in Sweden by 2024 which will be 100% powered by clean energy sources: 54.5% hydro, 42.8% nuclear, and 2.7% wind. Argo Blockchain [32] is creating a green mining pool powered by renewable energy sources.

Consensus model:

- The two largest and best known blockchains – Bitcoin and Ethereum both (currently) use a proof-of-work (PoW) consensus protocol. PoW is the original consensus algorithm whereby miners compete against each other to solve a complex mathematical puzzle and the winner (i.e., the first to solve the puzzle) may propose and then write a new block and receive the corresponding reward. While the efforts of the wining miner are rewarded, the efforts of the losing miners are not compensated. PoW is considered to be highly inefficient and wasteful of energy. An alternative to PoW, proof-of-stake (PoS) protocols are a class of consensus mechanisms for blockchains that work by selecting transaction validators in proportion to their quantity of holdings in the associated cryptocurrency (e.g., in proportion to their stake). This is done to avoid the computational cost of PoW schemes. PoS both rewards miners for honest behavior as well as imposing penalties for bad behavior in the form of reducing validator tokens (known as 'slashing').

- Projects include: The largest PoS blockchains already running PoS consensus algorithms in 2021 were Cardano [33], Avalanche [20], Polkadot [9], Solana [21], Tron [34], EOS [35], Algorand [32], and Tezos [36]. Following implementation of several Ethereum Improvement Proposals (EIPs) in August 2021 (also known as the 'London hard fork'), the Ethereum network [7] has paved to the way for its transition from PoW to PoS anticipated to take place in late 2022. PoS on the Ethereum blockchain will vastly increase transaction speeds and help drive scalability, address Ethereum's high transaction fees, and require 99% less energy than PoW. Once the PoS transition occurs, Ethereum will deploy its 'difficulty bomb' aimed at making it impossible – profitably – for miners to remain using PoW to perform validation on the Ethereum blockchain. Ethereum's difficulty bomb exponentially increases the difficulty of solving the hash puzzle on the Ethereum network and, thereby, acts a deterrent for miners, who may seek to continue with the PoW mechanism even after the Blockchain transitions to PoS.

Currency. Many crypto projects continue to explore ways to reduce risk and strengthen participation in the broader crypto ecosystem. One solution is to build price stability directly into the assets themselves using stablecoins to bridge the gap between fiat currencies like the U.S. dollar and cryptocurrencies. Stablecoins are price-stable digital assets that behave somewhat like fiat but maintain the mobility and utility of cryptocurrency. There are four primary stablecoin types, identifiable by their underlying collateral structure:

- Fiat-backed.
- Crypto-backed.
- Commodity-backed.
- Algorithmic.

Given the recent collapse of Terra's algorithmic stablecoin in May, 2022 (UST), regulators are looking with increased urgency at the stablecoin market. In the US, regulators proposed the Stablecoin TRUST Act [37] which seeks to embrace, fully regulate, and accept stablecoins as an official part of the financial and banking system.

Stablecoin growth has continued to accelerate in 2022 with an estimated value of $187 billion as of March 2022 [38]. Tether remains the dominant stablecoin by market capitalization, standing at $78 billion at the close of 2021. Stablecoin growth is expected to surge parabolically in the run up to 2025 with an anticipated market capitulation exceeding $1 trillion.

Stablecoins provide individuals and companies, irrespective of location, access to trade in a universal means of exchange without being confronted with legacy financial hurdles. This allows individuals to store savings in a stable asset instead of a local currency suffering from devaluation through inflation. However, regulators remain concerned for circumstances where stablecoins, and other cryptocurrencies, are used to evade government sanctions and other controls.

Many central banks are rapidly scaling their research and development efforts on central bank digital currencies (CBDCs) [39]. As of March 2022, the Atlantic Council [40] estimates that 87 countries are considering issuing a CBDC. The Atlantic Council Digital Currency Tracker continually monitors national projects exploring CBDC deployment [41]. In essence, CBDCs are digital tokens, similar to cryptocurrency, that are issued by a central bank and pegged to the value of that country's fiat currency.

CBDCs have the potential to offer a public alternative digital payment infrastructure characterized by lower fees, faster transaction and settlement, and streamlined global flows of currencies and foreign exchange markets. Furthermore, CBDCs can drive an expansion of the scope of financial inclusion where access to financial services is provided, typically via a smart phone, to those without a bank account.

Community or complementary currency systems have spread all around the world [42], allowing cities, towns, and neighborhoods to trial their own economic policies based on agreement and engagement from participating local stakeholders. The advent of blockchain facilitates a digital version of a community currency in a cost-effective, scalable, and manageable manner.

Projects such as MiamiCoin [43] demonstrate how community tokens can be deployed to raise funds without the need to raise taxes or take on debt. Other examples are enabled by organizations such as the Grassroots Economics organization [44] which "– is building and supporting systems that empower communities to digitally create their own financial systems based on local goods and services in regional markets that are built from the ground up."

Banking. Institutional interest in cryptocurrencies has been accelerating since 2018 [45]. Asset managers have seen interest, and pressure, from clients to provide exposure this new asset class. Chainanalysis [46] estimates that institutional investors with at least $10 million in assets accounted for approximately 45% of crypto trading volume at the close of the second quarter of 2021, a year-on-year increase of 37%.

The approval of the first bitcoin ETF in Oct 2021 [47] is indicative of the growing appetite for institutional participation in crypto markets. This has paved the way for further, considered, regulatory endorsement and the pace of approvals of new, innovative crypto products is expected to increase. As of June 2022, the SEC has approved six bitcoin ETFs and there are a further twelve awaiting a decision. Regulatory approvals are anticipated to open the doors to a vast array of funds that are currently precluded from cryptocurrency exposure.

According to Forbes, "Crypto banks are provisioning interest-bearing accounts, term deposits, credit cards, collateralized loans backed by crypto asset deposits, and other services similar to the product offerings from traditional banks, albeit delivering much higher interest rates/yields [45]." Recent providers of crypto banking services include Revolut [48], Monzo [49], Nuri [50], Coinbase [51], and BankProv [52].

Crypto banking will continue to offer a compelling, and high-risk, alternative for yield-seeking capital in the current and persistent climate of ultra-low global yields. Smart-contract-powered algorithmic lending, saving, staking, yield farming, flash loans, and liquidity pools will continue to drive service and product innovation. As corporate and retail interest in these new products intensifies, so will the efforts of governments seeking transparency, control, and regulatory oversight.

DeFi is an emerging financial technology based on secure distributed ledgers, similar to those used by cryptocurrencies, whereby smart-contracts (conditional, automated execution of transactions) remove or limit the control banks and institutions have on money, financial products, and financial services [53].

DeFi will continue to both threaten and disrupt the established financial services sector. DeFi Total Value Locked (TVL) increased from a $601 million at the start of 2020 to a predicted $239 billion in 2022. Institutional DeFi is relatively undeveloped when compared with other parts of the digital asset infrastructure, creating opportunities for innovators and early movers to capture significant market share in the is rapidly growing space [54].

Emerging Asset Types. NFTs are an evolution of cryptocurrencies that enable digital representations of physical assets using the ERC721 standard for representing ownership of non-fungible tokens on the Ethereum blockchain. ERC721 is a more complex standard than ERC20, with multiple optional extensions facilitating proof of uniqueness or scarcity, proof of provenance and authorship, and proof of ownership. Application areas for NFTs include real estate, creative media [55], passports academic (micro-)credentials, credit cards, gaming [56], and collateralization. Notable early NFTs include a tokenized version of Twitter CEO Jack Dorsey's first tweet which sold for $2.9 million 2021, and a digital artwork by Beeple which sold for $69 million in 2021.

The global NFT market is project size is projected to reach US$ 7.63 billion by 2028, from US$ 1.59 billion in 2021, at a compounded annual growth rate of 22.05% during 2022-2028 [57]. Use cases will continue to develop with (further) applications in gaming and in-game asset title, fan-ownership and collectible platforms (e.g. NBA Top Shot [58], as well as within the emerging Metaverse).

Synths are Blockchain-based cryptocurrency derivatives that act and feel like traditional derivatives. However instead of using contracts to link the derivative to an underlying asset (the derivative product), synths tokenize the relationship. This means that synthetic assets can offer exposure to any asset in the world — all from within the crypto ecosystem [59].

The global derivatives market size is projected to reach US$ 3.9 billion by 2027, from US$ 2.2 billion in 2020, at a compounded annual growth rate of 8.6% during 2021-2027 [60]. Crypto derivatives – synths – will continue to grow their share of the global derivatives market. However, incumbents such as CME Group, who entered the crypto futures markets in 2017, continue to lobby the SEC in attempts to prevent new(er) entrants such as FTX (ftx.com) from becoming authorized to offer margin derivative products to retail clients [61].

Metaverse. The Metaverse refers to integrated, interactive, and immersive digital experiences enabled by developments in virtual and augmented reality. In the Metaverse, users typically assume a digital identity (by deploying an avatar), that acts as a proxy to allow them to engage in gaming, shopping, socializing, employment, learning, and other activities. The term 'Metaverse', first coined in the 1993 novel Snow Crash by Neil Stephenson [62], can be best understood through its core attributes as summarized by venture capitalist and Metaverse visionary Matthew Ball [63]:

- Be persistent – which is to say, it never "resets" or "pauses" or "ends," it just continues indefinitely.
- Be synchronous and live – even though pre-scheduled and self-contained events will happen, just as they do in "real life," the Metaverse will be a living experience that exists consistently for everyone and in real-time.
- Be without any cap to concurrent users, while also providing each user with an individual sense of "presence" – everyone can be a part of the Metaverse and participate in a specific event/place/activity together, at the same time and with individual agency.
- Be a fully functioning economy – individuals and businesses will be able to create, own, invest, sell, and be rewarded for an incredibly wide range of "work" that produces "value" that is recognized by others.

- Be an experience that spans both the digital and physical worlds, private and public networks/experiences, and open and closed platforms.
- Offer unprecedented interoperability of data, digital items/assets, content, and so on across each of these experiences.
- Be populated by "content" and "experiences" created and operated by a wide range of contributors, some of whom are independent individuals, while others might be informally organized groups or commercially focused enterprises.

The Metaverse is not just single experience but, rather, a continuum of immersive experiences being driven by innovative companies in this space that include Roblox [64], Decentraland [65], The Sandbox [66], Second Life [67], Mesh [68], Nvidia Corp [69], Fortnight [70], and Cryptovoxels [71]. While crypto- and tokenecomics are expected to form a basis for meta-commerce, many of the existing players have developed their own in-world currencies for such purposes (Second Life, for example, uses the Linden dollar).

What the Metaverse eventually becomes remains speculative despite the hype. Broad implementation of the Metaverse may still be months or years away and will depend in part on network speeds, access for a broad base of users, and the quality of the 'reality' on offer. However, expectations surrounding the Metaverse have already triggered corporations to invest in creating the hardware and software infrastructure to facilitate it, or to adapt their products and services to run on it. One of the best-known examples is Meta Platforms, formerly known as Facebook, who will invest billions in the Metaverse in the next 5 years and has committed to creating 10.000 high-skill jobs within the EU to realize its Metaverse vision [62].

Web 3.0 represents the next phase of the evolution of the web/internet heralding a version of the internet based on public Blockchains [63]. The decentralized nature of Web 3.0 allows consumers who access the internet through services mediated by companies like Google, Apple or Facebook, to independently create, own and govern sections of the internet. In this paradigm, central authorities do not get to determine who has access to specific services, nor is 'trust' required (via intermediaries) for transactions to occur between one of more parties in a manner whereby transaction execution and integrity are guaranteed.

Web 3.0's central tenet concerns the ceding of centralized power and asset ownership by (primarily tech) companies to decentralized communities and individuals across the globe. An implication of this development is that government and corporate censorship will be reduced as will the effectiveness of denial-or-service attacks. Both the technologies of Web 3.0 and the Metaverse support each other. While the Metaverse is a digital space and Web 3.0 favors a decentralized web, the latter could serve as the basis for connectivity in the Metaverse. On the other hand, the creator economy in the Metaverse can supplement the vision of Web 3.0 by developing a whole new financial world with the implementation of decentralized solutions.

Decentralized Autonomous Organizations (DAOs) and Governance. A DAO is a digital organization operated by a community of stakeholders whose interests are aligned using tokens, economic mechanisms, and applied game-theory. A DAO is governed by rules encoded (and enshrined) in smart contracts running on the Ethereum blockchain. As such, a DAO has the ability to function autonomously, without the need for a central authority [64]. In essence, DAOs provide an architecture for open collaboration and automated governance. This architecture allows individuals and institutions to collaborate without having to know or trust each other and, as transactions are recorded on the blockchain, the operation of DAOs is completely transparent. Early examples of DAOs include PleaserDOA [65], BitDAO [66], and LexDAO, head-quartered in the Cryptovoxels metaverse [67].

DAOs remain experimental. Non-hierarchical organizations with no, or at least fluid, legal jurisdictions create challenges for regulators already struggling with how to understand and control a fast-moving blockchain space. Despite lack of regulatory clarity, DAOs are expected to disrupt traditional business structures [68] as they re-invent governance, participation, reward, and stakeholder engagement.

The unpredictable and hyper-rapid speed of evolution of the blockchain space makes long-term predictions challenging to determine with a high degree of certainly. Many of the trends identified overlap and drive, or intersect, with other trends. This chapter has focused on key challenges that blockchain needs to address, while examining some of the emerging trends along with their disruptive potential in a dynamic, vibrant, and volatile eco-system.

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II. THE EUROPEAN UNION'S LEGAL AND REGULATORY BLOCKCHAIN FRAMEWORK

The 2008 whitepaper 'A Peer-to-Peer Electronic Cash System', pseudonymously authored by Satoshi Nakaomto (Nakamoto, 2008), described a decentralized payments architecture whereby peer-to-peer transactions execute, with their integrity guaranteed, without the need for central oversight. The Bitcoin blockchain – on which the first transaction took place in January 2009 – is the best-known example.

While blockchain principles were initially developed with financial transactions in mind, blockchain use-cases have grown exponentially with utility and application across many sectors such as healthcare (Blockchain Applications in the Healthcare Sector, 2022) and food safety (Block Chain Food Safety Managment, n.d.).

Blockchain is regarded by many of the world's major political, social, and financial instructions as a disruptive technology. The OECD, United Nations, World Bank, World Economic Forum, International Labor Organization, and the European Union (among other institutions) as well as most nation states are developing strategy, policy and regulatory frameworks aimed at understanding and engaging with this rapidly evolving paradigm.

The European Union's Blockchain Strategy. The European Union (EU) has ambition to become a leader and innovator in blockchain technology. In realizing this ambition, the EU seeks to attract major platforms, applications, and companies (Shaping Europe's Digital Future, n.d.) to establish themselves within the group of 27 member states.

The European Commission's strategy has embraced a 'gold standard' for blockchain technology designed to facilitate EU ambition and which incorporates European values and ideals into its emerging legal and regulatory framework. With respect to DLT, aspects of this 'gold standard' encompass alignment with Europe's data protection and privacy regulations, respect for, and enhancement of, Europe's (self-sovereign) digital identity framework, high levels of cybersecurity, and the interoperability of platforms and solutions across DLT and legacy systems.

The European Commission supports blockchain on policy, funding, and legal and regulatory developments. Key elements of the Commission's blockchain strategy include:

- Building a pan-European public services blockchain: The European public sector is building its own blockchain infrastructure. This infrastructure will be interoperable with private sector platforms.

- Promoting legal certainty: The Commission is developing a legal framework for blockchain-based applications, including tokenization and smart contracts, to protect consumers and businesses. The Commission strongly supports a pan-European framework to avoid legal and regulatory fragmentation.
- Increasing funding for research and innovation: The EU provides funding for blockchain research and innovation through grants and supporting investments in AI and blockchain startups and projects.
- Promoting blockchain for sustainability: The EU supports the potential of blockchain in fostering sustainable economic development, addressing climate change, and supporting the European Green New Deal.
- Supporting interoperability standards: The Commission believes strongly in the importance of standards in promoting blockchain technology. It is involved in the work of ISO TC 307, ETSI ISG PDL, CEN-CENELEC JTC19 and IEEE and in ITU-T as far as blockchain is concerned, Furthermore, the Commission looks to engage with all relevant bodies globally such as the International Association of Trusted Blockchain Applications (INATBA).
- Supporting blockchain skills development: Initiatives focused on the development of relevant skills include the Digital Europe Program and CHAISE.
- Community interaction: The Commission interacts with the private sector, academia and the blockchain community primarily through the INATBA, and the European Blockchain Observatory and Forum (a European Parliament funded pilot project).

The following table 1 summarizes several EU level initiatives aimed at (in)directly furthering the EU's Blockchain ambitions.

Table 1. EU Blockchain initiatives

INITIATIVE	DESCRIPTION
The Digital Europe Programme	The Digital Europe Programme (with a budget of €580 million for digital skills over 7 years) provides strategic funding to address key challenges that include supercomputing, artificial intelligence, cybersecurity, advanced digital skills, and ensuring a wide use of digital technologies across the economy and society.
CHAISE	A Sector Skills Alliance initiative financed by the Erasmus+ programme aiming to develop a strategic approach on blockchain skills development for Europe as well as to deliver future-proof training solutions, to tackle blockchain skill shortages and to respond to the current and future skill needs of the European

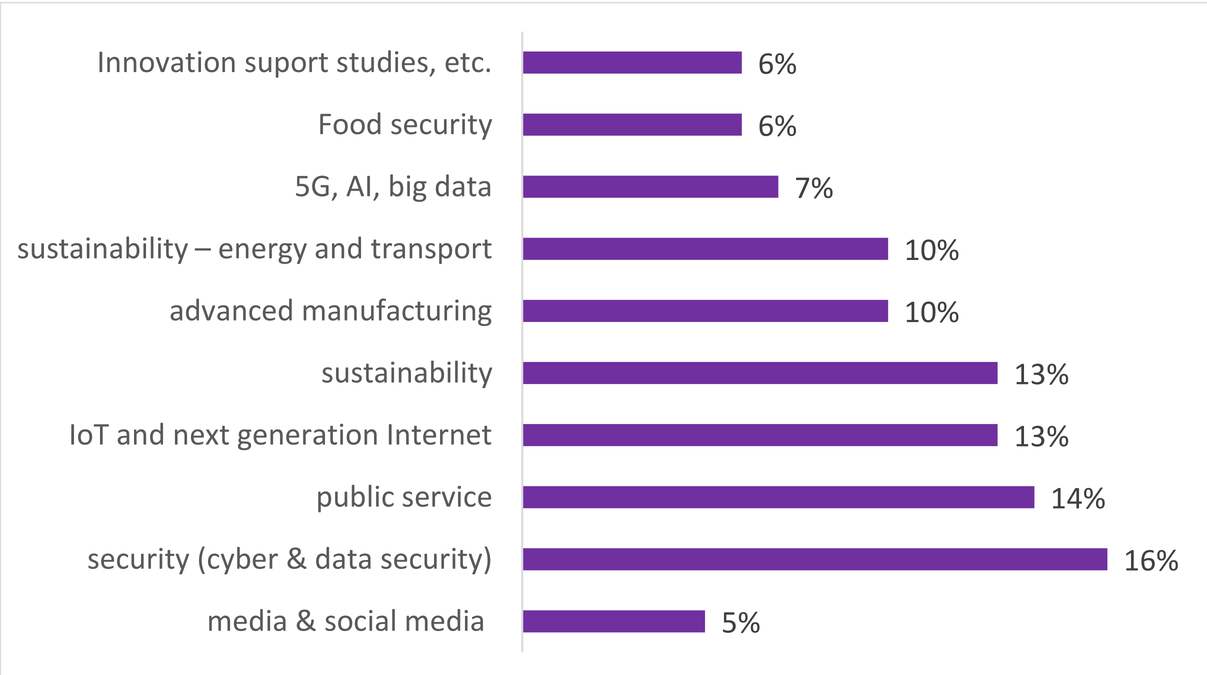
	blockchain workforce.
European Blockchain Partnership (EBP)	The EBP is an initiative to develop an EU strategy on blockchain and build a blockchain infrastructure for public services. By using blockchain themselves, European policy makers gain first-hand knowledge of how the technology works. The EBP serves as both a technological and regulatory sandbox aimed at more informed regulation on the technological and use case front.
European Blockchain Services Infrastructure (EBSI)	The EBSI consists of a peer-to-peer network of interconnected nodes running a blockchain-based services infrastructure comprising distinct layers: a base layer containing the basic infrastructure, connectivity, the blockchain and necessary storage; a core services layer that will enable all EBSI-based use cases and applications; additional layers dedicated to use cases and specific applications. The initial set of EBSI use cases are: • Notarization: Trusted digital audit trails, automated compliance checks in time-sensitive processes and proven data integrity. • Diplomas: Giving control back to citizens when managing their education credentials, significantly reducing verification costs, and improving authenticity trust. • European digital identity: Implementing a generic digital identity capability, allowing users to create and control their own identity across borders without relying on centralized authorities, and enabling for compliance with the eIDAS regulatory framework. • Trusted data sharing: Securely sharing data amongst authorities in the EU, starting with the IOSS VAT identification numbers and import one-stop-shops amongst customs and tax authorities.
EU Blockchain Observatory and Forum	The EU Blockchain Observatory and Forum is a community for discussing and highlighting key developments of blockchain technology. Key objectives include: • Map key initiatives in Europe and beyond. • Monitor developments, trends and address emerging issues. • Serve as a global knowledge hub on blockchain. • Create an attractive and transparent forum for sharing expert information and opinion. • Promote European actors while fostering engagement with the global blockchain

	community. • Represent a major communication opportunity for Europe to set out its vision and ambition on the international scene. • Inspire common actions based on specific use-cases. • Make recommendations on the role the EU could play in accelerating blockchain innovation and adoption.
MiCA Regulation	The EU's Markets in Crypto-assets (MiCA) Regulation, introduced in 2020, provides a sound legal framework for the development of crypto-asset markets within the EU. It aims to protect consumers and investors and prevent money laundering and terrorist financing.
Connecting Europe Facility — CEF Digital	The digital part of the Connecting Europe Facility (CEF Digital) will support and catalyze both public and private investments in digital connectivity infrastructures between 2021 and 2027.

Source: [72, 73, 74, 75, 76, 77, 78].

In recent years, the European Commission has actively supported and funded a range of Blockchain related projects across a range of sectors. The allocation of funds prior to February 2022 totaled € 347 million allocated as shown in the Figure 1.

Figure 1. Blockchain EU funding (€ 347 million) per sector prior to Feb 2022



Source: 79.

Funded by the European Union

The EU has funded a multitude of research and innovation projects in which DLT contribute to trust, societal, technical, and infrastructural solutions. The Horizon 2020 [80] program's € 80 billion budget was a major contributor to this funding. Horizon 2020 has been succeeded by Horizon Europe [81, 82] with a budget of € 96 billion for the period 2021 – 2027.

In 2019, the European Investment Fund (EIF) [83] launched a scheme to increase funding for European start-ups using artificial intelligence and blockchain technology. The scheme was very successful and provided more than € 700 million in 2020 to be invested as venture capital funds in European start-ups. Support to Venture Capital for deep tech, including blockchain, will continue during the period 2021-2027 additionally supported by the InvestEU [84] program.

European Parliament resolution of 3 October 2018 on distributed ledger technologies and blockchains: building trust with disintermediation

"The European Parliament,

- stresses the potential of DLT for verification of academic qualifications, encrypted educational certification (e.g. 'blockcerts') and credit transfer mechanisms;
- stresses that lack of knowledge about the potential of DLT discourages European citizens from using innovative solutions for their businesses;
- highlights the need to establish non-profit-making entities, for example research centres, that would be innovation hubs which would specialize in DLT technology in order to perform educational functions regarding the technology in Member State;
- calls on the Commission to explore the possibility of creating an EU-wide, highly scalable and interoperable network that makes use of the technological resources of educational institutions in the Union, with a view to adopting this technology for sharing data and information, thus contributing to the more effective recognition of academic and professional qualifications; also encourages Member States to adapt specialized curricula at university level in order to include the study of emerging technologies such as DLT;
- recognizes that for DLT to be trusted, awareness and understanding of the technology need to be improved; calls on the Member States to address this through targeted training and education."[85]

In addition to EU funded blockchain projects, the Commission manages EU Parliament pilot projects such as the European Blockchain Observatory and Forum (see above) and has established EU prizes such as the Blockchain for Social Good prize [86].

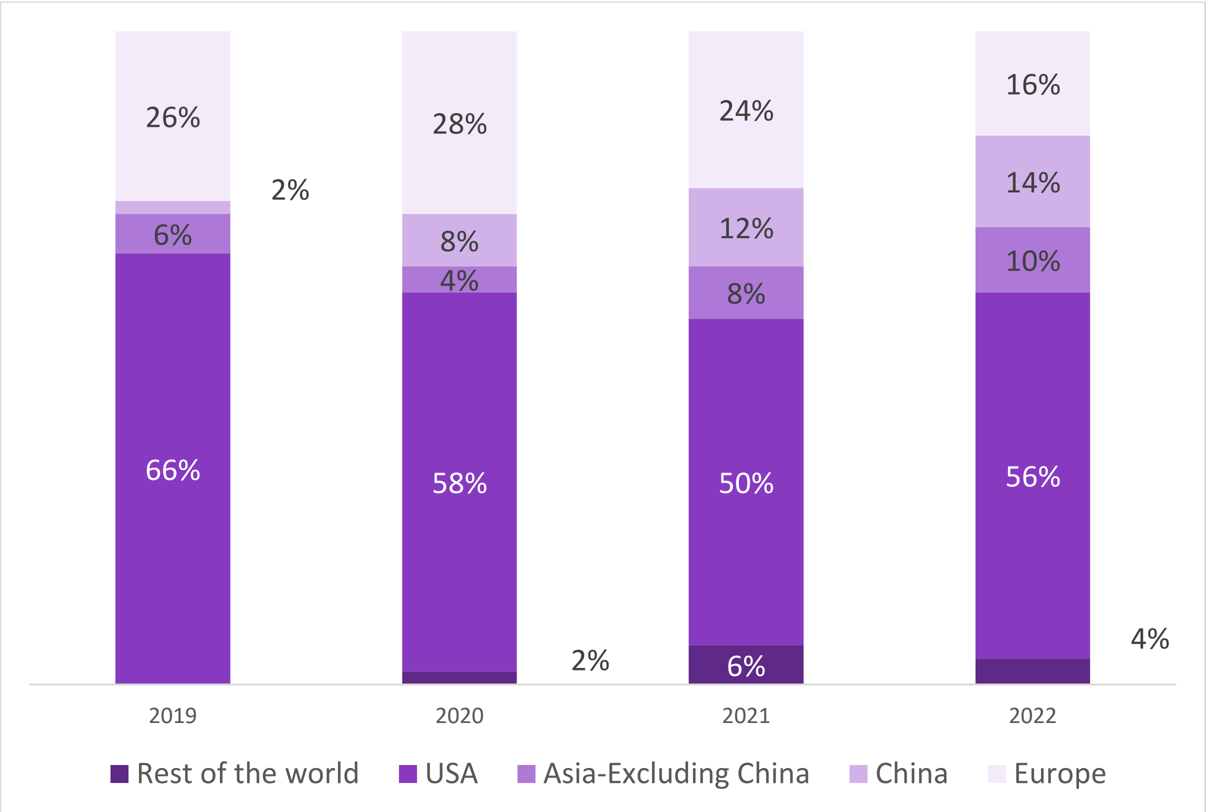
Further projects and reports include the: Blochain4EU [87], Blockchain for digital government [88], Blockchain Now and Tomorrow [23], and DLTs for Social and Public Good [89] (an overview of ongoing EU funded blockchain projects is provided is Appendix A; an overview of completed EU funded blockchain projects is provided is Appendix B).

The EUs ambition to become a leader and innovator in blockchain technology requires establishing a public sector infrastructure, supporting interoperability standards, promoting legal certainty, funding research, ensuring that relevant skills are available, and that economic development remains aligned with the EUs sustainability agenda. To facilitate this ambition, the EU engages with a host of multi-level initiatives ranging from strategic EU funded projects and pilots to the funding of more limited scale specific projects.

III. BLOCKCHAIN STATUS IN 2022 AND THE NEAR FUTURE

Based on an analysis of data collected between 2018 and 2022 from companies' submissions to the Forbes Blockchain 50, it can be concluded that the greatest dynamics of Blockchain work is currently taking place in Asia. In China, for example, as early as 2019, President Xi Jinping indicated that Blockchain: "play an important role in the next round of technological innovation and industrial transformation."[90] Nevertheless, the geographic region with the largest number of companies involved in this technology remains the United States, significantly dominating the rest of the world (Figure 2).

Figure 2. Blockchain-related companies by geography.

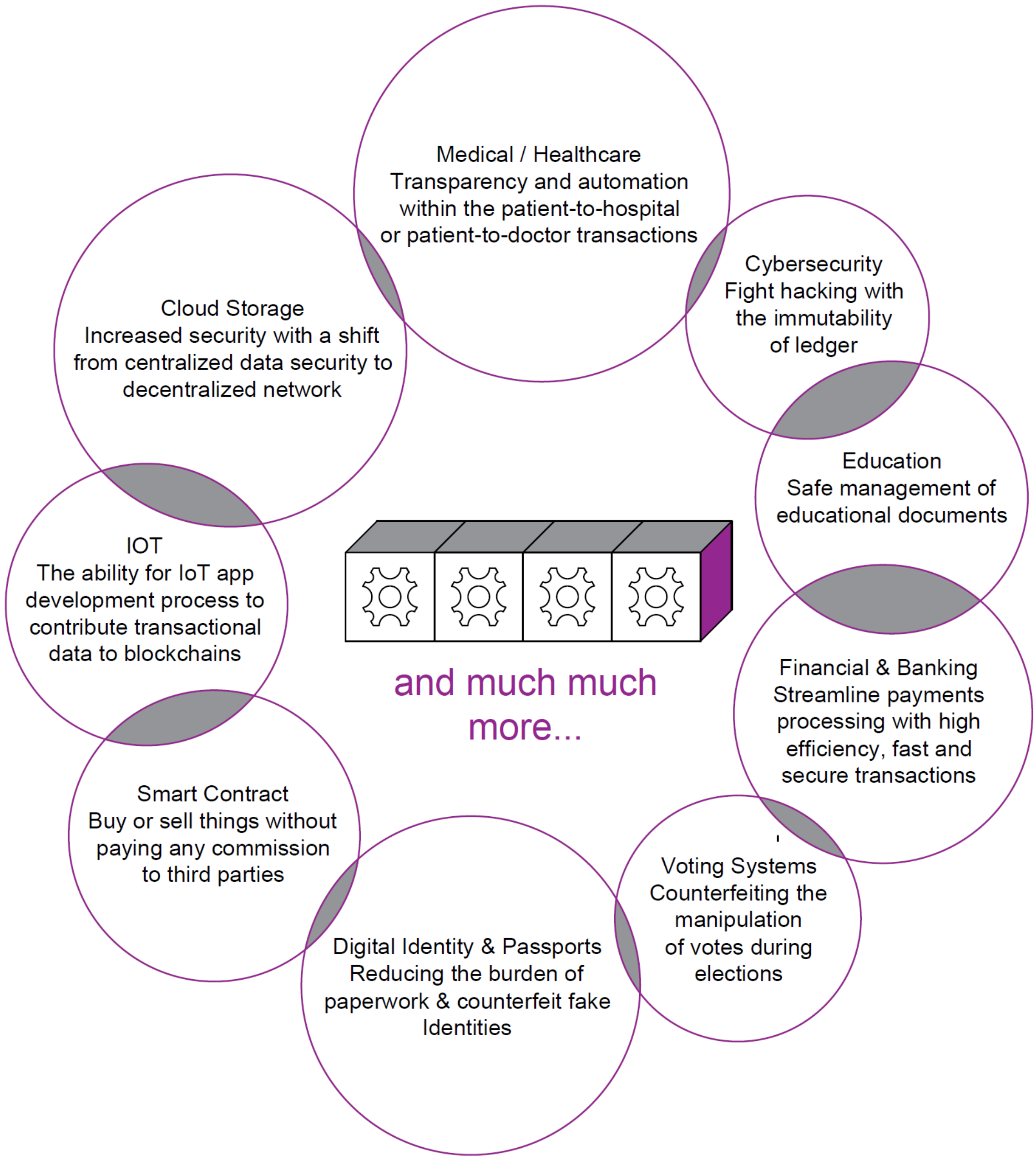


Source: own elaboration based on [90].

The very high level of interest in Blockchain in the U.S. has led to a kind of rivalry between the two main aggregation centers for companies involved in the technology. These are Silicon Valley in northern California and Silicon Alley, based in New York. The former includes groups such as Twitter and Adobe, for example, and the latter includes Coinbase and J.P. Morgan. The West Coast accounted for up to: 24% in 2019, 16% in 2020, 10% in 2021 and 16% in 2022 of the world's total Blockchain stakeholders, while the New York setting accounted for 16% in 2019, 16% in 2020, 10% in 2021 and 14% in 2022, with a focus on financial services and technology [90].

Shortly after the first attempts to implement the new technology into non-cryptocurrency solutions, there were attempts to classify the utility of the phenomenon into financial and non-financial solutions [91]. Another attempt at systematization was grouping with respect to Blockchain versions [92]. In the current era and the multifaceted and ever-lengthening list of application possibilities, such classifications seem insufficient or incomplete [93]. An expanded concept is provided in Figure 3.

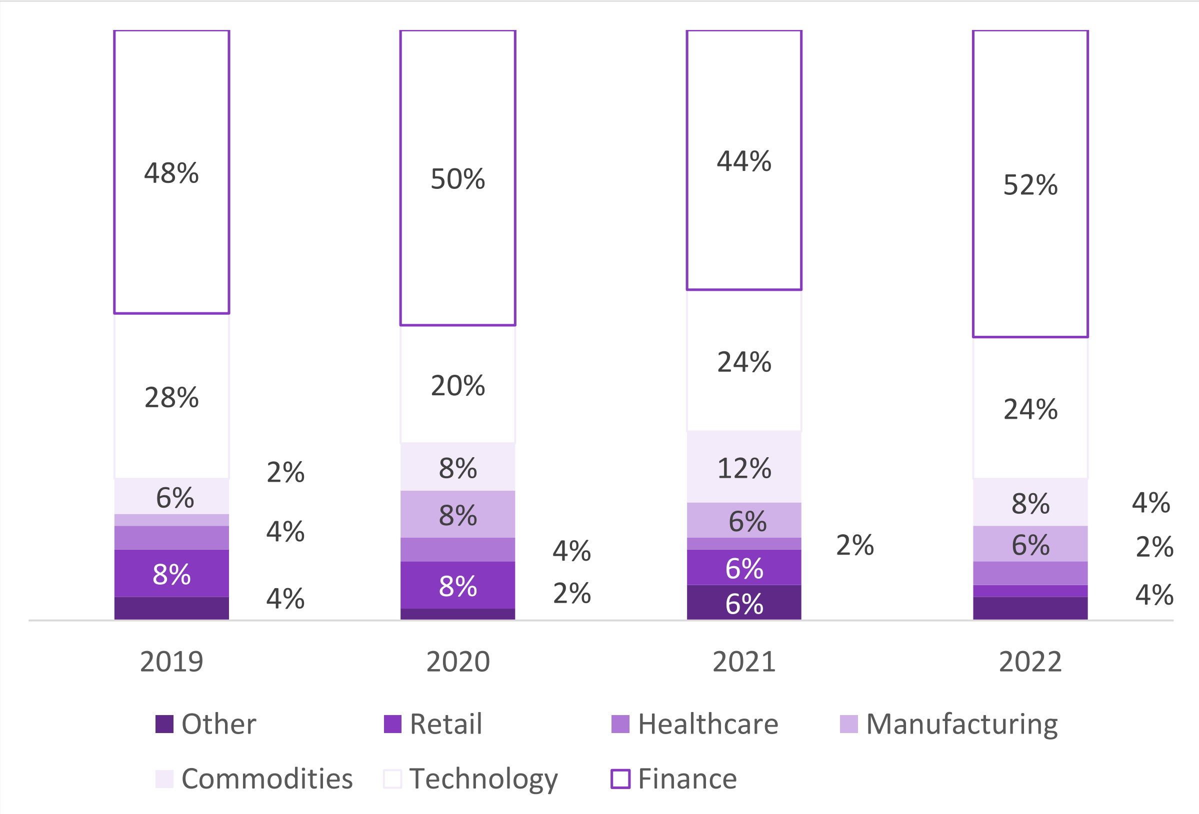
Figure 3. Main areas of Blockchain technology application



Source: own elaboration based on: [94].

Among the fifty most promising initiatives from the 2018 – 2022 Blockchain area, the largest and most numerous group by far are financial applications, which is certainly due in a way to the connection with cryptocurrency markets. In second place are technology applications, including hardware, software and web applications. These are followed by process improvements in supply chain, manufacturing and healthcare (Figure 4).

Figure 4. Blockchain deployment areas



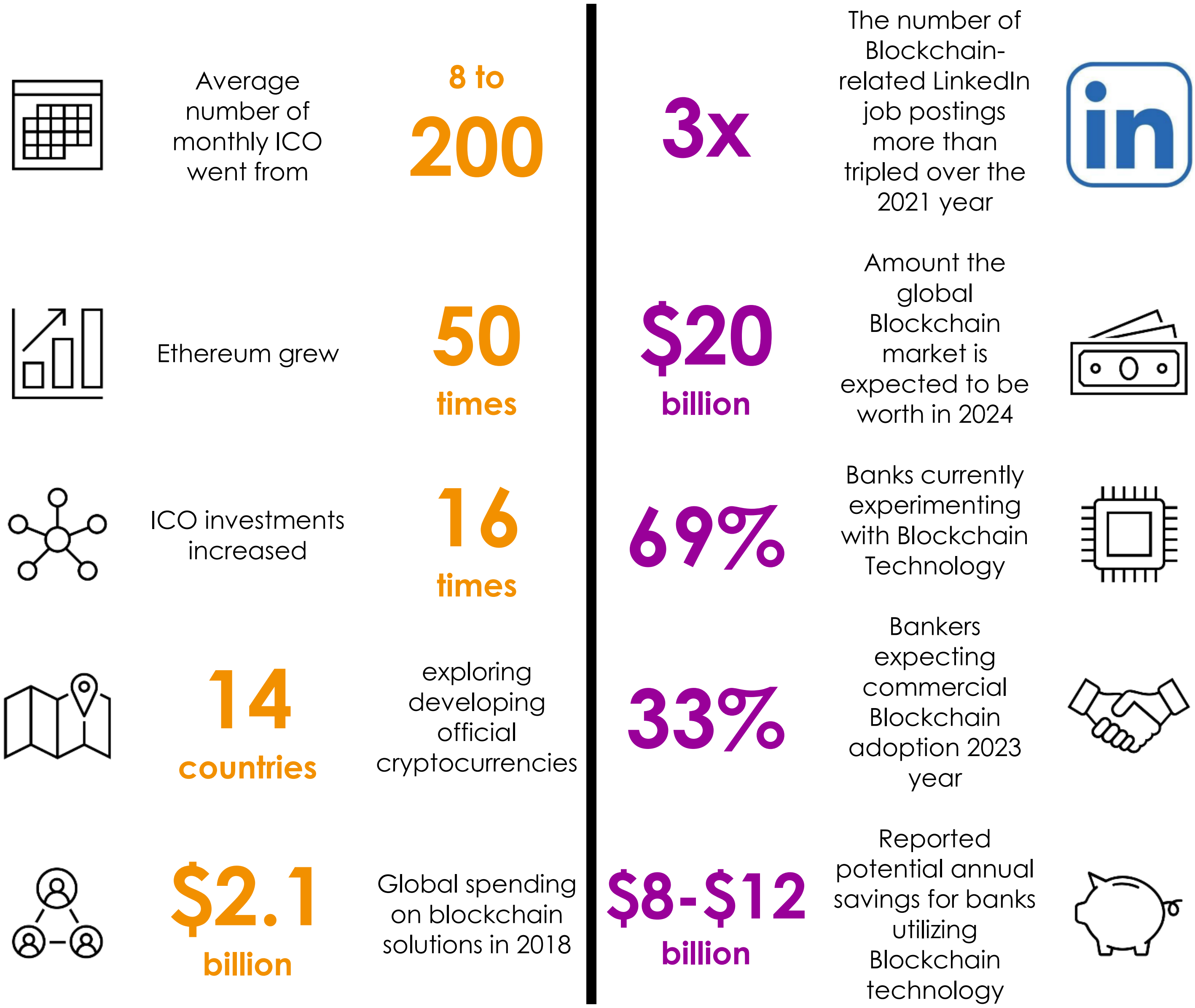
Source: own elaboration based on: [90].

Figure 4 confirms the statement that finance is currently l taking the undisputed lead in terms of the number of companies reaching for Blockchain. But in which specific subsectors is the technology most successful? It turns out that these are banking and payments, respectively. Slightly less common is its use in investment and foreign exchange [90].

Observing the market environment of Blockchain, it is possible to be very optimistic about its development and propagation in the future. Figure 5 shows the situation not only of the technology, but also of convening solutions and phenomena. All of these areas, which include, among others: the countries involved, the development of ICOs or the growing interest from banks, have seen very dynamic growth.

In the early years of the emergence of cryptocurrencies, the banking sector as a whole showed a very skeptical or even hostile attitude. However, this situation has been changing over time, and today it is possible to observe an attempt by banks to engage in brokering cryptocurrency transactions. The approach to Blockchain has also changed. The world's largest banks have joined the "digital race" looking for opportunities in this area by conducting research and testing innovative applications [91].

Figure 5. Blockchain technology and market development



Source: own elaboration based on: [86].

Even the significant fluctuations and unpredictability of cryptocurrency markets [95] are not currently a hindrance that could threaten Blockchain's expansion, as the numerous profits that can be achieved through it are in a wide range of fields and are highly diversified [96]. The key ones are presented in Figure 6.

Figure 6. Key attributes of Blockchain technology

Records and validate every transaction made, which makes it secure and reliable

★

Discards the need for any third-party for peer-to-peer transactions

★

Users are in control of all their information and transactions

★

Complete, consistent, timely, accurate and widely available

★

Reduce transaction times to minutes and are processed 24/7

★

The decentralized system, therefore, it is less risky to be hacked

Source: own elaboration based on: [94].

The implementation of Blockchain projects takes place with very diverse staff compositions, ranging from a few to even a few thousand people. It is rather hard to discuss clear trends in this regard, since it is quite difficult to find data on this subject. The companies show the problem of unequivocally categorizing a given employee as a specialist in this field. Nevertheless, most often such groups are between 50 and 200 people (22% of the total) or between 10 and 49 employees (18% of the total). Considering only the fifty most promising Blockchain initiatives collected and published by Forbes [90], the sum of their capitalization in 2022 reached as much as $6.3 trillion (despite the fact of a decrease from the previous year – 2021 – by 35%). The median for 2022 reached a value of $66 billion.

The vision for the future is also very promising. A forecast made by Gartner [97], using a new value prediction methodology, estimated the total added value resulting from the implementation of Blockchain technology at $176 billion in 2025 and more than $3.1 trillion in 2030. Compared to more recent publications (such as [90, 98]), it turns out how great an underestimation this was, as the dynamics of Blockchain's development turned out to be much greater than expected.

EXAMPLES OF BLOCKCHAIN TECHNOLOGY IMPLEMENTATIONS BY LARGE CORPORATIONS

Blockchain application mainly in supply chains to increase traceability and freshness of food. The first steps were already taken in 2017 [99].

★

Careffefour has also used Blockchain to monitor its food supply chain. The first tests began in 2017. In 2018, the system was first used in practice to monitor the poultry supply chain in Europe. Further development followed a year later and was subject to inclusion in the monitoring of four more food products. In 2022, the technology was expanded to all products in Carrefour's Quality Product Line [100].

★

Amazon has created and released a fully managed service: the Amazon Managed Blockchain. Using open source platforms Hyperledger Fabric and Ethereum, it makes it easy to join public networks or create and manage scalable private networks [101].

★

Alibaba Group has launched a digital BaaS service (Blockchain as a Service). It is used to build a secure and stable Blockchain environment. The technologies it supports are: Hyperledger Fabric, Ant Blockchain and Quorum [102].

★

In 2017, Nestle became a founding member of the IBM Food Trust. This was the point at which it began testing and using Blockchain technology on a small scale in practice. Since then, the company has expanded and diversified its use of the technology to increase transparency against particularly "sensitive" food products such as baby food [103].

★

Home Depot has used IBM's Blockchain solution to address mistrust issues in its supply chains. Emerging delays and other obstacles that could not be monitored in real time caused the company to be undermined in the eyes of its customers. Blockchain technology significantly increased the transparency of all processes and provided the ability to track shipments in real time, without the need for numerous additional interactions and painstaking trust-building and enforcement of collaboration standards [104].

★

In order to verify the authenticity of diamonds and trace them back to their source, through intermediaries and transportation to the store, De Beers decided to develop and implement a special TracrTM platform based on a distributed blockchain system. The research and first tests were conducted in 2018 [105].

★

To meet the challenges of the digital revolution, the Swedish manufacturer as well as distributor of furniture and accessories has opened a design and innovation lab called Space10, which addresses, among others, the possibility of effectively using technologies such as artificial intelligence, Blockchain or IoT. The Everyday Experiments project uses the visual concept of artificial intelligence, using Blockchain to share information about individual products and materials (such as how and where they were made) [106, 107].

★★★

The latest examples covering successful commercial Blockchain implementations in 2022 can be found in a Forbes review entitled: Forbes Blockchain 50 2022. The review is available for free online at:
https://www.forbes.com/sites/michaeldelcastillo/2022/02/08/forbes-blockchain-50-2022/ [90]

★★★

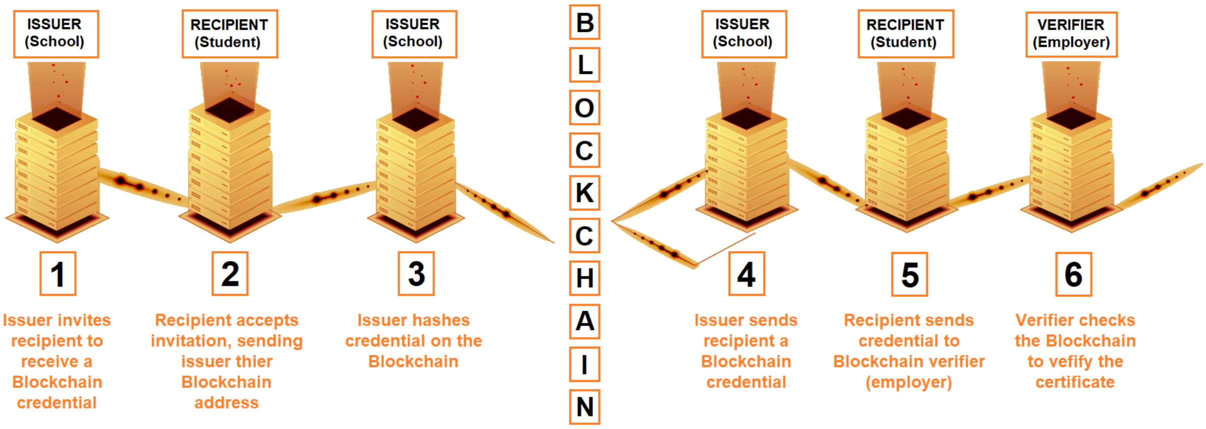
IV. BLOCKCHAIN IN EDUCATION

Blockchain is a new paradigm for digital data management and learning. Many researchers take the position that it represents a new megatrend of the digital world [108]. But can it play an important role in the education process? There is no doubt that it does on several levels. For example, it finds application in the organization of education, e.g. through the implementation of decentralized platforms containing grades, documents or diplomas of graduates, or the authentication and security of processes related to the verification of knowledge such as exams [109]. In addition, it represents valuable knowledge, which can and even should be taught.

Blockchain functions at the interface with other technologies such as artificial intelligence, IoT, Big Data. These solutions are slowly infiltrating the practice of teaching, for example, by technically supporting grading, supervision or profiling. This makes these techniques, despite their undoubted benefits, seem culturally invasive and may imply serious ethical questions. The traditional conveyance and transfer of knowledge, primarily through schools and universities, is a time-honored, valued and important determinant, representing intellectual development, progress and enhancement of daily life. However, on the other hand, in order to function effectively in a modern, dynamic and convergent environment, educational entities should be characterized by openness and high dynamism in absorbing novel ideas and innovations, especially from the ICT area [110].

Despite its great potential and its very expansive and annexationist nature, Blockchain remains most strongly linked to the IT and economic dimensions [111]. It can be interpreted as: "A database, similar to a cadaster of real estate titles, extended to events, covenants, patents, licenses, or other permanent records. All are hashed together mathematically from the origin of the series, each record distributed and publicized on decentralized Internet nodes" [108]. Its most important function remains the elimination of uncertainty about the authenticity of identity and information, thanks to sharing of this data by all parties involved and the use of additional, meticulously planned, however powerful, virtual cryptographic tools [112]. An example of such authentication chain using micro-credentials in the relationship between school, student, employer is presented in Figure 7.

Figure 7. Chain of micro-credentials



Source: own elaboration based on: [113].

Supporting education through the implementation of Blockchain-based solutions will involve the need to store and manage highly sensitive personal data in a decentralized network. This fact determines that every effort should be made to minimize any risk of unauthorized access by unauthorized entities. This raises the question of whether this type of information should not be secured in accordance with established system regulations developed by experts. Good practice in this regard can be observed, for example, in India, where the "SPDI Principles" (Processing of Personal Data/Information and/or Sensitive Personal Data/Information) were introduced as early as 2011 [114, 115]. According to them, business entities and other institutions that collect, receive, possess, store or process sensitive personal data in electronic form must comply with a number of principles established by law. In view of this, any educational entity wishing to use Blockchain technology will have to inform its students/trainees about the implications of using this tool like the fact that once stored, the information cannot be deleted [116].

> "The technology most likely to change the next decade of business is not the social web, big data, the cloud, robotics, or even artificial intelligence. It's the blockchain, the technology behind digital currencies like Bitcoin." [117]

Blockchain is in constant evolution. It is improving and changing not only its source code and IT architecture but also new application areas [118, 119]. This multidimensional evolution is correlated and mutually driving. Its stages are presented in Table 2.

Table 2. Evolution of Blockchain technology

LEVEL	APPLICATION
Blockchain technology 1.0	Cryptocurrencies as a peer-to-peer cash payment system
Blockchain technology 2.0	Applications in stocks, bonds, loans, smart property, and smart contacts, dapps (Decentralized Applications), DAOs (Decentralized Autonomous Organizations), DACs (Decentralized Autonomous Corporations)
Blockchain technology 3.0	Government, health, education, science, literacy, culture, cybersecurity, IoT, web services, voting, supply chains and art
Blockchain technology 4.0	Business usable platform to create and run applications thus converting the technology to fully mainstream

Source: own elaboration based on: [112, 120].

In most cases, the technology in question is used in education mainly as an element to support administration and teaching processes or in the context of administrative interaction with students [121] (e.g., "smart contracts managed in blockchain systems could establish conditions under which a student would receive a certificate from a provider, and a series of those contracts could define a full degree program. As these students' progress toward degree fulfillment, their blockchain records could be tracked automatically and shared in real time with potential employers" [122]). Successes in supporting the technical aspects of teaching using Blockchain came very early. As an example, a successful implementation by a Japanese company in February 2016 included "open and secure sharing of academic proficiency and progress records" [123].

Similar to authentication in cryptocurrency transactions, in teaching Blockchain can be a promoter and guarantor of openness, equality, security, accessibility, efficiency and even fairness [124]. Some of the more advanced considerations have led to more adventurous and abstract projects. One of these is the tokenization of educational outcomes, for example, in the form of digital units earned for completing specific tasks, which could be held in special digital "learning portfolios." Their dimension earned in a specific unit of time could form the basis for promotion and grading [125].

WOOLF – WORLD'S 1st BLOCKCHAIN UNIVERSITY

\WOOLF/

"As the first university built entirely on a blockchain architecture, Woolf promises to disrupt the economics of higher education by providing new opportunities for both students and academics."[126]

A group of Oxford academics have taken the initiative to create the world's first university organizationally based on Blockchain technology. This is how WOOLF University was established. Blockchain has been used to ensure regulatory consistency and honor regulations, minimize and even eliminate bureaucratic processes through their computerized automation, and effectively manage and protect students' sensitive data while authenticating their achievements and acquired skills. Oxbridge-style tutorials are the primary teaching material [126, 127].

"uber for students and airbnb for academics"[128]

"I very much hope it is the future of education. Woolf aims to solve two big problems in higher education: adjunct teaching and student access."
– Joshua Broggi, Woolf founder and director [128].

Fraud related to school and academic records is a serious problem worldwide. Studies conducted on this issue show that more than 100,000 higher education diplomas are purchased in the U.S. every year [129] (noting that a large part of this number may be documents certifying doctoral degrees). Such a large number testifies to the low security of these documents and the difficult and lengthy process of establishing their authenticity. This is due to the multiplicity of ways to realize the fraud: buying a fake document at a fake school, buying a document that is a forgery of the original, buying an original document using illegal practices issued by a genuine educational entity and, finally, buying a diploma or graduation from a "non-existent" university that is nothing more than a for-profit company and a "printer" of academic documents [130]. All of these practices are very dangerous and pose a real threat to people's lives and health, especially if a person with a fake diploma is hired in a responsible position. It is of great concern that, based on data collected in a study by the Ohio State University, there may be two million physicians practicing in the United States alone who possess false documents allowing them to practice their profession (diplomas or licenses) [131].

Despite several initiatives to reduce this practice, their effectiveness has left much to be desired. However, Blockchain can come to the rescue, which, based on a decentralized and transnational verification infrastructure, will prevent fraudsters from impersonating professionals. If a Blockchain-based solution had a global dimension, it would be possible to verify every employee and check the credibility of their credentials in real time from anywhere in the world [132].

V. HOW TO TEACH BLOCKCHAIN? PRACTICES, CONCEPTS AND EXPERIENCES

One of the fundamental characteristics of information societies is the need to constantly own professional skills, ensuring that retraining is easy and fast [133]. The more important an employees' position and value in the labor market, the more important it is for them to improve their know-how and gather experience. In the world of high-tech professionals, change happens very quickly. What was crucial yesterday and allowed a competitive advantage today is irrelevant. From the employer's point of view, a professional who consistently fails to learn new things becomes expendable.

A sector encompassing ICT and economic knowledge, which is characterized by very high deployment dynamics and even greater development prospects in the near future, is Blockchain. Of course, depending on specific needs, it is not necessary to assimilate all the knowledge related to this technology, but only general information and that part which is acutely needed for the task at hand. However, despite the fact that: "Blockchain is a new but powerful tool that has the potential to change the way we think about finance, engineering, and, perhaps most importantly, law (…) the educational resources are lacking." [134]

However, being an expert in this field requires in-depth knowledge, with all aspects of Blockchain – from its history and principle of operation, to its role in cryptocurrency systems, startups and new projects, to the ability to effectively "read," edit and create new code. In addition, in order to search for opportunities more effectively, it is necessary to learn about all possible interdisciplinary interactions of this solution with other fields, as well as to constantly follow technical innovations and develop your skills through practice.

The concept of learning Blockchain in six steps seems very interesting. These are [135]:

- STEP 1: basic knowledge and principle of Blockchain technology (definitions, features, types of Blockchain, smart contracts),
- STEP 2: how Blockchain-based platforms of large corporations function (e.g. Hyperledger, Ethereum, Corda),
- STEP 3: Blockchain's role in improving a number of services, technologies and economic fields (what are better solutions, what ventures are currently underway, how financial services will change in the near future),

- STEP 4: enroll in a professional, certified course on Blockchain (learn how Blockchain can improve your business, get a certificate for completing the course, treat the knowledge gained as capital),
- STEP 5: look for opportunities to leverage your knowledge and find potential areas in your industry that can be improved with Blockchain (seek self-improvement and self-education, conduct research and read the news),
- STEP 6: explore and learn about business transformations involving Blockchain (check out available solutions on the market, trace how the process of implementing Blockchain in new entities and projects went).

> "Blockchain is profoundly changing how the world works. If you've ever bought a house, you've probably had to sign a huge stack of papers from a variety of different stakeholders to make that transaction happen. If you've ever registered a vehicle, you likely understand how painful that process can be. I won't even get started on how challenging it can be to track your medical records."[136]

This concept implies differentiation of the level of initiation, due not only to the difficulty but also to the ranges of desired knowledge. In economic terms, this approach eliminates the need to create specializations, as it appears to be complete, but at the same time utopian, because it envisions multifaceted learning and acquisition of skills that are possessed by a very small group of people, and which were accumulated over a very long period of time. Despite the relatively correct holistic coverage of economic aspects and the identification of Blockchain's functional assumptions and applications, the six-step model is not and cannot be an effective and viable teaching model, but only an auxiliary tool indicating diverse scopes of knowledge.

There are many practical models for teaching Blockchain. Their main assumptions are aggregated in Table 3.

Table 3. Examples of Blockchain teaching models

INSTITUTION	course (C)/study (S)	stationary (S)/online (O)	multilevel	dedicated	additional materials	introductory course	issues related to cryptocurrencies	certificate, diploma
iMi, [137]	C	O	yes	no	yes	yes	yes	yes
CEBP, 101Blockchains, [138]	C	O	no	no	yes	yes	yes	yes
Coursera, Princeton University, [139]	C	O	no	no	no	no	yes	yes
edX, Berkeley University of California, [140]	C	O	no	yes	yes	no	yes	yes
Udemy, [141]	C	O	no	yes	no	no	yes	yes
Columbia Engineering, [142]	C	O	no	yes	yes	no	yes	yes
IMD, [143]	C	O	no	no	yes	no	yes	yes
University of Cape Town, [144]	C	O	no	no	yes	no	yes	yes
NUS, National University of Singapore [145]	S/C	S/O	no	yes	yes	no	yes	yes
RMIT, Royal Melbourne Institute of Technology [146]	S	S/O	no	no	yes	no	yes	yes
UZH, University of Zurich, [147]	other	S	no	yes	no	no	yes	yes
MIT, Massachusetts Institute of Technology, [148]	C	O	no	yes	yes	no	yes	yes
Hong Kong Polytechnic University, [149]	S	S	no	yes	yes	no	yes	yes
UCL University College London, [150]	S/C	S/O	no	yes	yes	yes	yes	yes
CUHK, Chinese University of Hong Kong [151]	S	S	yes	yes	yes	no	yes	yes
UNSW Sydney [152]	S	S	no	no	no	no	yes	yes
California State University, Chico [153]	C	O	yes	no	no	no	yes	yes

Source: own elaboration based on surveys conducted.

Table 3 is divided into 9 sections. The search for educational units offering Blockchain teaching was conducted exclusively via the Internet. The following aspects were taken into account:

- Is the content offered in the form of a course or official studies (other forms should be considered unprofessional and unreliable, they have also been omitted from these considerations)?
- Does the teaching take place exclusively remotely, i.e., is there the possibility of traditional on-site transfer of knowledge?
- The multilevel nature of the offered didactic content – i.e., is there dedicated material for beginners, intermediate and advanced learners, or has one material been created for all interested parties?
- Dedicatability – i.e., profiling the material for a specific audience (e.g., a person in a specific profession). Has the material been divided into thematic groups covering different courses/studies?
- Availability of additional learning material, e.g., in the form of webinars, podcasts, videos on YouTube or documents posted on e-learning platforms, etc.
- Has the provider prepared an introductory course to familiarize the user with very preliminary knowledge? This is especially important when learning online.
- Does the given course/study include topics or dedicated material on cryptocurrencies and the cryptocurrency market?
- Certification of the completion of course with an appropriate and reliable document (certificate or diploma).

Platforms such as Udemy or edX contain a variety of courses most often supported by academic entities. Table includes data related to specific sample courses. Sometimes Blockchain learning was offered in a form other than a course or degree program, e.g. as optional subjects – lectures on Blockchain Programming at the University of Zurich [147]. Courses were usually scheduled for 5-6 weeks but mini-courses of a few hours were also offered – these, however, were tried not to be included in this compilation (e.g. Nanyang Technological University, NTU-FTA Series – Enterprise Blockchain course, scheduled for 8 hours in online form and ending with a certificate [154]). Universities offered studies (depending on the organization) lasting from 1-2 years. The most balanced and transparent educational offering is at University College London, where there is a free online course for beginners (Introduction to Blockchain and Distributed Ledger Technology (DLT)), a certified professional course (DEC, Online Certifications for Blockchain, Digital Assets & Web3 Professionals), and degrees for engineers (Emerging Digital Technologies MSc) and economists (Financial Technology MSc) [150]. Only in the case of the Chinese University of Hong Kong, multi-level degree programs were offered to allow for continuation and further exploration: postgraduate and doctoral degrees [151].

In 2021, the information platform CoinDesk [155] conducted a survey of 230 universities, with a view to create an overall ranking that includes education involving Blockchain. The academic institutions represented all continents except Antarctica. The methodology included an assessment of five criteria: quality and contribution to research in the field, Blockchain educational offerings, collaboration with practitioners and business, cost of study, and academic reputation of the institution. Based on the results, a map was created showing the geographic location of the most thriving universities in the Blockchain context. This is included in Figure 8.

Figure 8. Location of universities providing Blockchain education

Source: [156].

The largest groupings were reported in the United States, Asia and Europe. This fact can be identified with the manifestation of increased interest and number of Blockchain technology implementations in these regions. The top 5 of the ranking (i.e. entities that scored more than 90 points out of a possible 100) are included in Table 4. It is interesting to note that in only 9% of cases education was completed with the possibility of obtaining a degree: 6% – a bachelor's degree and in 3% – a master's degree [156].

Table 4. Top 5 ranking of the best universities in the field of Blockchain

RANKING	SCHOOL	SCORE
1	National University of Singapore	100.00
2	Royal Melbourne Institute of Technology	97.65
3	University of California Berkeley	93.26
4	University of Zurich	91.66
5	Massachusetts Institute of Technology	91.57

Source: [156].

The Internet contains a great variety of forms to explore Blockchain knowledge on your own. One of the most popular and extensive is IBM's official website dedicated to Blockchain technology. It is possible to find there a lot of free materials and tools, which include: publications, content posted on the site, webinars, videos posted on YouTube, newsletters, a blog, etc. [157]

According to experts at the AACSB ("a global nonprofit association, connects educators, students, and business to achieve a common goal: to create the next generation of great leaders"), success in teaching Blockchain can be achieved through collaboration between practitioners, economists and computer scientists. The combination of these three sources of knowledge should be adapted to the specific field of study – little economics and a lot of computer science for engineers, computer scientists and technical specialists, and a lot of economics, a lot of case studies and little computer science for future economists and executives. With respect to the latter, considering potential professional tasks in the future, it can be concluded that only a small fraction of business or management school graduates will need to explore advanced cryptographic mechanisms or master programming at an advanced level. For the majority, in order to effectively operate in the market and participate in ventures involving or based on Blockchain, only a basic technical knowledge of the principles of operation and possibilities offered by this technology will suffice. They don't need to be computer scientists or cryptographers responsible for designing a specific platform/application/service, but only managers implementing these solutions and looking for market opportunities. This is because the economic implications and new application contexts are more important to them than perfect knowledge, understanding and transformation of the source code [158].

VI. STATISTICAL VERIFICATION OF HYPOTHESES USING THE STRUCTURE INDEX

The study adopts two hypotheses, which are presented in the "Introduction." Both of them are: "…judgments about the general population, without full knowledge of these populations" [159], and are parametric in nature because they concern the characteristics of the population under study. Their verification will be carried out in two stages: statistical (which will decide whether to accept the hypotheses for consideration) and substantive (which will decide whether they are true or false) [160].

The statistical test to which they will be subjected will be based on the subjective determination of the significance level of the *a* test, with respect to which, and after the necessary calculations, it will be possible to accept or reject the null hypothesis in favor of the alternative hypothesis. In some cases, more than one alternative hypothesis can be formulated. The adoption of subjective assumptions – the level of significance of the test – involves the risk of two types of errors. These are referred to as errors of the first and second type [161].

An error of the first type occurs when the null hypothesis (H_0), which is in fact true, is rejected. The probability of its occurrence is identified as the significance level of the test and denoted by the symbol *a*. An error of the second type occurs if the alternative hypothesis (H_1), which is false, is accepted. These probabilities, in turn, are identified by the symbol β [162].

Conducting fractional verification requires that for each hypothesis some specific reference values be adopted. The way H1 and H2 are formulated and constructed means that they can only be accepted for substantive consideration if the null hypotheses are rejected in favor of alternative hypotheses.

The hypotheses are as follows:

H1 (main hypothesis): Most academics and lecturers teaching economics and management classes lack the knowledge and skills needed to teach Blockchain-related topics, but at the same time understand and recognize the enormous potential of this technology.

H2 (complementary hypothesis): Most academics and lecturers teaching economics and management agree with the concept and the need to educate students in these fields about Blockchain technology.

An additional challenge is the complexity and multifaceted nature of H1. In order for it to be accepted and statistically accepted as a whole, each subthesis occurring in it must be considered. As they occur simultaneously, two separate null hypotheses ($H1_{10}$ and $H1_{20}$) and two alternative hypotheses ($H1_{11}$ and $H1_{21}$) must be accepted.

The significance level α=0.05 was used for testing. The initial verification parameters are listed in Table 5.

Table 5. Parameters of statistical hypothesis verification

HYPOTHESIS	H1	H2
Null hypothesis	$H1_{10}$ and $H1_{20}$	$H2_0$
Alternative hypothesis	$H1_{11}$ and $H1_{21}$	$H2_1$
Significance level of the test	α=0,05	α=0,05
Statistical test	structure indicator test	structure indicator test

Source: own elaboration.

H1 verification

The main hypothesis (H1) consists of two equivalent statements, thus both must be separately statistically verified. The first is the statement that: "most academics and lecturers teaching economics and management do not have sufficient knowledge and skills needed to teach Blockchain-related topics." The second reads, "most academics and lecturers teaching economics and management understand and recognize the enormous potential of Blockchain technology." Subtheses were assigned the designations: $H1_1$ and $H1_2$. In both cases, the phrase "most" appears, which prejudges the dimension of the population reference value (p) at 0.5 (since most is more than 50% or more than 0.5).

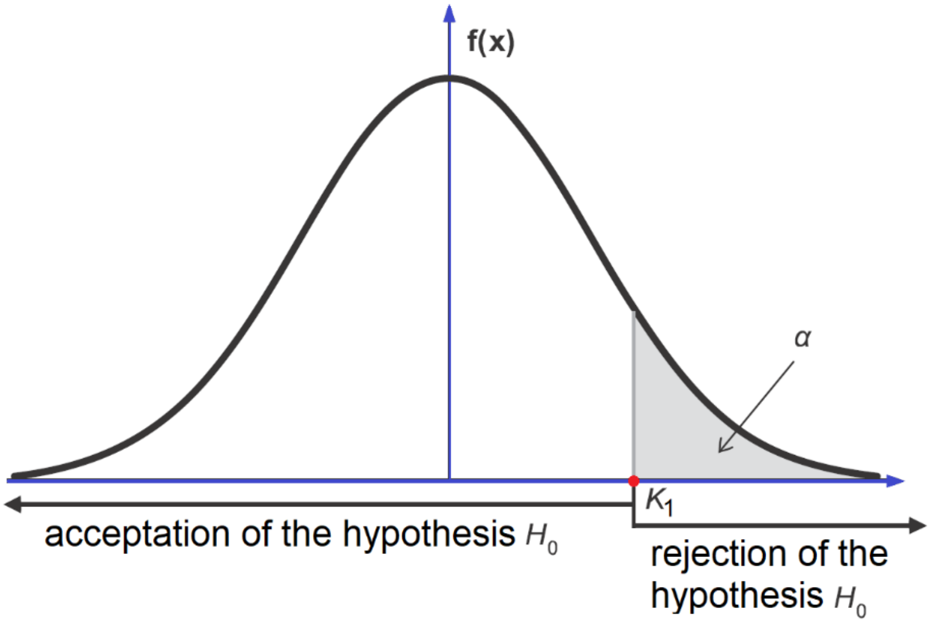
The verification of H1 required the introduction of an additional aggregation procedure for the results obtained, which were recalculated and assigned to specific ranges. E.g., in order to increase the degree of reliability, it was decided to categorize the answers "definitely yes" and "yes" or "relevant" and "very relevant" into groups consistent with $H1_{20}$, while the rest, including the answer "don't know" or "moderately relevant" into a group inconsistent with $H1_{21}$. Among the questions related to $H1_1$, the five most consistent responses were identified, while in the aspect of $H1_2$, three statements were selected.

For H1 to be substantively considered, $H1_1 \cap H1_2$ must be statistically accepted and this will happen when the accepted null hypotheses ($H1_{10}$ and $H1_{20}$) are rejected in favor of the alternative hypotheses ($H1_{11}$ and $H1_{21}$).

For $H1_1$, the null hypothesis presents as follows: $H1_{10}$: p=0.5. The alternative hypothesis, on the other hand, takes the form of: $H1_{11}$: p> 0.5.

The right-hand critical area for the test is considered, as illustrated in Figure 9. The K_1 value is the critical value for the test.

Figure 9. Diagram of the right-hand critical area



Source: own elaboration.

The left-hand critical area was as follows: K=<K_{11} ;+∞), K_{11} =1-a=0.95→after reading the value of distribution from the statistical tables→K_{11}=1.65→ K=<;1.65;+∞). The chosen test statistic (statistical test) is the structure index test, which is expressed by the equation:

$$U = \frac{\frac{m}{n} - p_0}{\sqrt{\frac{p_0 * (1 - p_0)}{n}}}$$

where:

U – structure indicator test,

$\frac{m}{n}$ – structure index from the sample,

P_0 – population reference value,

n – sample value,

m – number of elements distinguished in the sample.

After aggregation, the values of *m* and *n* were, respectively: 82 and 127. After calculations, the value of *U*=3.28 was obtained.

U=3.28 ϵ <1.65;+∞) → *U* belongs to the critical area.

There is a statistical basis for rejecting $H1_{10}$ in favor of accepting $H1_{11}$, which is consistent with the first thesis of the main hypothesis $H1_1$.

The procedure for $H1_2$ is analogous. The null hypothesis is presented as follows: $H1_{20}$: p=0.5. The alternative hypothesis, on the other hand, takes the form: $H1_{21}$: p>0.5. $K=<K_{12};+\infty)$, $K_{12}=1-a=0.95\rightarrow K_{12}=1.65\rightarrow K=<1.65;+\infty)$. For *m=75* and *n=127*, *U* was 2.04 $\rightarrow\epsilon$ <1.65;+∞) → *U* belongs to the critical area.

There is a statistical basis for rejecting $H1_{20}$ in favor of accepting $H1_{21}$, which is consistent with the second thesis of the main hypothesis $H1_2$. As there is no statistical rationale to disqualify H1, it can be verified on its merits.

H2 verification

Once again, the expression "most" contained in H2 determines the consideration of the right-hand interval and the adoption of an identical *p-values* as in other cases. For H2, the null hypothesis is expressed by the equation: $H2_0$: p=0.5, while the alternative hypothesis: $H2_1$: p>0.5. $K=<K_2;+\infty)$, $K_2=1-a=0.95\rightarrow K_2=1.65\rightarrow K=<1.65;+\infty)$. The declarations of two questions were taken into account, and on this basis *m=74* and *n=127* were determined. U=1.86 is within the critical range: <1,65;+∞).

There is a statistical basis for rejecting $H2_0$ in favor of accepting $H2_1$, which is consistent with the complementary hypothesis H2. As there is no statistical rationale to disqualify H2, it can be verified on its merits.

VII. DESCRIPTION OF THE RESEARCH PROCEDURE

The research was carried out on a pilot basis, which allows to test the adopted research procedure and also to learn about the preliminary results from which general conclusions and trends related to the audited phenomena can be drawn. A survey questionnaire was chosen as the basic research technique to gather the necessary information – a proven tool that has been found to be effective in the social sciences.

The general assumptions, the selection of analytical and technical tools, and the design and substantive scope of questionnaire were discussed internationally among partners coming from six European countries. Reasoned comments accepted by the majority were incorporated into the final form of questionnaire, which was eventually accepted by all interested parties.

The survey was anonymous. The final version of the author's questionnaire contained a total of 22 questions, which were aimed at finding out opinions and experiences about Blockchain technology. The questions were assigned to five thematic groups: demographics, section one: knowledge about Blockchain, section two: practical Blockchain competencies and skills, section three: Blockchain experiences, and section four: attitudes and opinions. The survey was quantitative but focused on the identification qualitative characteristics and opinions. Only closed-ended single- and multiple-choice questions were used, as well as multi-level single-choice matrices based on a five-point Likert scale (in one question – the eighth question – the five-point scale was extended by one additional degree; this was necessary due to the substantive aspect of this question, as it raised the question of knowledge of advanced IT techniques and knowledge, and based on the respondents' specificity, it was assumed to obtain declarations of a very poor level of knowledge in this area or no knowledge at all; the extreme degree: "very poorly" was insufficient and an additional option was added: "lack of knowledge").

A CAWI (Computer Assisted Web Interview) method was used, and the form was distributed using Google Forms. More complex analyses were conducted using MS Excel. Collection of responses began in the last week of March 2022 and lasted for one month. This paper presents only selected results of the survey.

Ultimately, the questionnaire was filled out by 129 respondents. 128 of the 129 questionnaires were qualified for analytical processing, as one was found to be largely incomplete and was rejected. Some of the questions were complex and multi-faceted. Due to this fact, as well as the specialized and difficult subject matter of the survey, the average time to fill out e the questionnaire was 27 minutes.

The classical analysis and visualization of the collected information was extended to the identification of regularities in the statistical correlation of phenomena. As the focus was on identifying the polytomy of qualitative features, the λ^2 statistic (chi-square)[163] was used. It is used to determine correlation coefficients such as T_{xy} Czuprow, V-Cramer, C-Pearson correlation coefficient, or Ø Yule. The authors, due to positive experience in other studies, decided to use a combination of methods: V-Cramer, C-Pearson correlation coefficient and T_{xy} Czuprow. Although all the methods mentioned are similar, the simultaneous use of these three methods reduces the likelihood of errors and mistakes. In addition, it provides an opportunity to verify the results obtained and increases the level of reliability of the whole procedure.

The selected methods allow measuring the relationship between variables the values of which are expressed on nominal scales. The results accept are in the range [0,1]. If the result obtained is close to unity, it means the presence of very strong relationships between qualitative variables. If it is zero or close to zero – it means independence of the analyzed characteristics [164].

The significance level for the λ^2 test (chi-square) was set at <= 0.05. The following thresholds were adopted for the V-Cramer and T_{xy} Czuprow coefficients to determine the correlation: <0;0.25> – no correlation between variables, (0.25;0.35> – weak correlation, (0.35;0.45> – moderate correlation, (0.45;0.55> strong correlation, (0.55;1> – very strong correlation. However, for the C-Pearson correlation coefficient the adopted scale needs to be corrected, as this tool is not as sensitive as the previous two indices to the dimensions of the contingency tables and usually provides slightly higher results with the same chi test value and chi-square statistic. An adequate correction was set at +0.1, thus the interpretation thresholds for the C-Pearson correlation coefficient index took the form: <0;0.35> – no correlation between variables, (0.35;0.45> – weak correlation, (0.45;0.55> – moderate strength correlation, (0.55;0.65> strong correlation, (0.65;1> – very strong correlation

Noteworthy is the fact that the established ranges are subjective and were determined by the authors, based on: comparisons, models and literature references, comparisons of the obtained results with the assumed correlations resulting from substantive and logical analysis, as well as research experience and general statistical knowledge.

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BLOCKCHAIN IS SUITABLE FOR SECURING PRIVATE AND PUBLIC NETWORKS

Although Blockchain can effectively secure both private and public networks, when designing an application it is very important to determine precisely what specific task it is to be used for. Private or authorized networks are generally more secure. However, public networks can achieve a greater degree of decentralization and distribution [164].

Public Blockchains are public, and anyone can join them and validate transactions.

Private Blockchains are restricted and usually limited to business networks. A single entity, or consortium, controls membership.

Permissionless Blockchains have no restrictions on processors.

Permissioned Blockchains are limited to a select set of users who are granted identities using certificates.

VIII. CHARACTERISTICS OF RESPONDENTS

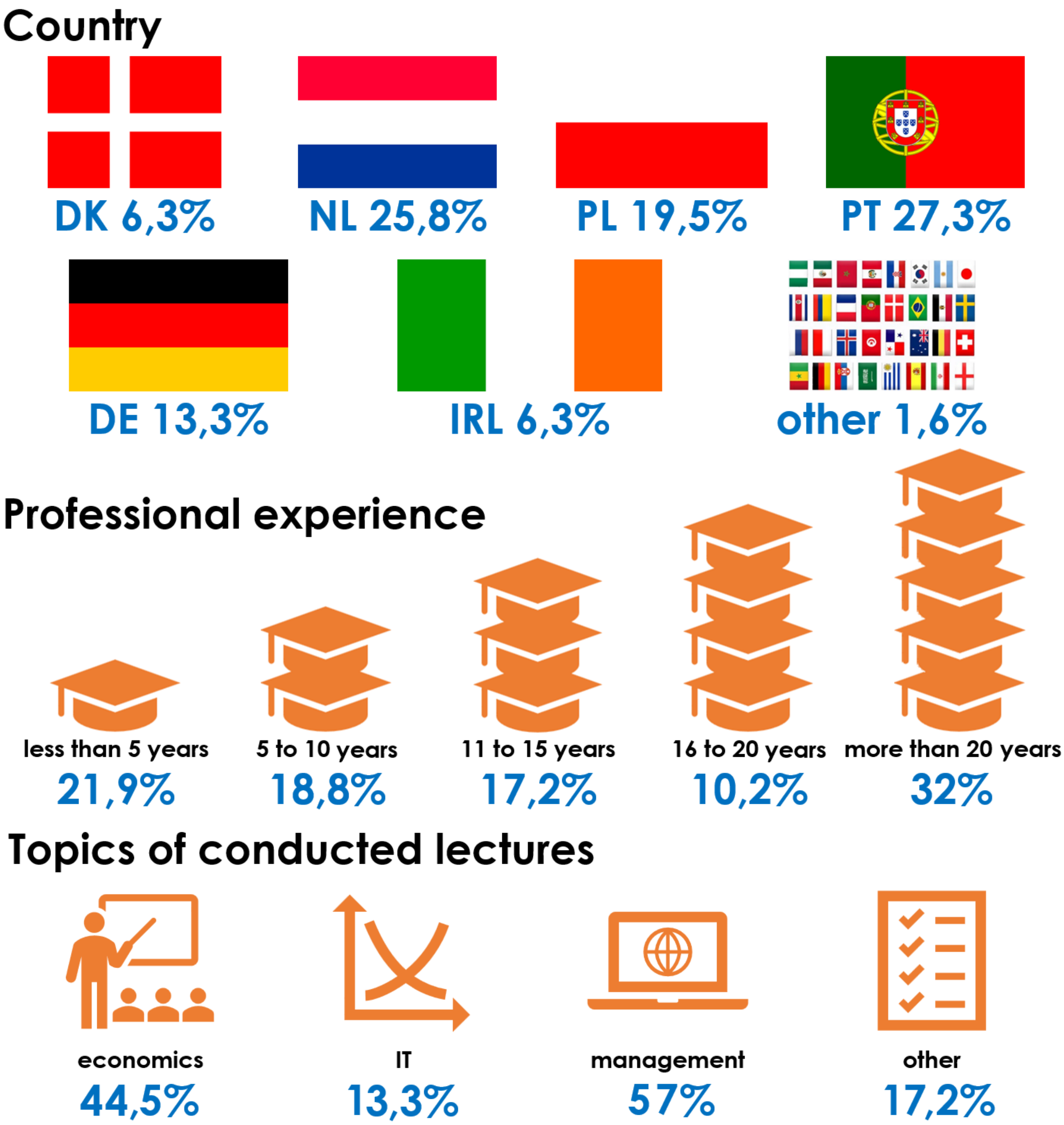
The survey was conducted among academics and lecturers coming from more than six European countries. Portuguese were the most numerous, followed by: Dutch, Polish and German. In Denmark and Ireland, fewer than ten people filled out the survey. Two respondents were of a different nationality than those indicated above. Data related to the origin, level of experience and specific teaching sector of the respondents are presented in Figure 10.

The respondents were mainly very experienced teachers. Responses that they had work experience of more than twenty years were given by as many as 32% of the total. The remaining declarations were spread more or less evenly among the other time groups: less than five years of experience – 21.9%, five to ten years of experience – 18.8%, eleven to fifteen years of experience – 17.2%, and finally: 16 to 20 years of experience – 10.2%. This distribution of respondents' characteristics means that the declarations they give can have a more representative value in terms of comparison to the general population, and therefore minimizes the value of adjustment error of the results [165].

33% of people declared that in terms of the subject matter of teaching, they were multidisciplinary, meaning that they indicated more than one option. The choices were: economics, management, IT and other. The choice of such narrowly defined groups was deliberate, related to the underlying assumptions of the project. The research concerned the possibility and scope of implementing Blockchain technology in economics and management faculties. Thus, it was based on the opinions and experiences of teachers involved in these sectors of study but who also had at least a basic knowledge of IT.

In conclusion, from a purely statistical point of view, the largest number of responses were given by Portuguese, those with more than twenty years of work experience and those teaching economic subjects.

Figure 10. Figure of the respondents*



Source: own elaboration based on surveys conducted.
* data may not add up to 100% due to the use of rounding or statistical techniques.

IX. PRESENTATION OF SELECTED SURVEY RESULTS

In the history of Blockchain, there are some important and groundbreaking dates corresponding to the key events through which the world became familiar with the solution and begins to use it on a large scale. The idea appeared as early as 1991. It was presented by two scientists: Stuart Haber and W. Scott Stornet as a tool for digital document security using a cryptographically secured blockchain for this purpose. In 1992, the project was expanded to include so-called Merkle Trees, which allowed multiple documents to be collected in a single block. However, entities interested in the technology were not found and the patent expired in 2004. January 3, 2009 is the official date marking the birth of Bitcoin. It was on this day that Satoshi Nakamoto dug up the first block and consequently received a reward of 50 Bitcoins. The first transaction, on the other hand, was already made on January 12, 2009 – Hal Finney received 12 Bitcoins from Satoshi Nakamoto. Another important date was 2013 – at that time Vitalik Buterin created a new distributed and decentralized platform for processing data and called it Ethereum [166].

The survey results, determining the point in time when the respondents first heard about Blockchain (Figure 11), should be interpreted optimistically. 3.1% of them declared that they had heard about the technology in question even before 2009, so they can be considered IT enthusiasts actively following any technical news in the field and thus having a wide and continuously updated knowledge. 19.5% declared that it was between 2009 and 2014, which was the time of Bitcoin's development and the emergence of Ethereum that was the herald of the Blockchain 2.0 era.

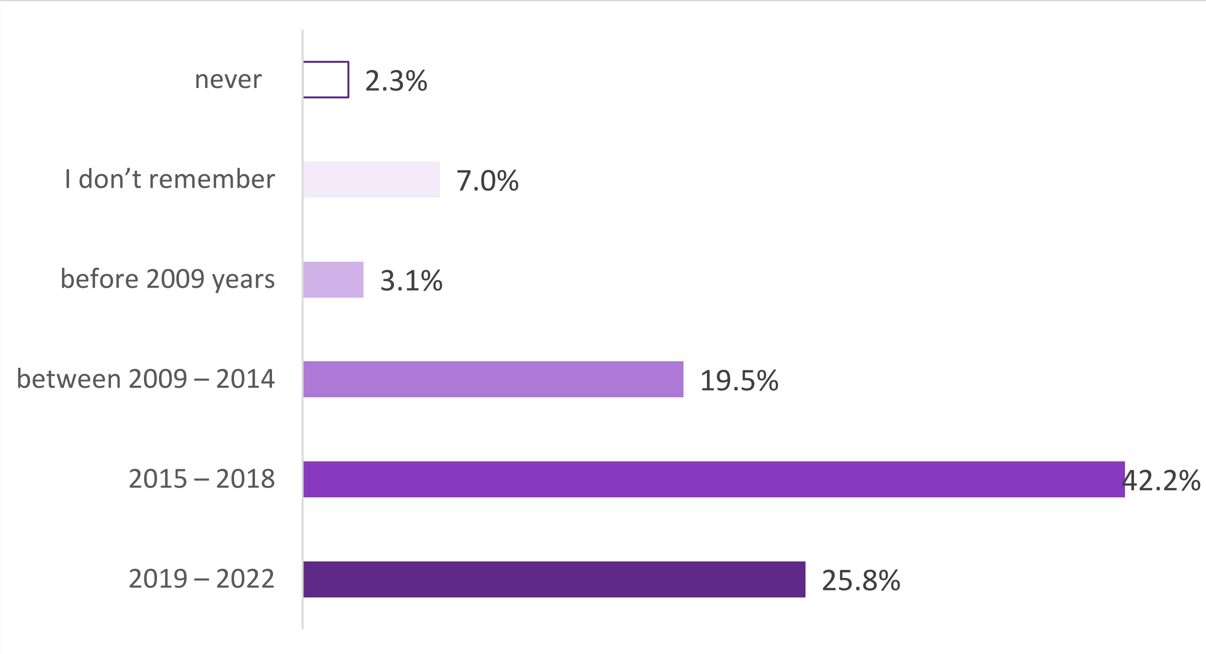
The years 2015 – 2018 were a real "big bang" in the world of cryptocurrencies. Every now and then new coins and new exchange platforms appeared, but there were also a lot of scandals related to various frauds and illegalities. This was the most turbulent but also dynamic period of this young market. At that time, Blockchain was first heard of by the largest group of respondents, 42.2%. It was then that the world understood the huge potential behind this solution, and new concepts and projects assuming its application in a space other than cryptocurrency services, e.g., for monitoring goods in supply chains, tentatively began to emerge.

Blockchain technology has been significantly improved over the past 3 years. Version 4.0 has appeared, significantly increasing the spectrum of potential implementations and benefits. Real services based on this solution have become widespread, which realistically increased their quality and security for users. Also, the interest of the whole world has increased, which in turn has made the number of new projects and ideas never before so significant.

Blockchain caused a revolution in the creative and artistic sector by transferring and securing works of art to the virtual space (NFT). With so much publicity, information about the phenomenon reached the rest of the lecturers and academics teaching economic subjects in management, who accounted for 25.8% of the total.

Only 2.3% stated that Blockchain was unfamiliar to them, which given that it is only just beginning to be directly tied to their profession, can be considered a very good predictor.

Figure 11. Knowledge of Blockchain technology – point in time*



* some results do not add up to 100% due to the rounding used.
Source: own elaboration based on surveys conducted.

Table 6 includes data distinguished by the time of acquiring the first information about Blockchain and the country in which the people who took part in the survey work. The indications that exceeded 10 people are highlighted in color. The most proportional distribution was observed for Polish people. In Germany, the dominant record fell on the most dynamic development of cryptocurrency markets, and therefore between 2015 and 2018. The Dutch increased their interest in the sector slightly earlier, since 2009. The Portuguese, on the other hand, have done so mainly in recent years.

Table 6. Knowledge of Blockchain technology – point in time in relation to countries

TIME	COUNTRY						
	Denmark	Germany	Ireland	Netherlands	Poland	Portugal	other
2019 – 2022	3	3	2	3	5	16	1
2015 – 2018	4	12	5	14	9	10	
between 2009 – 2014	1	2		13	2	6	1
before 2009 years					3	1	
I don't remember			1	2	4	2	
never				1	2		

Source: own elaboration based on surveys conducted.

The survey had too small sample to draw clear conclusions about correlation in the context of the academics' and lecturers' experience. From Table 7, it is only clear that regardless of seniority in the profession, the information about Blockchain with the most publicity reached these people between 2015 and 2018. This is a logical conclusion, as this is when the capitalization of the cryptocurrency market increased so significantly, which effectively drew the attention of economists.

Table 7. Knowledge of Blockchain technology – point in time in relation to experience

TIME	EXPERIENCE				
	less than 5 years	5 to 10 years	11 to 15 years	16 to 20 years	more than 20 years
2019 – 2022	8	6	2	2	15
2015 – 2018	13	11	10	7	13
between 2009 – 2014	4	7	6		8
before 2009 years			2	1	1
I don't remember	3		1	2	3
never			1	1	1

Source: own elaboration based on surveys conducted.

Financial and cryptocurrency services (currency function, e.g., cryptocurrencies, decentralized finance (DeFi) – 77% and transactions and banking, e.g., payments and micropayments or buying and selling stocks, digital securities – almost 75%) are the most widespread and well-studied, which is consistent with the respondents' profession, the popularity of such solutions and the Blockchain's history related to cryptocurrencies. This was followed by NFT [167](46%) and cyber security (safety and security of electronic information exchange – 38.1%), which are taking the market by storm and gaining popularity.

Non-economic implementations are less well known. They make up the majority in the group of Blockchain applications marked with the lightest color in Table 8 (because items with similar results were assigned color codes). This group includes items ranging from 31% to 23.8%, thus about a third of all respondents have knowledge of them. Applications in physical security, such as biometrics, remain relatively least known.

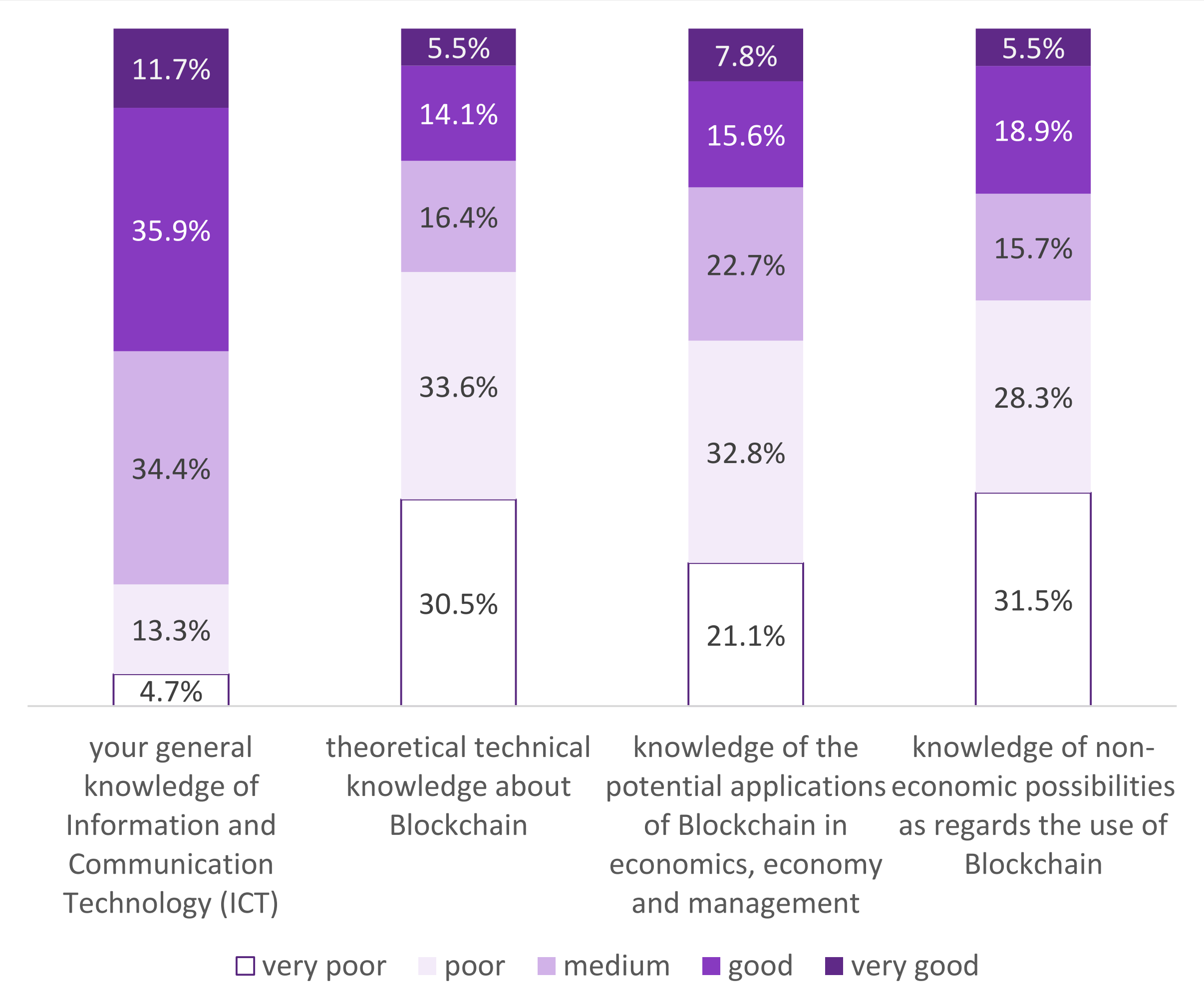
Table 8. Knowledge of Blockchain technology application area

AREAS	%
currency function, e.g., cryptocurrencies, decentralized finance (DeFi)	77,0%
transactions and banking, e.g., payments and micropayments or buying and selling stocks, digital securities	74,6%
NFT (non-fungible token)	46,0%
increase in the safety and security of electronic information exchange	38,1%
creation of secure and trustworthy documentation	31,0%
authentication and smart contracts, e.g. conclusion of a contract only after the parties meet certain requirements, elimination of the need for an intermediary authentication institution such as a notary	29,4%
new funding opportunities for startups and charity fundraising, new financial models	27,8%
public records and registries, e.g., land records, lists of prosecuted offenders, or civil registry records	27,8%
tokenization of assets	27,8%
private records and registers, e.g., medical records, electronic gradebooks, or work experience records	26,2%
protection of intellectual property, e.g., patents or trademarks	26,2%
personal and entity identification, e.g., confirmation of identity at an election, verification of a driver's license or authentication of a company against a debtor register	25,4%
authentication of goods and services, e.g., confirmation of car mileage, origin and shelf-life of foodstuffs or elimination of counterfeit medicines from circulation	23,8%
physical security, e.g., access to an apartment or hotel room	13,5%
other	7,1%

Source: own elaboration based on surveys conducted.

The global predilection for Blockchain is growing. Not only are new projects and interested economic sectors emerging, but also the level of publicly available knowledge on the subject is growing – the number of academic publications and papers increases, as well as the search index on the popular Google browser [168]. Unfortunately, based on Figure 12, it can be presumed that there is a relatively low level of knowledge of the Blockchain-related environment, both in the technical context and in the context of economic and non-economic projects. In all of these cases, knowledge at the average level or higher can be boasted by less than half of the respondents: respectively: 36%, 46,1% i 40,1%. The exception is the knowledge base on ICT, which can be described as high.

Figure 12. Identification of the level of knowledge covering selected Blockchain issues*.



* some results do not add up to 100% due to rounding used.
Source: own elaboration based on surveys conducted.

The next table, 9, shows that lecturers and academics are mostly unfamiliar with Blockchain-related terms. Relatively the most recognized were peer-to-peer – 63.3%, crowdfunding – 62.5% and tokenization – 58.6%. More than half encountered NFT – 50.8%. However, these should not be assessed harshly, as it turns out that even among those actively investing in cryptocurrencies, as many as 33.5% either have no knowledge of them (or the markets, projects or technologies behind them), or that knowledge is residual and comes from interactions with acquaintances [169].

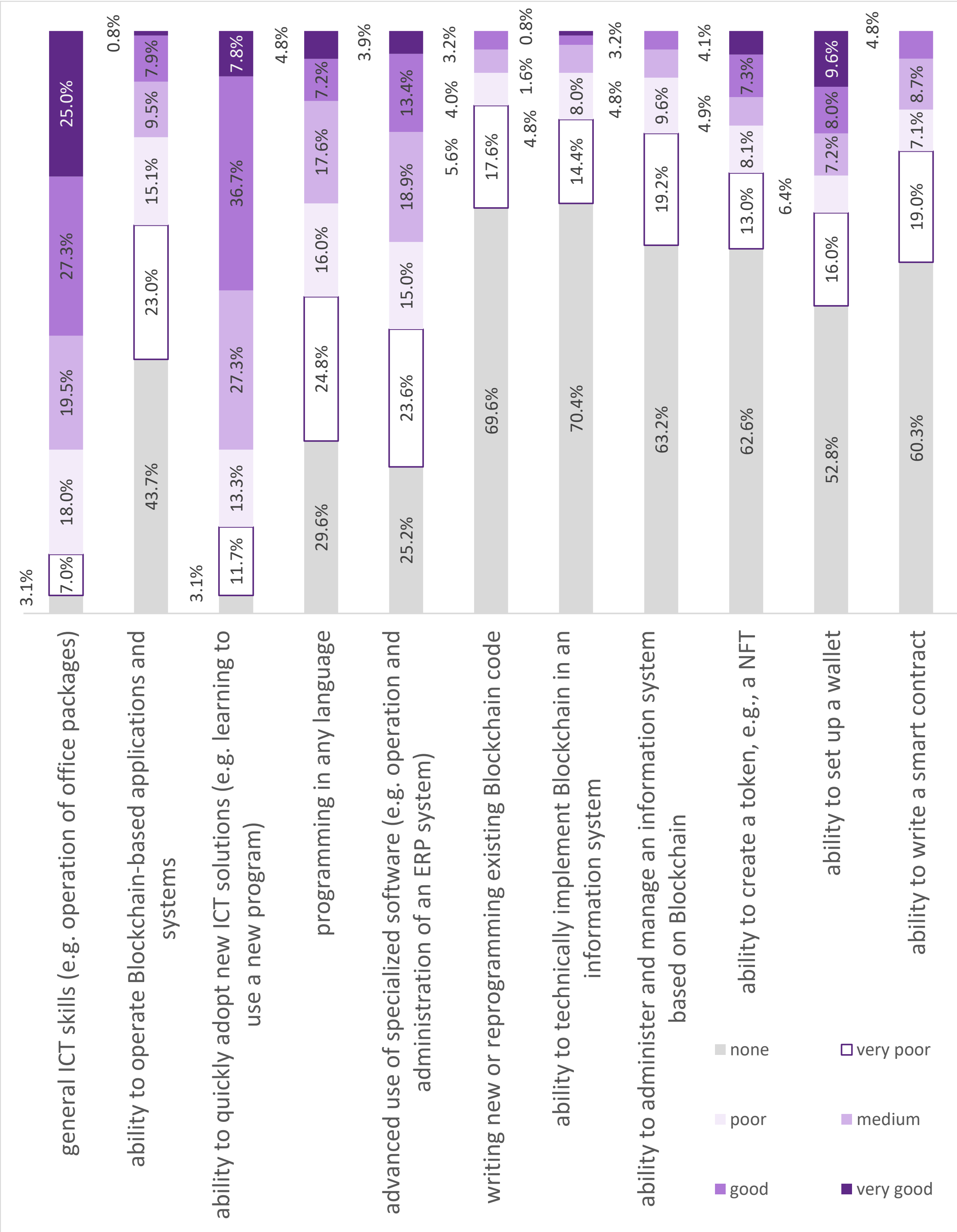
Table 9. Knowledge of selected terms related to Blockchain

TERMS	%
peer-to-peer (P2P)	63,3%
crowdfunding	62,5%
tokenization	58,6%
NFT	50,8%
distributed networks	44,5%
Satoshi Nakamoto	38,3%
DAO	18,8%
hashing	17,2%
hyperledger	14,8%
GPU	11,7%
halving	10,9%
EEA	3,1%

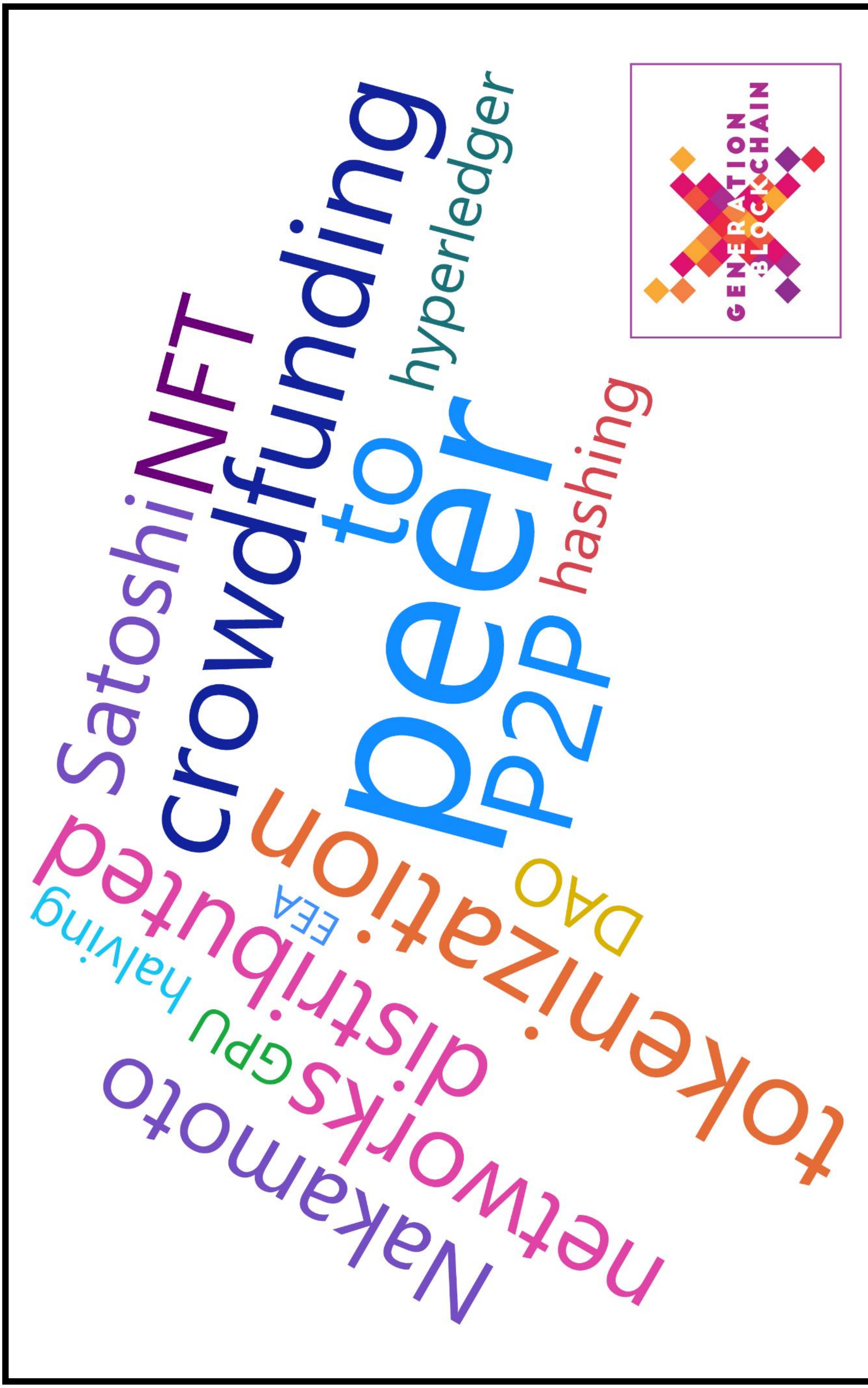
Source: own elaboration based on surveys conducted.

Respondents are confident that they have a high level of skills and are quick to learn new things in the broader field of ICT (Figure 12). Unfortunately, as their IT skills increase, their self-assessment in this regard decreases significantly. The vast majority of them rated their competence in operating Blockchain-based applications (81.8%), programming in any language (70.4%) and advanced operation of specialized software (63.8%) as poor, very poor or even none. Other aspects received even weaker results. The lack of any skills in more than 50% of cases was declared in: the ability to create or edit Blockchain source code (69.6%), implementation of Blockchain technology (70.4%), management and administration of a Blockchain-based IT system (63.2%), creation of a token, e.g. NFT (62.6%), configuration of a wallet (52.8%) and creation of a smart contract (60.3%). It should be borne in mind that the aim of this study is to create an effective teaching model related to the early emergence of advanced information technology in a very specific audience, the sphere of interest of which, most likely, is the effects of its implementations rather than its technical secrets. The study conducted in the first phase consisted of collecting information that will enable better management of the resources at hand and more effective planning of the task. It is important to emphasize that the low-skill assessment that follows from Figure 13 is not any attempt at criticism, but only an assessment of the state of affairs in scientific consideration.

Figure 13. Identification of skill level of selected areas regarding Blockchain*



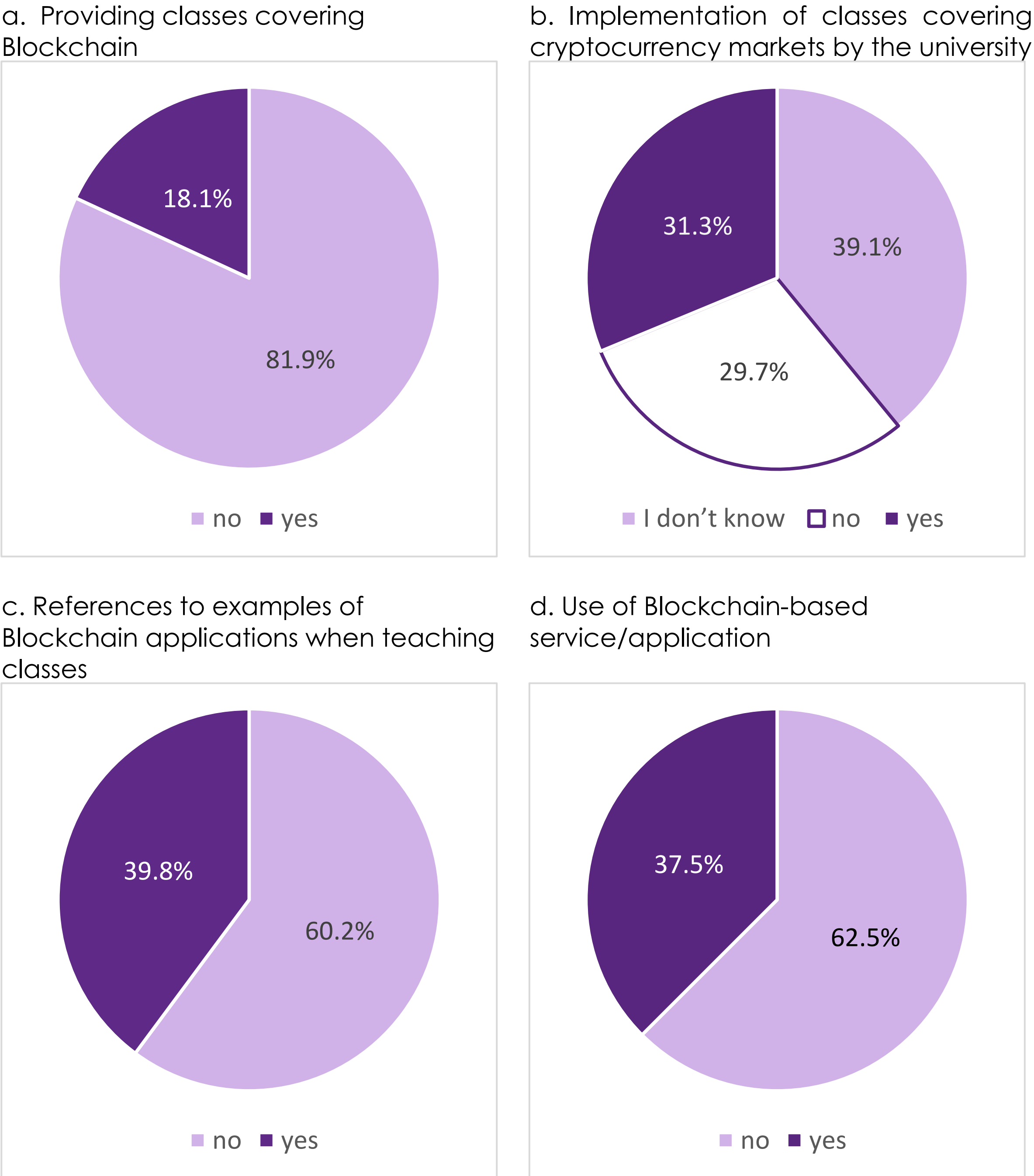
* some results do not add up to 100% due to rounding used.
Source: own elaboration based on surveys conducted.



Word Map. Knowledge of concepts associated with Blockchain

Due to the common content overtones, the next figure presents four charts collectively on the experience of teaching classes on Blockchain, implementing classes on cryptocurrency markets in the workplace (at the university), using examples related to, e.g., Blockchain implementation when teaching other classes, and using Blockchain-based services/apps (Figure 14).

Figure 14. Selected aspects of education, Blockchain and cryptocurrencies



* some results do not add up to 100% due to rounding used.
Source: own elaboration based on surveys conducted.

The study by CoinDesk [170] conducted in 2018 argued that 42% of the universities surveyed provide Blockchain classes. In 2019, that number was expected to increase up to 56%. The same entity conducted a renewed study in 2021, which should be considered more reliable, ad the research sample increased from 50 to 230 schools. They verified the previous results by determining the number of universities conducting educational activities in this area at 37% [156]. This value, is more than double the result obtained in the author's study – 18% (Figure 14). It is hard to assess the reason for such a discrepancy, but it is possible to presume that it is due to the different scales of measurement: 230 in the world and 128 in Europe, whereby not facilities but employees were surveyed, which despite the similarities, may change the final context. This makes a real case for treating and considering the two audits independently. It is also impossible to determine whether the results are consistent or divergent, because a given person may work at several schools or several of the teachers may work at the same location. An attempt was made to find reliable comparative data in the literature so that there would be an opportunity to verify or determine changes in this phenomenon over time and, as a result, determine a developmental trend, but it failed. However, given the nature of the environment, rather dynamic growth should be assumed. According to Figure 14b, there is a real chance that 30% of respondents may have had practical experience in teaching topics consistent with Blockchain. This figure may even be higher, as in the same group, as many as 31.3% did not know whether their university had classes covering cryptocurrency markets. Unfortunately, this ignorance may suggest a lack of interest in such topics. More than a third of teachers use examples involving Blockchain when teaching other classes. A similar number (37.5%) admitted that they have used a Blockchain-based service or application at least once.

The clear leader in education about Blockchain, and related topics, remains teachers and educational entities located in Germany (Table 10). The results prove that they are eager to embrace technological innovations and use them in teaching. Against this background, the Dutch also stand out positively. Their experience in this matter can be very helpful in developing specific didactic content. However, the question remains on how and to what extent these classes are conducted – were they formally approved by the administration? Are they taught as part of a degree program, and if so, which courses? Are they online courses? Are they conducted in terms of more technical or economic effects and management capabilities? All of these questions are extremely important, and in order to find out specific answers, it would make sense to conduct additional in-depth research investigations (e.g., in the form of interviews) that would focus on respondents who have had actual contact with Blockchain in the didactic sphere.

Table 10. Selected aspects of education, Blockchain and cryptocurrency markets in relation to the nationality criterion of respondents

ISSUE	RESPONSE	COUNTRY						
		Denmark	Germany	Ireland	Netherlands	other	Poland	Portugal
DEDICATED SUBJECT/COURSE RELATED TO BLOCKCHAIN	no	6	5	7	29	1	22	34
	yes	2	12	1	3	1	3	1
LECTURES ON CRYPTOCURRENCY MARKETS AT UNIVERSITY	I don't know	1		2	14		12	21
	no	4	4	4	7		9	10
	yes	3	13	2	12	2	4	4
BLOCKCHAIN-RELATED TOPICS OR CITED EXAMPLES OF ITS IMPLEMENTATIONS, BUSINESS MODELS, PROJECTS, ETC. WHILE CONDUCTING LECTURES	no	5	3	4	17	1	20	27
	yes	3	14	4	16	1	5	8
BLOCKCHAIN-BASED TECHNOLOGY OR SERVICE IN PRACTICE	no	6	3	2	24		15	30
	yes	2	14	6	9	2	10	5

Source: own elaboration based on surveys conducted.

The absorption level of technological innovations is varied in different age groups (this is evidenced by many publications and statistical compilations such as [171]). With age, the level of technocratic skills and interests decreases. This trend is slowly changing over time. However, it is a very slow process. Less experience in the profession does not necessarily coincide with the teacher's age, but most often it does. Based on this finding, it can be concluded that the data in Table 11 seems to confirm the inverse relationship between professional experience and the implementation of classes based on and regarding new technologies.

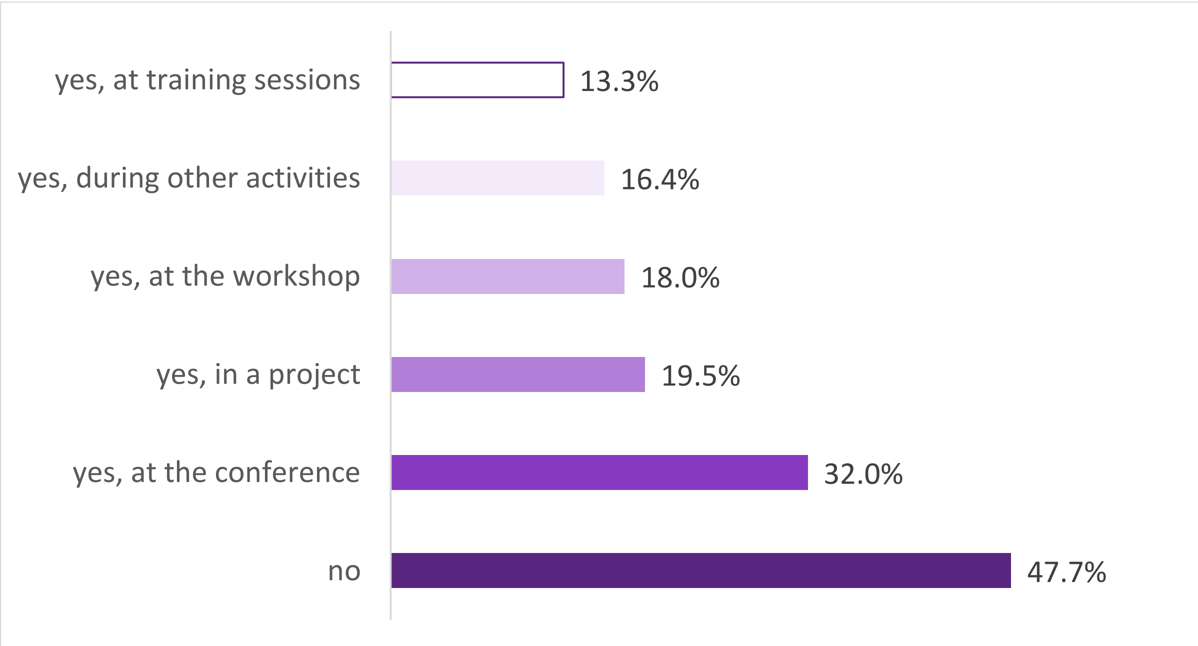
Table 11. Selected aspects of education, Blockchain and cryptocurrency markets in relation to the criterion of respondents' experience*

ISSUE	RESPONSE	COUNTRY				
		less than 5 years	5 to 10 years	11 to 15 years	16 to 20 years	more than 20 years
DEDICATED SUBJECT/COURSE RELATED TO BLOCKCHAIN	no	17	18	21	11	37
	yes	**11**	**6**	1	2	3
BLOCKCHAIN-RELATED TOPICS OR CITED EXAMPLES OF ITS IMPLEMENTATIONS, BUSINESS MODELS, PROJECTS, ETC. WHILE CONDUCTING LECTURES	no	13	11	16	9	28
	yes	15	13	6	4	13
BLOCKCHAIN-BASED TECHNOLOGY OR SERVICE IN PRACTICE	no	11	13	13	9	34
	yes	**17**	11	9	4	7

* in the table, the summary of the implementation of classes related to cryptocurrencies in relation to age was omitted, as there is no clear and logical relationship (or very little) between the employee's experience and the educational strategy of the institution.
Source: own elaboration based on surveys conducted.

Researchers, educators and lecturers are potentially very likely to interact with current and future solutions that generate excitement in the techno-scientific-business world. This is because the nature of their work encourages them to frequently exchange ideas with other researchers and (in the case of academics) to make public and share their research results, which should address important and timely topics and issues. They should also self-improve their skills (mainly teaching staff and lecturers), take part in specialized courses and development programs. It is also often the policy of universities to strongly stimulate cooperation with the broader business, which due to the economic criterion, often becomes a herald of new solutions before the scientific institution. So how do these interactions present in relation to Blockchain technology? A clue is provided by the data visualized in Figure 15. It turns out that almost half of the respondents had no exposure to Blockchain topics. Of those who were in the opposite situation, the largest group encountered Blockchain at academic conferences (32%). Slightly fewer, 19.5%, participated in projects directly or indirectly relating to the technology. Still others encountered it at workshops: 18%, trainings: 13.3% or in other activities: 16,4%.

Figure 15. Contact with Blockchain during various teaching and research activities*

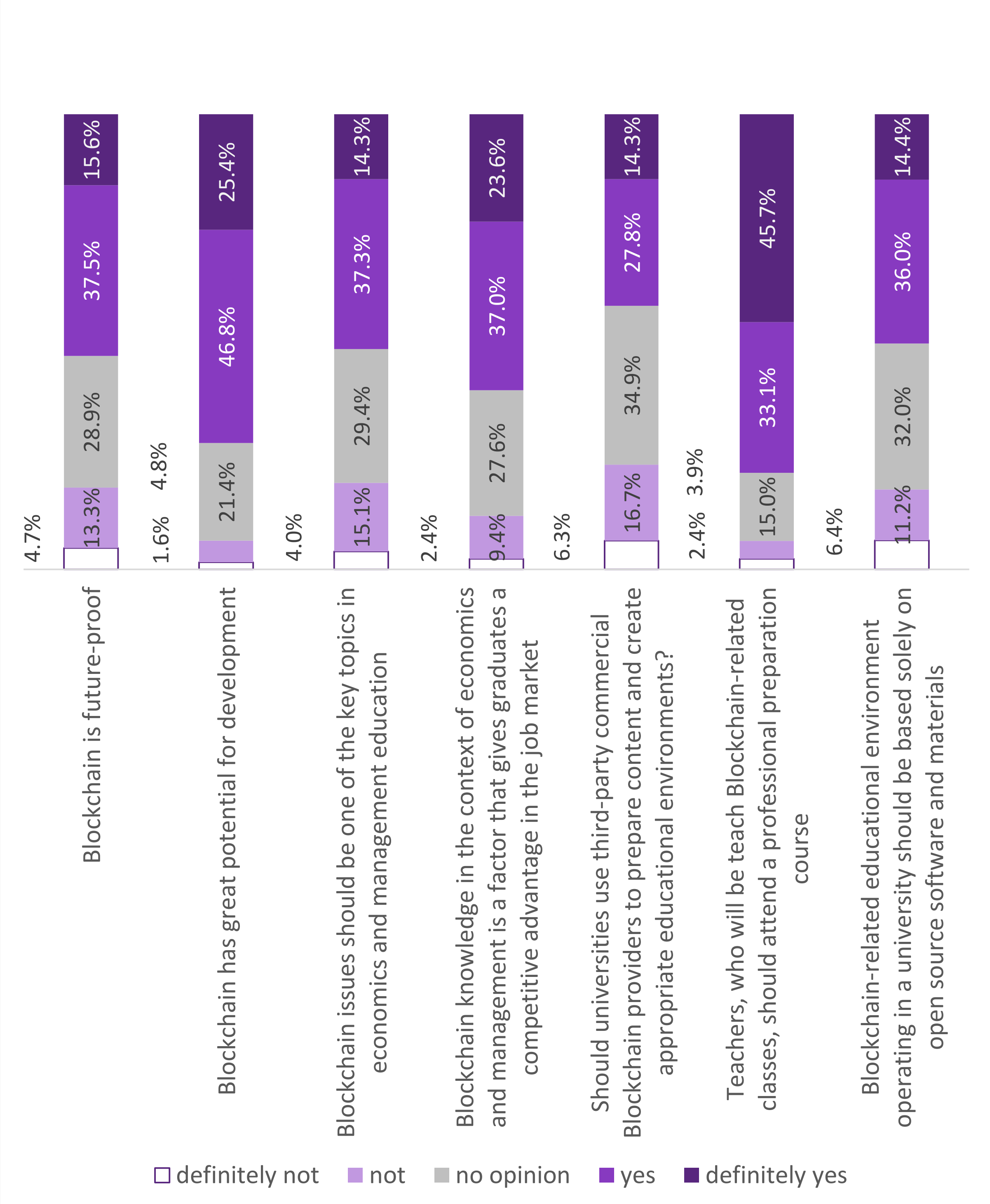


* possibility to provide more than one answer.
Source: own elaboration based on surveys conducted.

Respondents appreciate the role that Blockchain technology plays and will play in the near future for the economy and social services, and that it will give graduates a competitive advantage in the job market (Figure 16). They are also convinced of its development trend. Slightly more than half (51.6%) took the position that it should be a subject of education in fields related to economics and management. When designing the survey, the author expected a higher result, but it should be noted in the almost 30% proportion of people who had no opinion on this issue, which significantly affects the quick visual interpretation (that's why "no opinion" responses were marked in gray). Eliminating the data that do not change the situation (neutral answers), the result obtained should be directly juxtaposed with the opposite opinion, so that it takes on a whole new tone. Support for Blockchain education was given by 51.6% and the opposite opinion was only 19.1%. This proves that more than two and a half times as many teachers who filled out the questionnaire agree with the need to introduce this subject into the curriculum of economics and management studies.

Teachers do not feel comfortable facing the challenge of educating towards Blockchain. This is certainly influenced by the previously identified lack of sufficient knowledge and competence especially in specialized computer science. Probably this is the main reason for the declaration of the need to complete a specialized preparatory course to work effectively with students.

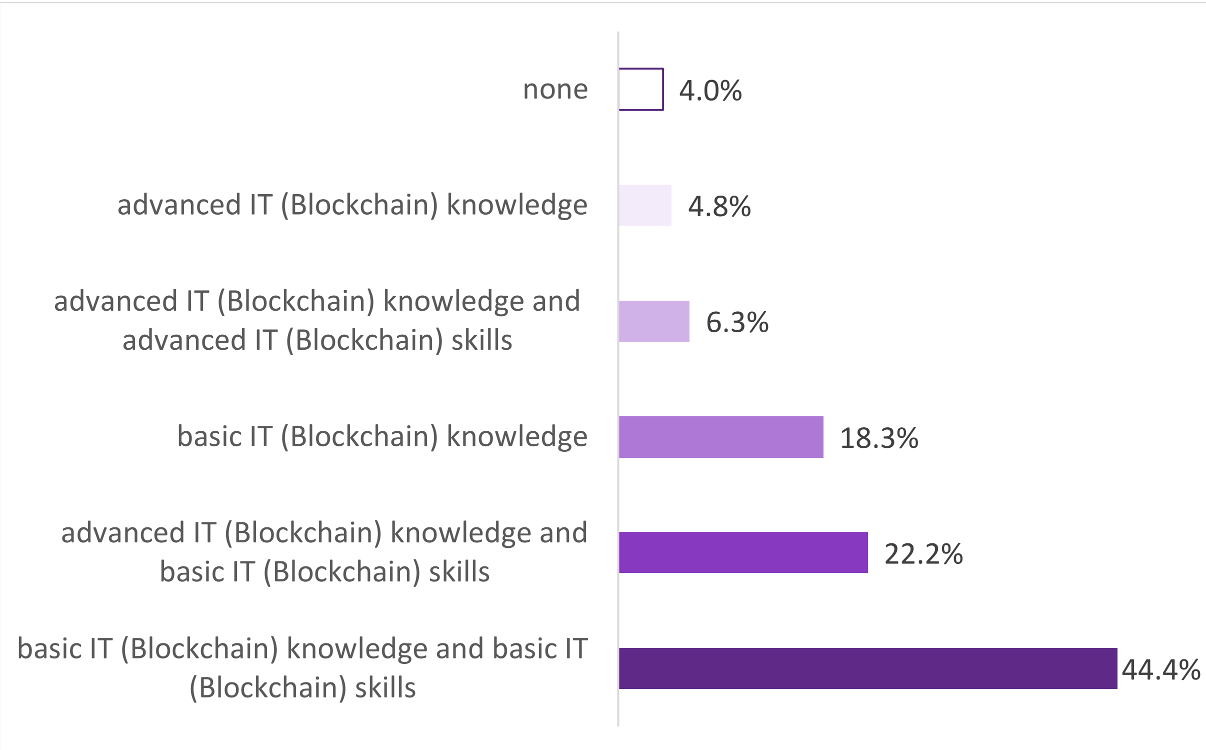
Figure 16. Opinion on selected aspects of Blockchain and Blockchain-related education*



* some results do not add up to 100% due to rounding used.
Source: own elaboration based on surveys conducted.

It seems to be extremely difficult to effectively teach advanced technical subjects to majors belonging to the humanities. However, such a hermetic identification and classification in the age of the digital revolution does not seem to stand the test of time. Ubiquitous convergence forces merging and interdisciplinarity, further determined by the expectations of labor market. Leading the consideration of an effective model that can facilitate the planning and strategy of teaching Blockchain, it is necessary to ask about the balance between practical IT skills and knowledge of the technology and the ways and effects of its use. There appears to be no logical justification for educating economists and executives in the direction of advanced programming and cryptography. Respondents expressed a similar opinion, as evidenced in Figure 17. Averaging the results but at the same time taking into account the percentages, it can be concluded that such teaching should be done in accordance with the idea: basic/advanced theoretical knowledge and only basic IT skills.

Figure 17. Level of IT knowledge and skills in the Blockchain teaching model for economics and management majors



Source: own elaboration based on surveys conducted.

The conclusions of Figure 17 are confirmed by Table 12. It shows that the most preferred technique for teaching Blockchain-related topics are exercises (68.8%), case studies (68%) and lectures (60.9%). Less popular were techniques with a higher technical index like projects and experiments (43%) and laboratories (40.6%).

Table 12. Preferred Blockchain teaching techniques

TEACHING METHOD	%
exercises	68,8%
case studies	68,0%
lectures	60,9%
design experiments	43,0%
laboratories	40,6%
other	4,7%

Source: own elaboration based on surveys conducted.

Respondents expressed the opinion that teaching Blockchain should take place in bachelor's (68.8%) or master's (65.6%) studies. 35.9% reserve this field of knowledge for doctoral studies (Table 13).

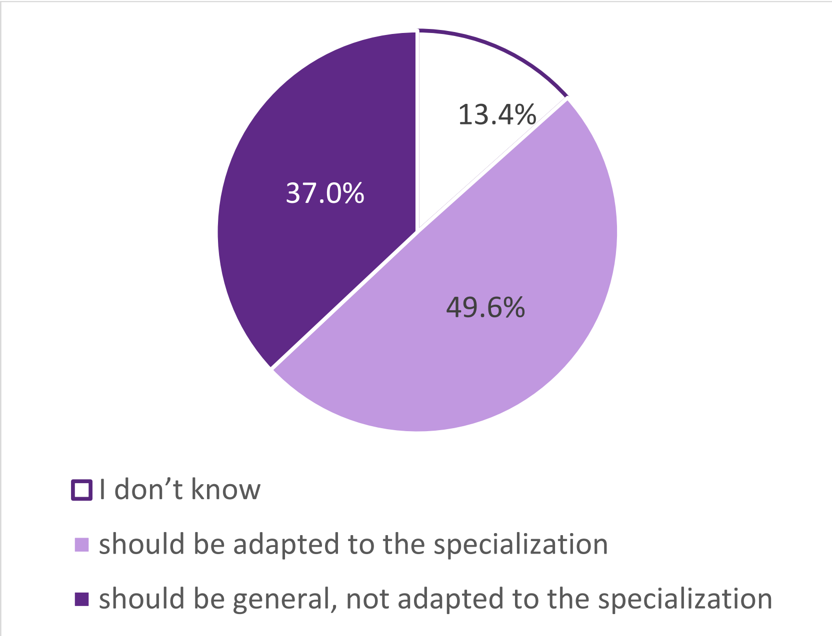
Table 13. At what educational level should Blockchain classes be taught

EDUCATIONAL LEVEL	%
bachelor degree studies	68,8%
master degree studies	65,6%
doctoral studies	35,9%
I don't know	13,3%
should not be conducted	0,8%

Source: own elaboration based on surveys conducted.

When asked about the issue of adapting the substantive content covering Blockchain to a specific study specialization, respondents disagreed. Although the largest group, 49.6%, stated that the content should be adapted to the chosen profile, slightly fewer, 37%, persisted in the belief that the content should be universal and the same for all students studying economics or management (Figure 18).

Figure 18. Adaptation of educational content to specialization



Source: own elaboration based on surveys conducted.

The survey, the results of which were published in an academic paper entitled: "Why should Business schools teach blockchain technology?" showed that university students are optimistic about learning of Blockchain and cryptocurrency markets. Therefore, it makes perfect sense to include this topic in the curriculum, and this demand should be implemented in all business schools [172]. There is no shortage of arguments in the literature supporting such an idea (e.g., [173, 174, 175, 176]). This coincides with the opinions of respondents, who overwhelmingly supported such a position (Figure 19). All aspects of knowledge related to Blockchain were considered important, but the following were identified as the most important and of greatest value to economics and management students: cryptocurrency markets, Blockchain-based economic projects, Blockchain-based business models, and case studies of innovative Blockchain-related projects and startups.

Figure 19. Evaluation of the importance of conveying knowledge on selected aspects of Blockchain to students*

* some results do not add up to 100% due to rounding used.
Source: own elaboration based on surveys conducted.

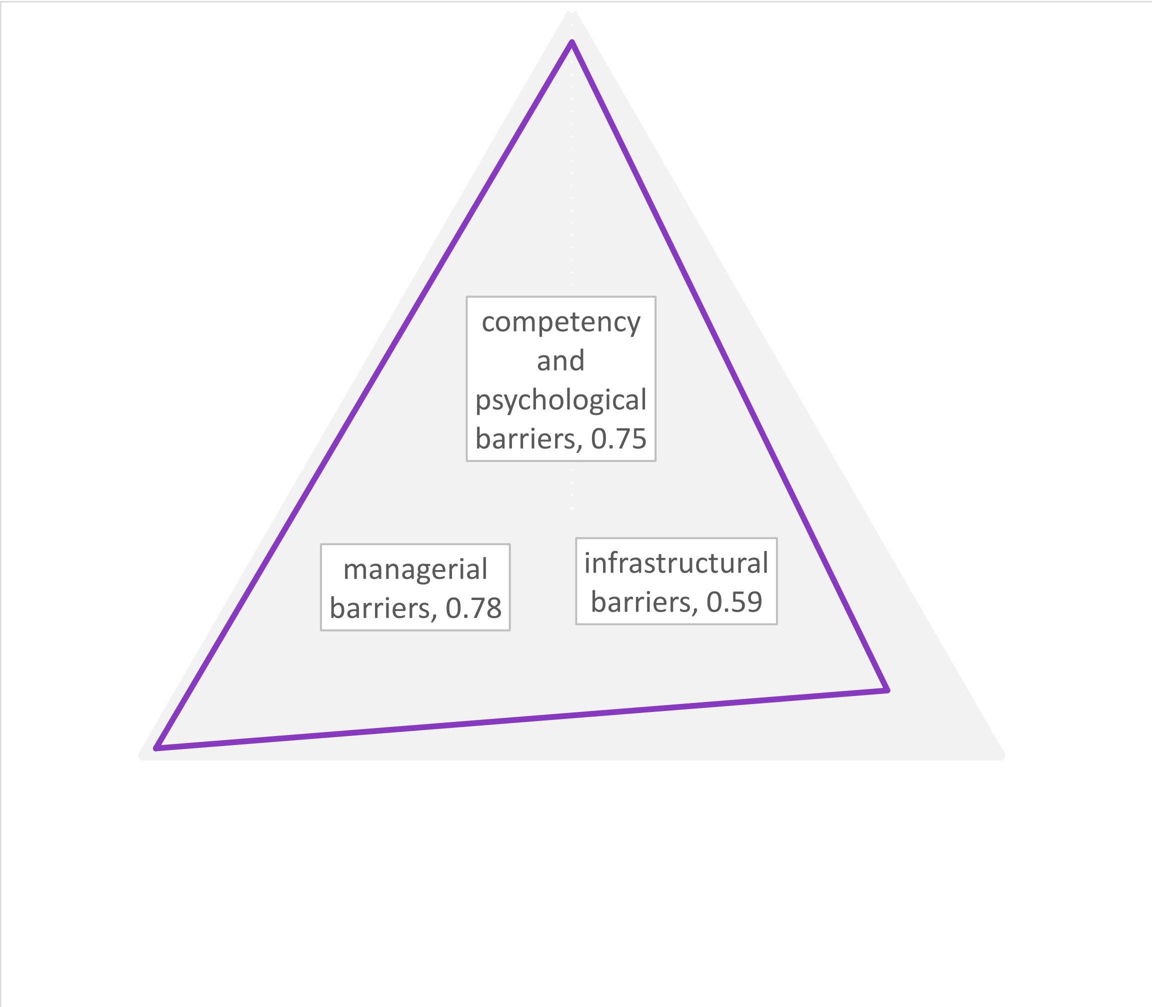
There are three main types of barriers in teaching Blockchain-related topics. These barriers include:

- psychological and related to under-competence,

- organizational/management,
- infrastructure.

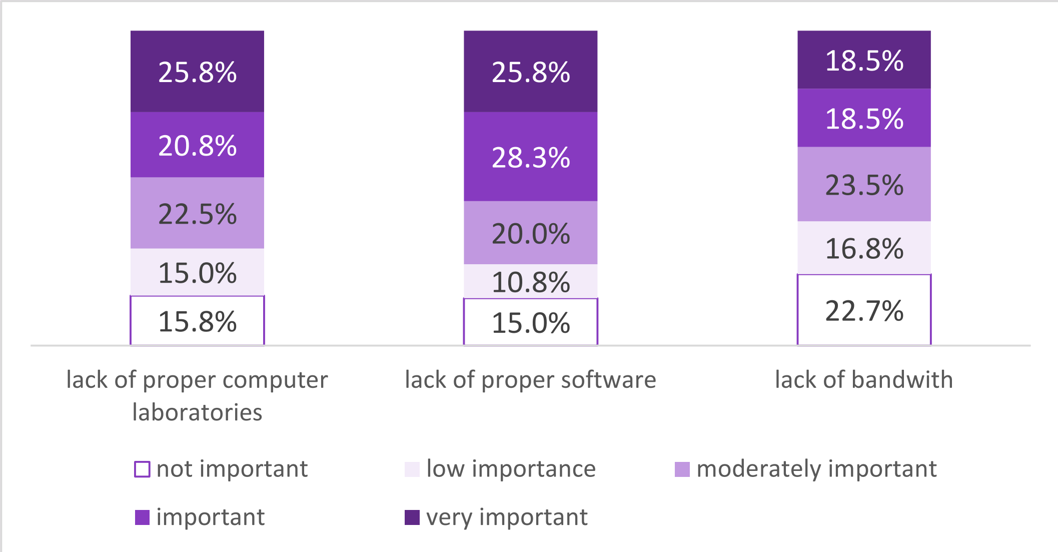
According to the respondents' opinions, all of them are real and significant obstacles (Figure 20). The easiest to overcome are those arising from the level of infrastructure in place. Their relevance was rated at 59 points on a 100-point scale. Barriers in skills and concerns about conducting such difficult classes ranked second (75 points out of 100). However, organizational and management issues were considered the most critical, which were assigned 78 points out of 100. Teachers aptly hierarchized these barriers rightly believing that top-down regulatory, managerial or systemic factors may be insurmountable adversaries. Similar conclusions were drawn from a study the results of which were presented in a paper entitled "Organization's Barriers to the Education Blockchain." [177]

Figure 20. Barriers to teaching topics involving Blockchain



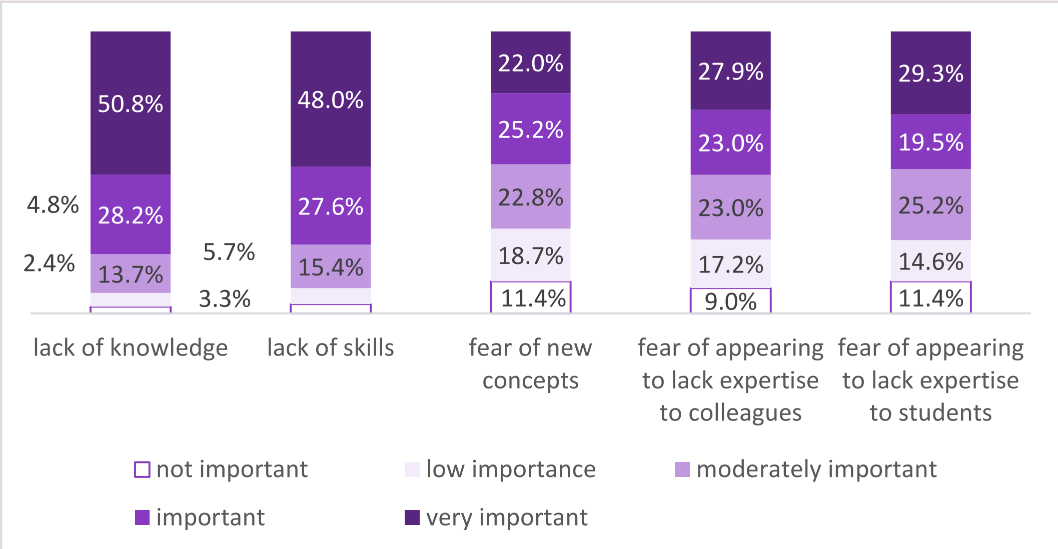
Source: own elaboration based on surveys conducted.

The biggest infrastructure barrier is the lack of software



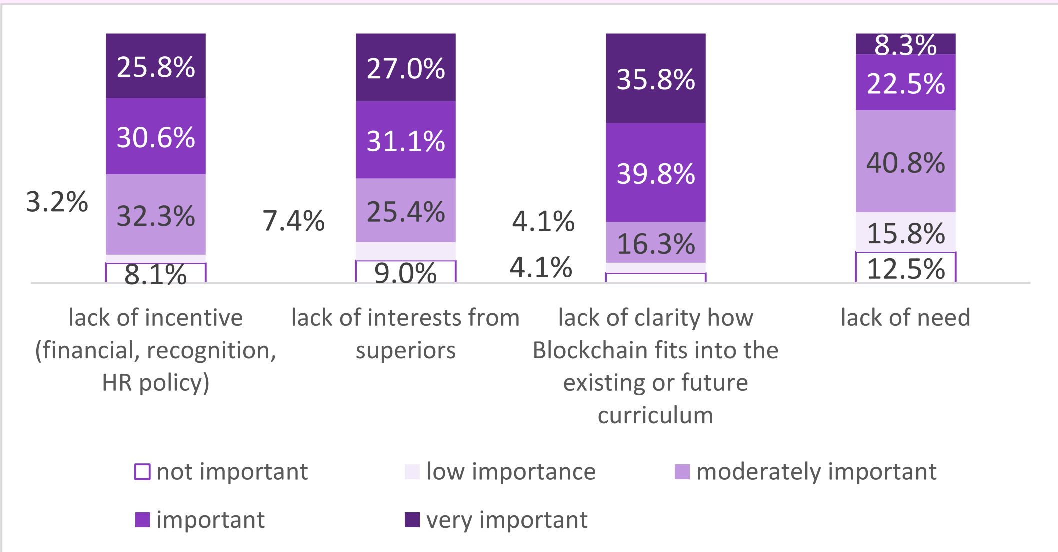
INFRASTRUCTURE BARRIERS

The biggest psychological barrier is the lack of knowledge



PSYCHOLOGICAL AND COMPETENCE BARRIERS

The biggest organizational barrier is uncertainty about the curriculum



ORGANIZATIONAL AND MANAGEMENT BARRIERS

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X. IDENTIFICATION OF HIDDEN RELATIONSHIPS BETWEEN THE STUDIED PHENOMENA

The results of this survey were subjected to statistical analysis in order to identify mathematically significant relationships between the phenomena studied. The analysis was carried out in the context of declarations placed in the demographics, which ultimately resulted in more than 100 possible combinations. Unfortunately, comparisons against the option indicating the field of instruction had to be abandoned, because more than one answer was possible in this question.

In order to optimize the results obtained, the λ^2 statistic (chi-square) and three coefficients V-Cramer, T_{xy} Czuprow and C-Pearson correlation coefficient were used. As each of these tools has its own specification, interpretation thresholds were redefined, the values of which are listed in Table 14.

Table 14. Interpretive thresholds for V – Cramer, T_{xy} Czuprow and C-Pearson correlation coefficient coefficients.

V-CRAMER	T_{xy} CZUPROV	C-PEARSON
<0;0,25> lack of correlation	<0;0,25> lack of correlation	<0;0,35> lack of correlation
(0,25;0,35> weak correlation	(0,25;0,35> weak correlation	(0,35;0,45> weak correlation
(0,35;0,45> moderate correlation	(0,35;0,45> moderate correlation	(0,45;0,55> moderate correlation
(0,45;0,55> strong correlation	(0,45;0,55> strong correlation	(0,55;0,65> strong correlation
(0,55;1> very strong correlation	(0,55;1> very strong correlation	(0,65;1> very strong correlation

Source: own elaboration.

It was assumed that the correlation would be real if at least two of the three coefficients used proved its existence. The results obtained are shown in Table 15.

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Table 15. Results of statistical analysis for detection of statistically significant correlations

#	DEPENDENT VARIABLE	INDEPENDENT VARIABLE	RESULTS
1	theoretical technical knowledge about Blockchain	country	**chi-square test** **0,005122985<=0,05** **chi-square** 57,21218159 **V – Cramer** 0,334279138 **weak correlation** **T_{xy} Chuprov** 0,302055299 **weak correlation** **C-Pearson correlation coefficient** 0,555788403 **strong correlation**
2	theoretical technical knowledge about Blockchain	experience	**chi-square test** **0,005142<=0,05** **chi-square** 36,09106 **V – Cramer** 0,2655 **weak correlation** **T_{xy} Chuprov** 0,2655 **weak correlation** **C-Pearson correlation coefficient** 0,468983 **moderate correlation**
3	knowledge of the potential applications of Blockchain in economics, economy and management	country	**chi-square test** **0,000161096<=0,05** **chi-square** 69,14179665 **V – Cramer** 0,367481389 **moderate correlation** **T_{xy} Chuprov** 0,33205692 **weak correlation** **C-Pearson correlation coefficient** 0,592217143 **strong correlation**

4	knowledge of the potential applications of Blockchain in economics, economy and management	experience	**chi-square test** **0,00841<=0,05** **chi-square** 37,34017 **V – Cramer** 0,270056 **weak correlation** **T_{xy} Chuprov** 0,270056 **weak correlation** **C-Pearson correlation coefficient** 0,475225 **moderate correlation**
5	knowledge of non-economic possibilities as regards the use of Blockchain	country	**chi-square test** **0,00003302<=0,05** **chi-square** 77,06788892 **V – Cramer** 0,38949768 **moderate correlation** **T_{xy} Chuprov** 0,351950884 **moderate correlation** **C-Pearson correlation coefficient** 0,614538924 **strong correlation**
6	knowledge of non-economic possibilities as regards the use of Blockchain	experience	**chi-square test** **0,04843<=0,05** **chi-square** 28,34661 **V – Cramer** 0,236221 **lack of correlation** **T_{xy} Chuprov** 0,236221 **lack of correlation** **C-Pearson correlation coefficient** 0,427169 **weak correlation**
7	writing new or reprogramming existing Blockchain code	country	**chi-square test** **0,014074909<=0,05** **chi-square** 50,11819448 **V – Cramer**

			0,316601309 weak correlation **T_{xy} Chuprov** 0,286081577 weak correlation **C-Pearson correlation coefficient** 0,534973258 moderate correlation
8	ability to create a token, e.g., a NFT	country	**chi-square test** **0,00000893<=0,05** **chi-square** 102,5557804 **V – Cramer** 0,447213595 moderate correlation **T_{xy} Chuprov** 0,390164007 moderate correlation **C-Pearson correlation coefficient** 0,674299894 very strong correlation
9	ability to set up a wallet	country	**chi-square test** **0,000492899<=0,05** **chi-square** 82,0038708 **V – Cramer** 0,362223955 moderate correlation **T_{xy} Chuprov** 0,346084267 weak correlation **C-Pearson correlation coefficient** 0,629401746 strong correlation
10	ability to set up a wallet	experience	**chi-square test** **0,043627769<=0,05** **chi-square** 38,3211855 **V – Cramer** 0,276843586 weak correlation **T_{xy} Chuprov** 0,261822498 weak correlation

			C-Pearson correlation coefficient 0,484393388 **moderate correlation**
11	ability to write a smart contract	country	**chi-square test** **0,002168845<=0,05** **chi-square** 57,37936375 **V – Cramer** 0,33741361 **weak correlation** **T_{xy} Chuprov** 0,304887614 **weak correlation** **C-Pearson correlation coefficient** 0,55937446 **strong correlation**
12	technical and IT knowledge related to Blockchain	country	**chi-square test** **0,038168843<=0,05** **chi-square** 46,07861986 **V – Cramer** 0,301174276 **weak correlation** **T_{xy} Chuprov** 0,272141679 **weak correlation** **C-Pearson correlation coefficient** 0,51597424 **moderate correlation**
13	lack of knowledge	country	**chi-square test** **0,025610741<=0,05** **chi-square** 45,09556599 **V – Cramer** 0,301526914 **weak correlation** **T_{xy} Chuprov** 0,272460324 **weak correlation** **C-Pearson correlation coefficient** 0,516417334 **moderate correlation**
14	lack of skills	country	**chi-square test**

			0,047070158<=0,05 **chi-square** 44,95760108 **V – Cramer** 0,302286682 **weak correlation** **T_{xy} Chuprov** 0,273146851 **weak correlation** **C-Pearson correlation coefficient** 0,517370585 **moderate correlation**
15	fear of new concepts	experience	**chi-square test** **0,027657<=0,05** **chi-square** 29,8498 **V – Cramer** 0,246313 **lack of correlation** **T_{xy} Chuprov** 0,246313 **lack of correlation** **C-Pearson correlation coefficient** 0,441915 **weak correlation**

Source: own elaboration based on surveys conducted.

In view of the criterion adopted, the correlations placed in items 6 and 15 of Table 15 must be rejected. In addition, the values obtained raise uncertainty about the correctness of the adopted interpretive correction in the context of C-Pearson correlation coefficient. A certain regularity can be observed, consisting in the fact that the values obtained from calculations using the V-Crammer and T_{xy} Czuprow coefficients are similar, and in most cases the result of interpretation is the same or similar correlation (items 3 and 9). Meanwhile, the use of the third coefficient causes the result to be an order or even two orders higher. Practical hints and tips related to these disparities have not been found in the literature. This is an important and interesting scientific problem in the field of statistics, the solution of which requires a separate study. Perhaps the introduction of correction coefficients with larger values would be sufficient.

The strongest relationships were found for items 5 and 8 and thus: the assessment of the level of knowledge about the possibility of non-economic use of Blockchain technology and the place (country) of the respondent's work, and the declaration of the ability to create a token and again the place (country) of the respondent's work. The first of these is presented in Table 16.

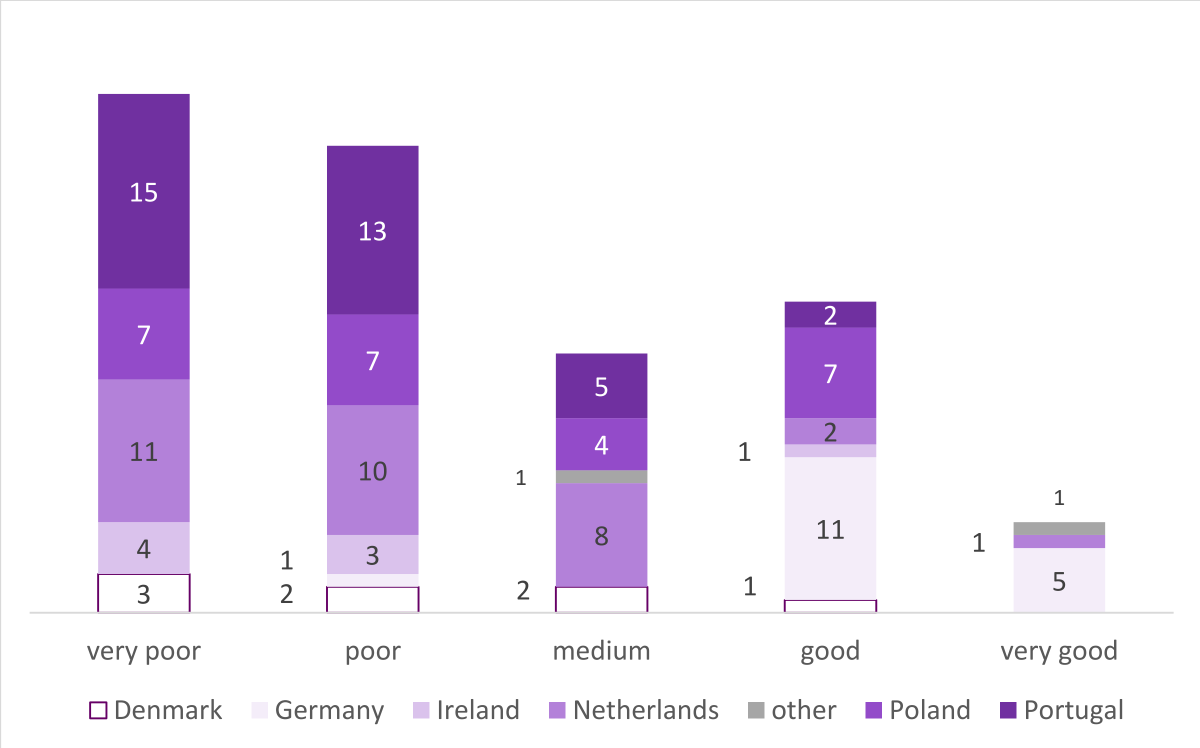
Table 16. Assessment of the level of knowledge on the possibility of non-economic use of Blockchain technology in relation to the location of the university

ASSESSMENT	COUNTRY							TOTAL
	Denmark	Germany	Ireland	Netherlands	other	Poland	Portugal	
very poor	3		4	11		7	15	40
poor	2	1	3	10		7	13	36
medium	2			8	1	4	5	20
good	1	11	1	2		7	2	24
very good		5		1	1			7
TOTAL	8	17	8	32	2	25	35	127
%								
very poor	2,4%	0,0%	3,1%	8,7%	0,0%	5,5%	11,8%	31,5%
poor	1,6%	0,8%	2,4%	7,9%	0,0%	5,5%	10,2%	28,3%
medium	1,6%	0,0%	0,0%	6,3%	0,8%	3,1%	3,9%	15,7%
good	0,8%	8,7%	0,8%	1,6%	0,0%	5,5%	1,6%	18,9%
very good	0,0%	3,9%	0,0%	0,8%	0,8%	0,0%	0,0%	5,5%
TOTAL	6%	13%	6%	25%	2%	20%	28%	100,0%

Source: own elaboration based on surveys conducted.

In the analytical procedure carried out, the quantitative disproportion in relation to the number of respondents coming from different countries is very expressive. However, in terms of content, once again, a clear leader with the greatest knowledge of the studied phenomena has clarified. This leader are teachers representing German teaching centers. The record indication of 31.5% appeared in the case of Portugal and referred to the answer "very low." A graphical representation of Table 16 is included in Figure 21.

Figure 21. Assessment of the level of knowledge on the possibility of non-economic use of Blockchain technology in relation to the location of the university

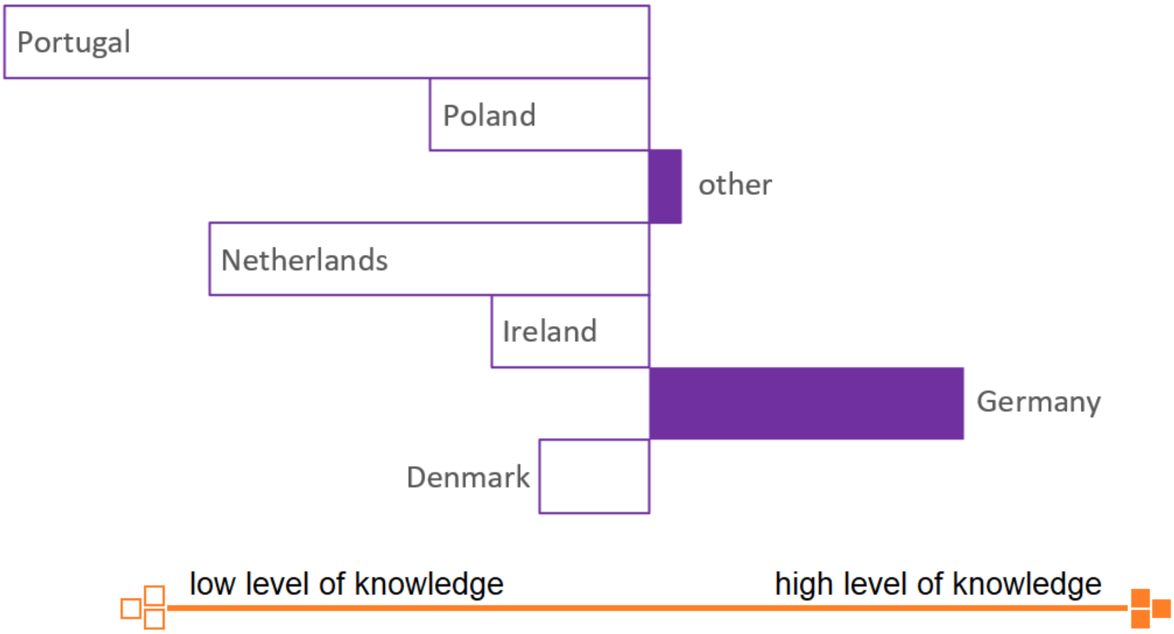


Source: own elaboration based on surveys conducted.

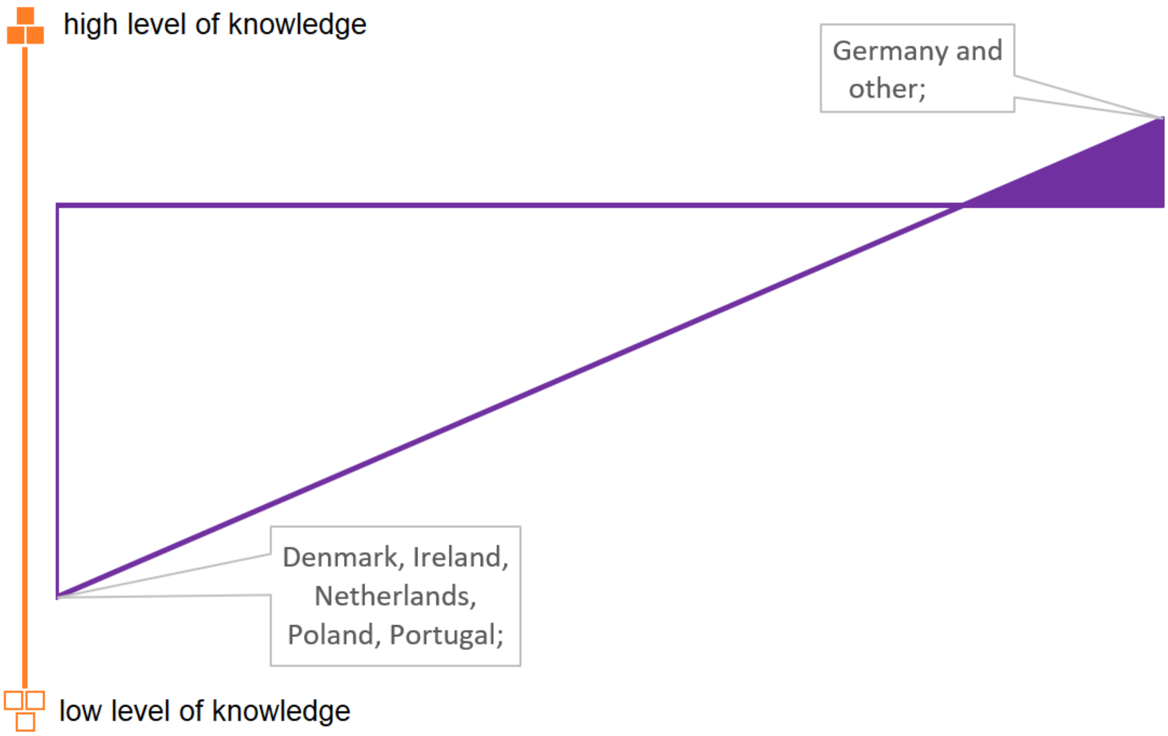
After assigning numerical values to each response option according to the following assumption: very poor (-2), poor (-1), medium (0), good (1) and very good (2) and summing them in relation to each country, a very interesting conclusion was obtained highlighting the magnitude of differences occurring in relation to the geographic criterion (Figure 22 a and b). This technique allows to reduce the significance of the number of responses in favor of declarations made and to finally summarize the results (highlighting key differences and characteristic levels). 22b, on the other hand, shows the overall state of affairs.

Figure 22. Assessment of the level of knowledge on the possibility of non-economic use of Blockchain technology in relation to the location of the university

a) after coding and summing the responses



b) after coding, summing and aggregating the responses



Source: own elaboration based on surveys conducted.

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A second highly statistically significant correlation was identified between the declaration of the ability to create a token and the location of teaching institution where the reviewer works. Data on this correlation are collected in Table 17.

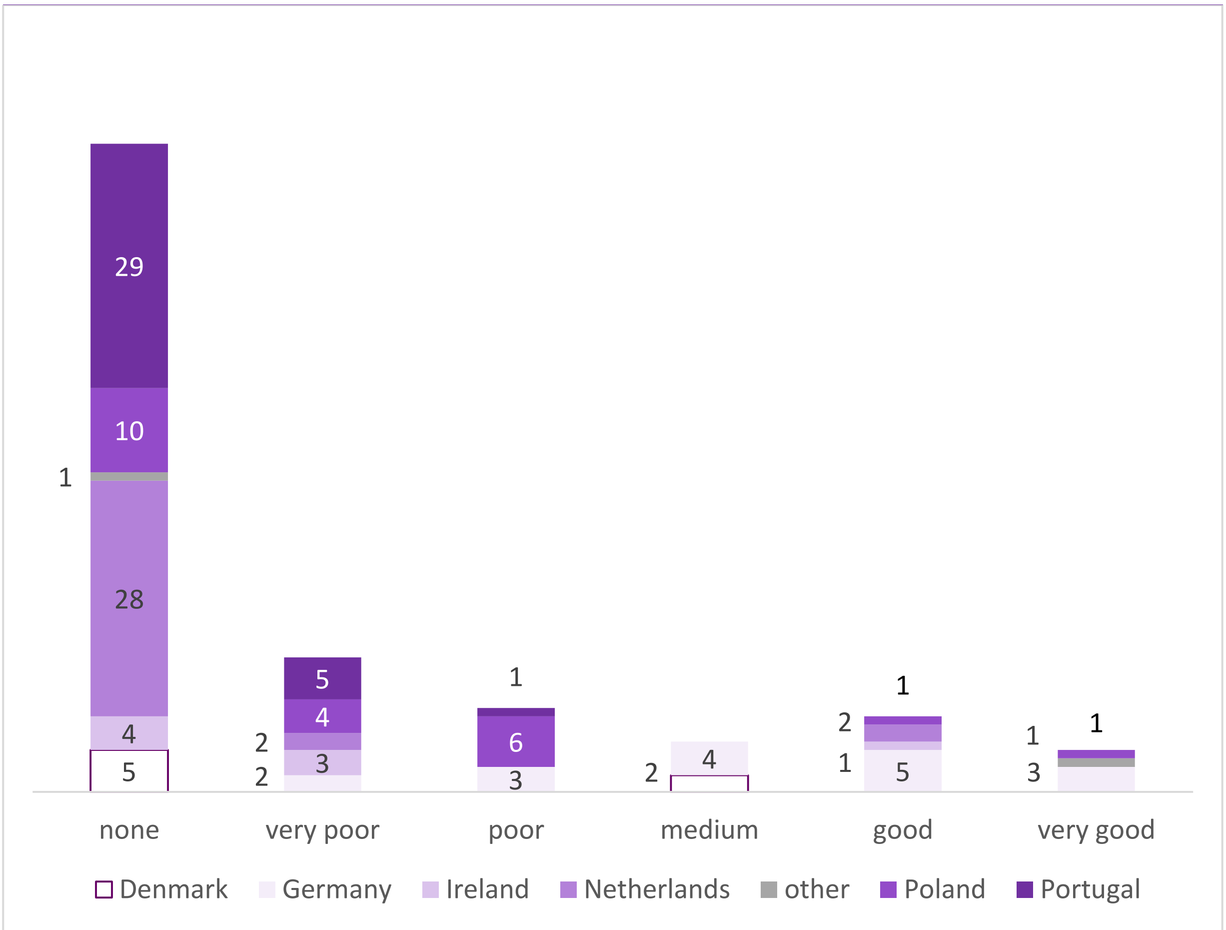
Table 17. Declaration of the level of skills to create a token in relation to the location of the university

ASSESSMENT	COUNTRY							TOTAL
	Denmark	Germany	Ireland	Netherlands	other	Poland	Portugal	
none	5		4	28	1	10	29	77
very poor		2	3	2		4	5	16
poor		3				6	1	10
medium	2	4						6
good		5	1	2		1		9
very good		3			1	1		5
TOTAL	7	17	8	32	2	22	35	123
%								
none	4,1%	0,0%	3,3%	22,8%	0,8%	8,1%	23,6%	62,6%
very poor	0,0%	1,6%	2,4%	1,6%	0,0%	3,3%	4,1%	13,0%
poor	0,0%	2,4%	0,0%	0,0%	0,0%	4,9%	0,8%	8,1%
medium	1,6%	3,3%	0,0%	0,0%	0,0%	0,0%	0,0%	4,9%
good	0,0%	4,1%	0,8%	1,6%	0,0%	0,8%	0,0%	7,3%
very good	0,0%	2,4%	0,0%	0,0%	0,8%	0,8%	0,0%	4,1%
TOTAL	5,7%	13,8%	6,5%	26,0%	1,6%	17,9%	28,5%	100,0%

Source: own elaboration based on surveys conducted.

The most proportional distribution of responses was obtained with respect to Germany. There, the most numerous self-assessments indicating a high level of IT skills to create a token were reported (even though there were not many). The remaining declarations accumulated mainly in the "no skills" option. A record indication (23.6%) appeared with the response "no skills," and this represented teachers working in Portugal. A graphical representation of Table 17 is provided in Figure 23.

Figure 23. Declaration of the level of skills to create a token in relation to the location of the university

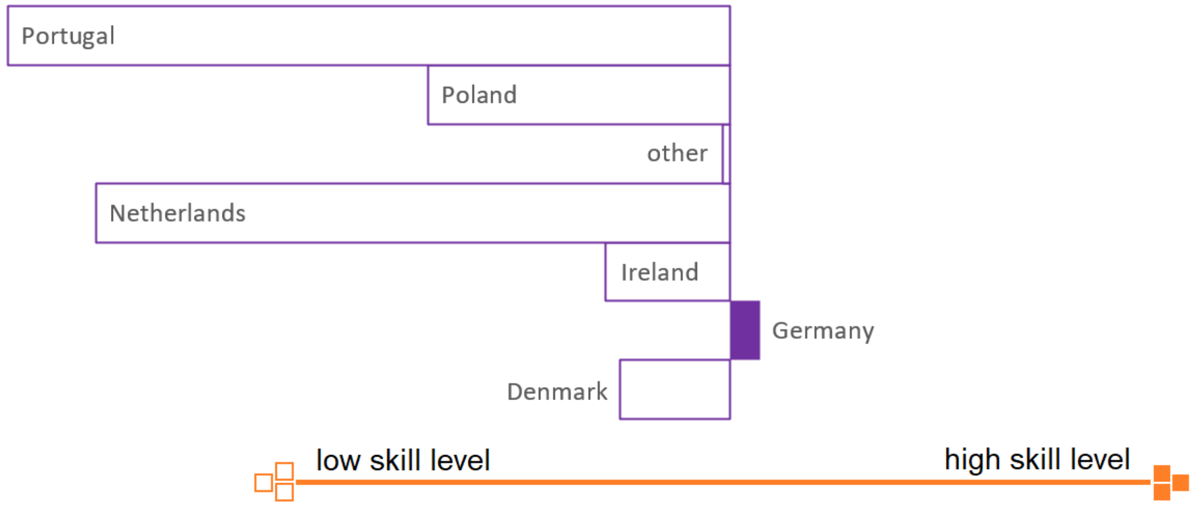


Source: own elaboration based on surveys conducted.

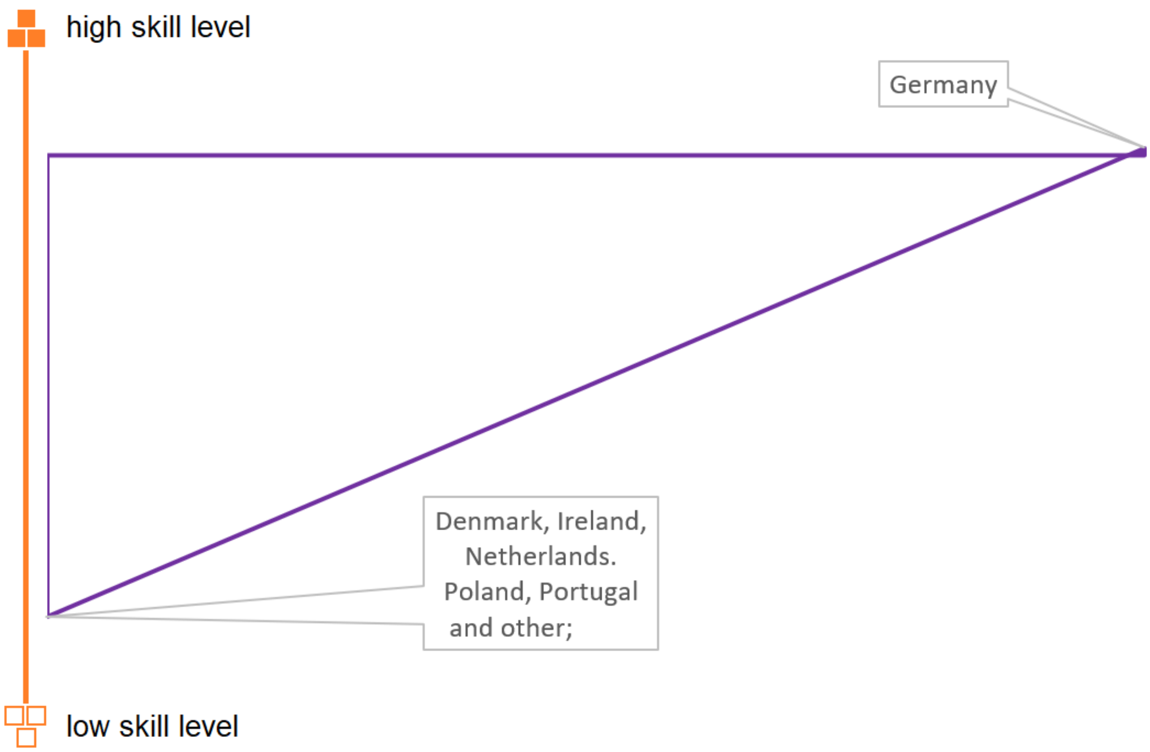
The analyzed correlation applies to a question in which the response scale has been expanded to include one additional item "no skills." Accordingly, the assignment of numerical values to the response options will be as follows: none (-3), very poor (-2), poor (-1), medium (0), good (1) and very good (2). Graphical form of results is illustrated in Figure 24 a and b.

Figure 24. Declaration of the level of skills to create a token in relation to the location of the university

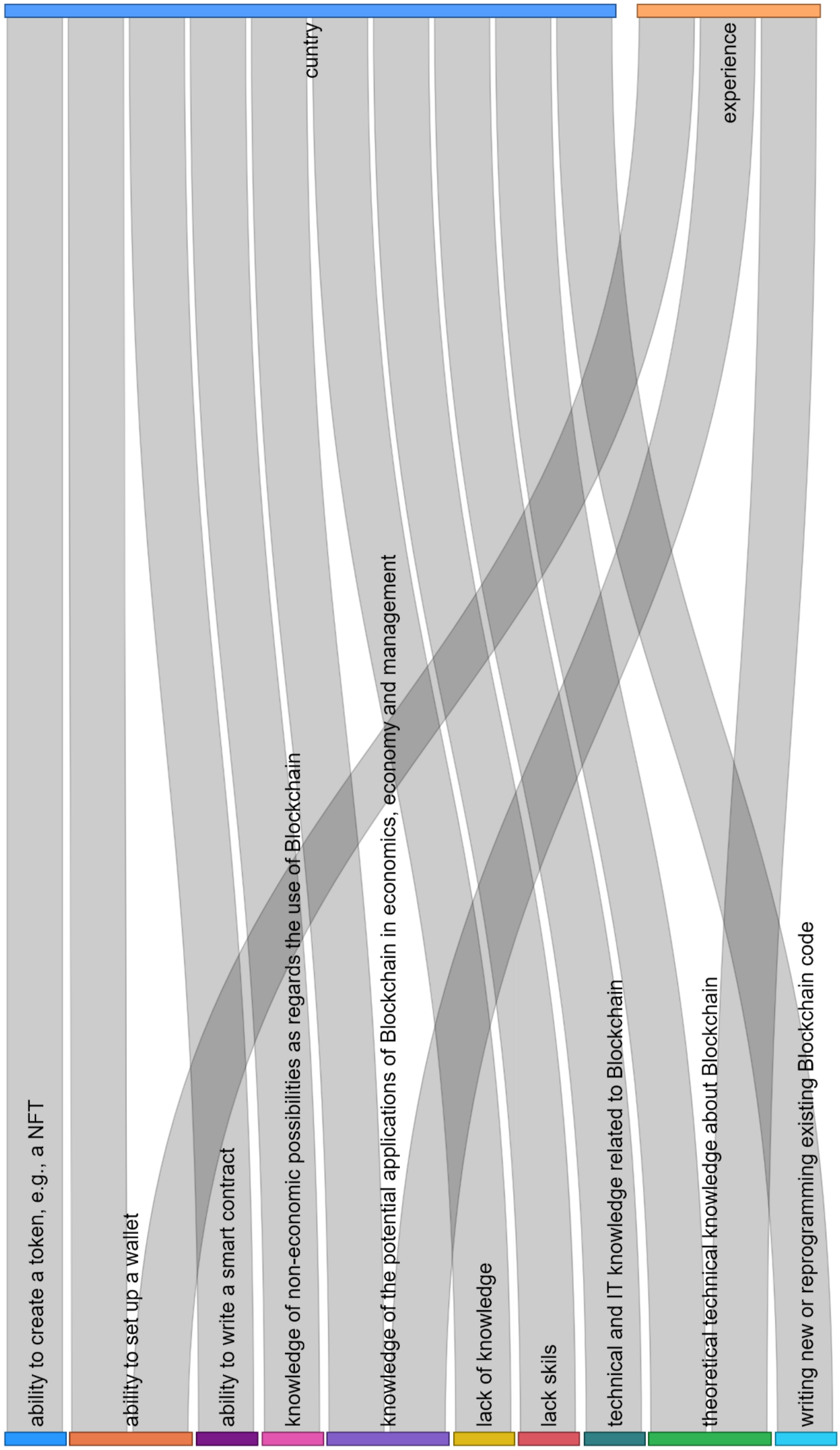
a) after coding and summing the responses



b) after coding, summing and aggregating the responses



Source: own elaboration based on surveys conducted.



Map of identified correlations

SUBSTANTIVE VERIFICATION OF HYPOTHESES

H1 (main hypothesis): *Most academics and lecturers teaching economics and management do not have sufficient knowledge and skills needed to teach Blockchain-related topics, but at the same time understand and recognize the enormous potential of this technology.*

Based on the literature review and the results from the survey and, in particular, the data in Figures: 12, 13, 14, 15, 16 and Tables: 8 i 9.
H1 was verified positively and proved to be TRUE.

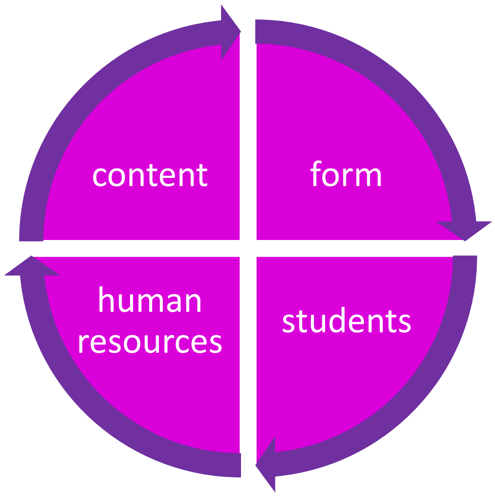
H2 (complementary hypothesis): *Most academics and lecturers teaching economics and management agree with the concept and the need to educate students in these fields about Blockchain technology.*

Based on the literature review and the results from the survey and, in particular, the data in Figures: 16, 17 i 19.
H2 was verified positively and proved to be TRUE.

XI. EDUCATIONAL MODEL ON BLOCKCHAIN FOR ECONOMICS AND MANAGEMENT STUDENTS

The model was based on a survey and literature study with the inclusion of an analysis of Blockchain-related educational curriculums implemented by universities. A review of dedicated courses offered by commercial digital platforms, for example, completed the full picture. Given the limitations (e.g., the relatively narrow scope of research conducted), the model should be treated as an auxiliary material, indicating general directions. The general idea of the model's architecture is included in Figure 25.

Figure 25. Main elements of the model



Source: own elaboration.

Human resources. These resources are, of course, the academics or lecturers who will implement the teaching plan on Blockchain. Unfortunately, their level of knowledge in this area can be assessed as moderately low. Some issues remaining in the field of economic effects related to the technology under discussion (e.g. economic models or the functioning of cryptocurrency markets) are moderately familiar to them. Unfortunately, pushing the boundary of knowledge towards technical issues (mainly IT and cryptography), the level drastically decreases (although there are thematic exceptions (such as general knowledge of ICT) and personal ones).

The level of skills is even lower. Overall, it can be assessed as very poor. As with knowledge, it decreases even further, or even disappears, with more advanced IT issues.

Despite this state of affairs, the teaching staff realizes the necessity and potential of educating students on Blockchain. However, being aware of their limitations, they face very serious psychological barriers that may completely prevent them from carrying out such an educational endeavor.

Taking the above into account, and based on the clear message from the respondents, the conduct of classes covering Blockchain topics by teachers of economics and management majors **absolutely requires preparing them for this task, in the form of a specialized and dedicated training course.** Left to their own, only a few of them will be able to accomplish such a teaching task.

Another problem is the thematic scope of education in the context of Blockchain. If it is only related to economic effects issues, then a refresher course seems to be a sufficient preparatory solution. If, on the other hand, it is to be related to more advanced IT knowledge and skills, then a thorough retraining of teachers is required, which seems undesirable, questionable and even impossible to implement.

Students. Students are to be the final beneficiaries of the teaching strategy being prepared. They are showing an eagerness and willingness to learn more about Blockchain [178]. However, it is unclear at what exact point this eagerness is focused and what specific subject is involved. Without this knowledge, it is necessary to rely only on the one-sided opinion of teachers, which can be misleading. However, there are some clues. When students choose a particular field of study, they do so in accordance with their interests and competencies. Economics, management and quality sciences belong to the group of humanities. But these two fields are characterized by great absorption, flexibility and susceptibility to interdisciplinary projects and research, especially those at the interface of technology and business. Combining this with the open-mindedness of students and their pro-technology approach, it is possible to assume that economic aspects related to Blockchain technology and cryptocurrency markets are likely to be of great interest and popularity. On the other hand, when dealing with more technical issues, great care must be taken to properly adapt the curriculum to the resources, infrastructure, potential and capabilities of the students. It is then necessary to plan in advance and prepare accordingly for such a challenge.

CASE STUDY – SAMPLE MASTER'S STUDIES OFFER
STUDIES CARRIED OUT FULL-TIME AND ONLINE
(OFFER PRESENTED ONLINE) [178]

UNIVERSITY of NICOSIA

MASTER'S IN
BLOCKCHAIN AND DIGITAL CURRENCY

1100 graduates since 2014
language of instruction is English
3 semesters or 1 calendar year
free studies
author: Andreas Antonopoulos

The MSc in Blockchain and digital currency is designed to help financial services and business professionals, entrepreneurs, government officials and public administrators better understand the technical underpinnings of cryptocurrencies and Blockchain technology, how it will likely interact with existing monetary and financial systems, and what opportunities exist for innovation in digital currency systems. The Master's degree is designed to prepare participants to become competent professionals in the field of digital currency and Blockchain technology. Graduates benefit from a broad background, combining courses in Finance, Management, Computer Science, and Information Systems to provide a holistic analysis of Cryptocurrencies and Blockchain systems, applications, and services. Students get exposed to an enriching and stimulating curriculum that covers important areas of Blockchain technology like Blockchain and Digital Currency, Blockchain Systems and Architectures, Blockchain and Entrepreneurship Management, Emerging Topics in Blockchain and Digital Currency, Digital Currency Programming, Smart contract programming, Permissioned Blockchain Programming, Cryptographic Systems Security, Emerging Topics in Fintech, Token Economics, Law and Regulation in Blockchain, Emerging Topics in Law and Regulation, Principles of Money, Banking and Finance, Open and Decentralized Financial Systems and others.

Teaching Methodology
Within the distance-learning paradigm, the program deploys various teaching methods: while the majority of the courses consist of lectures delivered by the faculty course lecturer(s), in some cases it may be deemed appropriate and beneficial to host guest lecturers with academic and business background related to topics covered in courses. Moreover, practical exercises, individual and group projects, simulations, and case study analyses, will form an integral part of the teaching methodology employed in the program.

The program is structured into three semesters
The first two semesters include three courses each, which are required for the completion of the program, whereas the third semester includes courses that students should choose among a wide list of elective courses. There is a thesis option for students wishing to substitute elective courses during the third semester.

1st SEMESTER

- Introduction to Blockchain and Digital Currency
- Principles of Money, Banking and Finance
- Law and Regulation in Blockchain

2nd SEMESTER

- Blockchain and Entrepreneurship Management
- Blockchain Systems and Architectures
- Emerging Topics in Blockchain and Digital Currency

3rd SEMESTER (Elective Courses (3 of 9) or Thesis option)

- Digital Currency Programming
- Smart Contract Programming
- Permissioned Blockchains Programming
- Cryptographic Systems Security
- Emerging Topics in Law and Regulation
- Emerging Topics in FinTech
- Open and Decentralized Financial Systems
- Token Economics

Formula. The learning formula should be variable with respect to expectations and expected outcomes. Moreover, the message should, in most cases, be strictly dedicated to specific audiences. The area of knowledge related to Blockchain is vast and constantly developing. In addition, it is convergent and multi-threaded. It is suggested to consider four teaching formulas:

F1. Online course available to all university students for free:

- form: course posted on any e-learning platform; redirect to the course posted on the university's official website; materials available in mixed form: electronic documents, lectures, podcasts, videos, webinars, etc.
- course duration: 30 lesson hours.
- completion of the course should be confirmed by receiving a certificate.

F2. Basic subject the same for all students of economics and management of the first degree (bachelor's degree):

- form: classes in the form of lectures that can be held in-class and/or online.

- course duration: 30 hours.

F3. Profiled subject tailored to a specific field of study – second degree (master's degree) studies.

- form: classes in the form of lectures and exercises. Full-time classes.
- course duration: lectures: 15 hours, exercises: 30 hours.
- subject directed to students who have a certificate for completing an online course or at the bachelor's level credit the subject described in F2.

F4. Course related to Blockchain and cryptocurrencies – second degree (master's degree) studies.

- form: classes in the form of lectures, exercises and laboratories. Should be extended by study visits and student internships. Full-time classes.

These formulas can and rather should be combined with each other, as they are not substitutive but complementary. The assumption is that the best results can be obtained by combining F1 and F2, F1 and F3, or F1, F2 and F4.

In the author's opinion, the first two F1 and F2 should be mandatory at any university with an economics or management profile. F3 should be an optional "subject of choice," while item F4, due to the high "barriers to entry" and maintaining quality, should remain completely optional. Its introduction should be considered mainly by teaching centers that educate in economics and computer science and have specialized staff and IT infrastructure.

Content. Respondents indicated that educational content should be developed according to the principle: medium-low technical knowledge of Blockchain and only basic IT skills. They confirmed this attitude by declaring that they prefer lectures, case studies and exercises to learn the issue, which clearly defines the advocacy of a theoretical approach. At the same time, economic issues should be presented extensively and analyzed in depth.

The fact that Blockchain is inseparably related to cryptocurrencies should not be forgotten. These issues cannot be taught completely separately. In the case where there are classes on cryptocurrencies at a given university, a subject related to Blockchain can be held simultaneously or in the next semester. In the case where there are no such classes (and, according to the survey, this may be the case in 68.7%), then part of the hours in the Blockchain-related topic should be devoted to exploring the essence of digital currencies. Such a state of affairs will be the subject of the following discussion.

Table 18 lists the ranges of content that curricula corresponding to F1, F2 and F3 should include. Due to the optionality, subjectivity and ambivalence resulting from the current needs of the audience and the experience and resources of teaching entity, F4 has been omitted.

Table 18. Blockchain content in learning formulas F1, F2, and F3

FORMULA	CONTENT
F1	The history of origin, definitions and basic knowledge of the principles of Blockchain technology and the services and platforms that use this technology. Basic knowledge of cryptocurrencies and cryptocurrency markets and exchanges. Threats and opportunities associated with cryptocurrencies. Blockchain and cryptocurrency regulations. Overview of the most well-known Blockchain-based projects and ventures.
F2	The history of origin, definitions and basic knowledge of the principles of Blockchain technology and the services and platforms that use this technology. Basic knowledge of cryptocurrencies and cryptocurrency markets and exchanges. Threats and opportunities associated with cryptocurrencies. Blockchain and cryptocurrency regulations. Overview of the most well-known Blockchain-based projects and ventures.
F3	Lectures: the essence of crowdfunding. An overview of the opportunities and risks as well as regulations associated with the use of Blockchain in the profiled area. Examples of non-economic initiatives based on Blockchain and with universal applications (e.g., personalization and authentication). Exercises: analysis of projects, ventures and startups based on Blockchain and implemented in the profiled area (e.g., in the case of logistics – monitoring supply chains using Blockchain). Analysis and evaluation of business models and the history of creation of these initiatives. Credit exercise project: concept of implementation of Blockchain technology in a selected institution or business entity.

Source: own elaboration.

CASE STUDY – SAMPLE COURSE OFFER ON BLOCKCHAIN TOPICS [179]

MIT MANAGEMENT EXECUTIVE EDUCATION

ONLINE SHORT COURSE

TITLE: BLOCKCHAIN TECHNOLOGIES: BUSINESS INNOVATION AND APPLICATION

6 weeks, excluding orientation
5-8 hours per week, entirely online
weekly modules, flexible learning
earn an MIT Sloan digital certificate

Course developed by: MIT Sloan School of Management, written by Professor Christian Catalini – a specialist in cryptoeconomics. The course allows to learn about Blockchain technology from an economic perspective. The participant acquires knowledge of how Blockchain functions (from the practical and technical aspects), learns about its potential and limitations, as well as the possibilities and ways to use it in own organization.

MODULE 1. AN INTRODUCTION TO BLOCKCHAIN TECHNOLOGY
How to think about problems that may require a blockchain?

- common misconceptions about blockchain technology
- the challenges of predicting technological evolution and its impact on the economy
- emergence of blockchain technology to that of other general purpose technologies
- role of entrepreneurial strategy in a time of technological uncertainty
- business application of blockchain through the lens of a strategic framework

MODULE 2. BITCOIN AND THE CURSE OF THE DOUBLE-SPENDING PROBLEM
The technological breakthrough behind Bitcoin

- bitcoin as a medium of exchange, store of value, and unit of account
- double-spending problem and how it is addressed by Bitcoin
- technical details of the Bitcoin protocol
- how the PoW algorithm works?
- algorithms used to establish consensus in a blockchain to ensure its integrity
- alternative cryptocurrencies and how they might address the challenges presented by bitcoin
- role of mining in bootstrapping Bitcoin's infrastructure
- current issues with scaling the Bitcoin blockchain and how they can be addressed

MODULE 3. COSTLESS VERIFICATION: BLOCKCHAIN TECHNOLOGY AND THE LAST MILE PROBLEM
Why blockchain technology may lead to cheaper, more reliable verification?

- situations where settlement and reconciliation are expensive today
- cost of verifying the attributes of a transaction
- how to build data integrity with costless verification?
- blockchain technology that may help to solve the last mile problem (online and offline)
- applications of cheaper settlement and reconciliation across different industries
- feasible solutions to the last mile problem

MODULE 4. BOOTSTRAPPING NETWORK EFFECTS THROUGH BLOCKCHAIN TECHNOLOGY AND CRYPTOECONOMICS
How blockchain technology reduces the cost of networking and the implications this has for market structure?

- the economic consequences of a reduction in the cost of networking
- nature of intermediation may change as a result of blockchain technology
- risks associated with smart contracts
- conditions under which relational contracts can be automated
- role of tokens in incentivizing the growth, operations, and security of a platform
- ability of case examples to capitalize on the reduction in the cost of networking
- reward system for an incumbent adding a token to its ecosystem

MODULE 5. USING TOKENS TO DESIGN NEW TYPES OF DIGITAL PLATFORMS
ICO landscape and the opportunities that native tokens present to businesses

- examples of tokens
- value that tokens may bring to a business's ecosystem
- role of tokens in funding blockchain innovations and platforms
- how challenges around securities regulation can affect the successful tokenization of an ecosystem?
- ranking of various tokens in terms of capital raised and trading performance

Funded by the European Union

Project Generation Blockchain, project number: 2021-1-PL01-KA220-HED-000031176

MODULE 6. THE FUTURE OF BLOCKCHAIN TECHNOLOGY, AI, AND DIGITAL PRIVACY

Primer for a blockchain-based solution and the role of broader digital platforms and digital privacy in the formulation of that solution

- how blockchain technology may interact with broader changes in digital platforms, AI, and the IoT?
- capacity of blockchain technology to increase competition and lower barriers to entry
- impact of blockchain technology and incentives on the consumer privacy paradox
- produce a primer for a blockchain-based solution to a business problem within your own context
- reflect on the key outcomes of this program

Funded by the European Union

SUMMARY

Based on the considerations made, as well as the literature review and conclusions drawn from the study, it can be concluded that the potential of blockchain technology has not yet been fully exploited in the education sector [180], and both in an administrative context and as a subject of study. “Although the volume of literature on the application of blockchain to education has been increasing in the last few years, it is still fragmented, and no systematic review has yet been conducted on the topic”[181]. In most sources, it is possible to find outlines and concepts of implementations, rather than concrete facts and proven solutions supported by experience and practice. These usually include the possibility of transferring some Blockchain functionalities to various subsectors related to knowledge sharing. Implemented projects and experiments in this area are conducted very slowly and, due to the very rapid development of the technology, are prone to obsolescence [112]. Once again, technological development is outpacing the ability to consider or effectively implement intermediates, with the risk of missing out on interesting solutions and, as a result, failing to reap the benefits. Nevertheless, this situation should be viewed as an opportunity rather than a threat. This is a great opportunity to revolutionize ossified and biased educational structures and systems [182].

A decentralized network of connections, certainly promises greater efficiency, transparency but also administrative control over the management process in education [112]. The uniqueness of Blockchain technology, its novelty and its numerous attributes cause that there is a sizable area and opportunity to apply it to all stages of education – from elementary through secondary schools, to universities and e-learning [182].

The hypotheses adopted in the paper, H1 and H2, were verified from a statistical and substantive point of view. Finally, they were accepted and proved to be true. It was confirmed that most academics and lecturers teaching economics and management do not have sufficient knowledge and skills needed to teach Blockchain-related topics, but at the same time understand and recognize the enormous potential of this technology. They agree with the concept and the need to educate students in these majors about Blockchain technology.

There are many barriers delaying effective Blockchain education on a large scale. They have been grouped and identified as organizational and management barriers, infrastructure barriers and psychological barriers. The latter are discussed more extensively in this paper, but the other two groups have not been given due attention. IT infrastructure deficiencies (unless they relate to critical aspects such as lack of Internet access) at the assumed level of teaching are not a significant obstacle. However, barriers related to organization and management can be very difficult to overcome and undermine even the best educational strategy.

Universities and other teaching centers should strive to maximize the use of their resources especially in terms of teaching staff. Wanting to implement more technically advanced subjects in the form of laboratories, they need to focus their efforts even more on the proper preparation of teachers. However, no pressure can be exerted to retrain them. In case of failure, it is worth considering establishing cooperation with centers have more experience and reach for their proven solutions, which will significantly facilitate the launch of the first classes.

Blockchain and cryptocurrency issues are irrevocably intertwined. Schools that teach classes on digital money and currencies have an easier substantive and organizational distance to cover. If the organization of a course or subject on Blockchain seems too difficult an undertaking, it is worth considering first implementing a class covering cryptocurrency topics, which is a bit more accessible to both students and instructors and is an excellent introduction to further exploration of distributed networks.

It is important to keep in mind several principles when creating a course or designing a subject area. In addition to correctly structured and audience-tailored didactic content, the message should be optimized as much as possible. This means introducing diversification of the forms of message, not only to make them attractive to the student, but also accessible using different platforms and devices. In the case of courses, it is also worthwhile to make class participation as flexible as possible.

The research conducted is an excellent introduction to further exploration of the issue addressed. However, before proceeding further, it would be necessary to remove a few flaws. The data were collected under significant limitations. Above all, the sample size is not satisfactory, as is the selection of respondents, which should have been more structured and made using a multidimensional quota technique. Nevertheless, the survey is a pilot study burdened by the limitations of the project's assumptions. The results obtained can be considered as a guide, but on their own they are not sufficient to draw reliable conclusions about the entire population. In order to improve the proposed model, a further logical step would be to conduct a survey among students, who in fact are the primary interested parties, and thus their opinions and expectations could prove very valuable.

Putting the model into practice would provide another opportunity to conduct an analysis of opinions, experiences and comments, *post facto*. It would also be helpful to carry out an additional expert survey, which, combined with quantitative data, would further increase the effectiveness of developed strategy.

The publication made, in addition to the obvious possibility of use by project participants and other scientific and educational institutions, can be an excellent resource for local administrative bodies, for example. It can be used to plan development activities or set new directions for the development of schools.

APPENDIX A. OVERVIEW OF ONGOING EU FUNDED BLOCKCHAIN PROJECTS

Project	EU funding	Overall budget	Sector	More information
PROCONTRA	2.5	2.5	Other – Studies (Science & technology)	https://cordis.europa.eu/project/id/885666
Blockchain Gov	2	2	Secure societies (e.g. cyber & data security)	https://cordis.europa.eu/project/id/865856
BIG	2.5	2.5	Sustainability – Sustainable Business Ecosystem	https://cordis.europa.eu/project/id/952226
BBTWINS	4.1	5.3	Food security	https://cordis.europa.eu/project/id/101023334
TRICK	8	9.6	Sustainability – Traceability of products	https://cordis.europa.eu/project/id/958352
CITIES2030	11.8	12.5	Food security	https://cordis.europa.eu/project/id/101000640
HEREWEAR	6.2	7	Sustainability – Circular textiles	https://cordis.europa.eu/project/id/101000632
IMPULSE	4	4	Public services	https://cordis.europa.eu/project/id/101004459
Feature Cloud	4.6	4.6	Public services	https://cordis.europa.eu/project/id/826078
COPA EUROPE	4.9	6.2	Media & Social Media	https://cordis.europa.eu/project/id/957059
BRIGHT	4.7	5.9	Sustainability – Energy	https://cordis.europa.eu/project/id/957816
DiTECT	4.1	4.1	Food security	https://cordis.europa.eu/project/id/861915
TrustEat	0.9	0.9	Food security	https://cordis.europa.eu/project/id/952600
NGI Assure	8	8	Industrial Technologies – Big Data	https://cordis.europa.eu/project/id/957073
PlatOne	7.5	9.6	Sustainability – Energy	https://cordis.europa.eu/project/id/864300
TruBlo	6.1	6.1	Next generation internet	https://cordis.europa.eu/project/id/957228
OntoChain	6	6	Next generation internet	https://cordis.europa.eu/project/id/957338
TRAPEZE	5	6	Secure societies (e.g. cyber & data security)	https://cordis.europa.eu/project/id/883464
PUZZLE	4	5.3	Secure societies (e.g. cyber & data security)	https://cordis.europa.eu/project/id/883540
Pop-Machina	10	11	Sustainability – Collaborative production	https://cordis.europa.eu/project/id/821479
PLANET	7	7.1	Sustainability – Transport	https://cordis.europa.eu/project/id/860274
CyberKit4SME	3.9	4.9	Secure societies (e.g. cyber & data security)	https://cordis.europa.eu/project/id/883188
PARITY	7.2	9.4	Sustainability – Energy	https://cordis.europa.eu

				/project/id/864319
5GaaS	2.4	3.2	Industrial Technologies – 5G	https://cordis.europa.eu/project/id/958832
CREST	7	7	Secure societies (e.g. cyber & data security)	https://cordis.europa.eu/project/id/833464
BAnDIT	1.1	1.1	Internet of Things (IoT)	https://cordis.europa.eu/project/id/814284
INFINITECH	15.9	20.8	Internet of Things (IoT)	https://cordis.europa.eu/project/id/856632
Pharma Ledger	8.3	22.1	Public services	https://cordis.europa.eu/project/id/853992
DE4A	8	8	Public services	https://cordis.europa.eu/project/id/870635
COLLABS	6	6	Advanced manufacturing	https://cordis.europa.eu/project/id/871518
TOKEN	3.8	3.8	Sustainability – Collaborative government	https://cordis.europa.eu/project/id/870603
Slot Machine	1.9	2.2	Sustainability – Transport	https://cordis.europa.eu/project/id/890456
BLOCKCHAIN SOCIETY	1.5	1.5	Other – Studies (Science & technology)	https://cordis.europa.eu/project/id/759681
P2PMODELS	1.5	1.5	Sustainability – Other	https://cordis.europa.eu/project/id/759207
AICHAIN	1	1.8	Sustainability – Transport	https://cordis.europa.eu/project/id/894162
euCanSHare	5.4	6	Public services	https://cordis.europa.eu/project/id/825903
MOLIERE	2	2.7	Industrial Technologies – Space data	https://cordis.europa.eu/project/id/101004275
AVANGARD	14	23.2	Advanced manufacturing	https://cordis.europa.eu/project/id/869986
5GZORRO	5	5	Industrial Technologies – 5G	https://cordis.europa.eu/project/id/871533
TNT (Truth-not-Trust)	1.9	2.7	Secure societies (e.g. cyber & data security)	https://cordis.europa.eu/project/id/881092
Circularise Source	1.5	2.1	Sustainability – Other	https://cordis.europa.eu/project/id/961989
AMABLE	8	8.2	Advanced manufacturing	https://cordis.europa.eu/project/id/768775
ARTICONF	4.2	4.2	Media & Social Media	https://cordis.europa.eu/project/id/825134
CRITICAL-CHAINS	4.2	5	Secure societies (e.g. cyber & data security)	https://cordis.europa.eu/project/id/833326
FleXunity	3	3.8	Sustainability – Energy Flexibility	https://cordis.europa.eu/project/id/870146
LOCARD	6.8	6.8	Secure societies (e.g. cyber & data security)	https://cordis.europa.eu/project/id/832735
MINESPIDER	2.3	3.3	Sustainability – Tracking minerals	https://cordis.europa.eu/project/id/946437
Preemie	1.7	2.4	Public services	https://cordis.europa.eu/project/id/879228
BlockStart	1.5	1.5	Innovation Support for SMEs	https://cordis.europa.eu/project/id/828853

WeldGalaxy	7.5	15	Advanced manufacturing	https://cordis.europa.eu/project/id/822106
CUREX	5	5	Public services	https://cordis.europa.eu/project/id/826404
CATTLECHAIN 4.0	2	2.5	Sustainability – Other	https://cordis.europa.eu/project/id/853864
SOTER	3	4.1	Secure societies (e.g. cyber & data security)	https://cordis.europa.eu/project/id/833923

APPENDIX B. OVERVIEW OF COMPLETED EU FUNDED BLOCKCHAIN PROJECTS

Project	EU funding	Overall budget	Sector	More information
LEDGER	7	7	Next generation internet	https://cordis.europa.eu/project/id/825268
Block.IS	4.9	5.5	Innovation Support for SMEs	https://cordis.europa.eu/project/id/824509
BEACON	1.7	2.4	Industrial Technologies – Weather intelligence	https://cordis.europa.eu/project/id/821964
QualiChain	4	4	Public services	https://cordis.europa.eu/project/id/822404
CO3	3.3	3.3	Public services	https://cordis.europa.eu/project/id/822615
B-HUB FOR EUROPE	1.6	1.9	Innovation Support for SMEs	https://cordis.europa.eu/project/id/871869
EUNOMIA	2.5	2.9	Media & Social Media	https://cordis.europa.eu/project/id/825171
SocialTruth	2.5	3.2	Media & Social Media	https://cordis.europa.eu/project/id/825477
M-Sec	1.5	1.5	Sustainability – Other	https://cordis.europa.eu/project/id/814917
CYBER-TRUST	3	3	Secure societies (e.g. cyber & data security)	https://cordis.europa.eu/project/id/786698
B4TDM	1.9	2.8	Other – Document Management	https://cordis.europa.eu/project/id/858630
PRIViLEDGE	4.5	4.5	Secure societies (e.g. cyber & data security)	https://cordis.europa.eu/project/id/780477
eDREAM	3.8	3.8	Sustainability – Energy	https://cordis.europa.eu/project/id/774478
FIN-TECH	2.5	2.5	Industrial Technologies – Big Data	https://cordis.europa.eu/project/id/825215
DECENTER	2.2	2.2	Industrial Technologies – Artificial Intelligence	https://cordis.europa.eu/project/id/815141
BLOCKPOOL	1.5	1.5	Innovation Support for SMEs	https://cordis.europa.eu/project/id/828888
PoSeID-on	2.5	3.1	Secure societies (e.g. cyber & data security)	https://cordis.europa.eu/project/id/786713
SettleMint	1.8	2.6	Other – Blockchain middleware	https://cordis.europa.eu/project/id/849969
SHOGANAI	2.2	3.2	Sustainability – Transport	https://cordis.europa.eu/project/id/806470
BLOCKCHERS	1.5	1.5	Innovation Support for SMEs	https://cordis.europa.eu/project/id/828840
CHARIOT	4.9	4.9	Internet of Things (IoT)	https://cordis.europa.eu/project/id/780075
SOFIE	4.5	4.5	Internet of Things (IoT)	https://cordis.europa.eu/project/id/779984
Blockchain KYC	1.2	1.8	Secure societies (e.g. cyber & data security)	https://cordis.europa.eu/project/id/850059
BLOOMEN	2.8	3.3	Media & Social Media	https://cordis.europa.eu

				/project/id/762091
Smart-Trust	2.1	3	Secure societies (e.g. cyber & data security)	https://cordis.europa.eu/project/id/778571
DECODE	5	5	Secure societies (e.g. cyber & data security)	https://cordis.europa.eu/project/id/732546
MH-MD	3.5	4	Public services	https://cordis.europa.eu/project/id/732907
Ptwist	1.8	2.2	Sustainability – Other	https://cordis.europa.eu/project/id/780121
Billon	2	2.8	Other – Digital payments	https://cordis.europa.eu/project/id/783861

APPENDIX C. SAMPLE COURSE CHARTER (ECTS)*

<table>
<tr><td colspan="4">Subject name:
Introduction to Blockchain and Cryptocurrency</td><td>Subject code:
US26AIIJ2470_39S</td></tr>
<tr><td colspan="5">Major field of study: management</td></tr>
<tr><td colspan="2">Form of study: first degree, bachelor's degree, full-time studies</td><td colspan="3">Education profile: general academic</td></tr>
<tr><td>Year: II</td><td>Semester: 3</td><td>Status: compulsory subject</td><td colspan="2">Language: English</td></tr>
<tr><td colspan="5">Course form: lecture</td></tr>
<tr><td colspan="4">Course contents</td><td>Number of hours</td></tr>
<tr><td colspan="4">1. Basic definitions in the Blockchain technology environment and cryptocurrencies</td><td>2</td></tr>
<tr><td colspan="4">2. Technical aspects of Blockchain technology functioning</td><td>4</td></tr>
<tr><td colspan="4">3. Applications, platforms, apps and services operating on the basis of Blockchain</td><td>4</td></tr>
<tr><td colspan="4">4. Blockchain technology interactions with IoT, artificial intelligence, Big Data</td><td>2</td></tr>
<tr><td colspan="4">5. The essence, history and types of cryptocurrencies. The Bitcoin phenomenon. Characteristics of basic cryptocurrencies and related projects</td><td>6</td></tr>
<tr><td colspan="4">6. The principle of cryptocurrency markets and exchanges</td><td>2</td></tr>
<tr><td colspan="4">7. Cryptocurrencies in the global financial system</td><td>2</td></tr>
<tr><td colspan="4">8. Blockchain and cryptocurrency regulations</td><td>2</td></tr>
<tr><td colspan="4">9. Case studies of flagship projects, startups and other Blockchain-based ventures</td><td>6</td></tr>
<tr><td colspan="4">TOTAL</td><td>30</td></tr>
<tr><td colspan="2">Teaching techniques</td><td colspan="3">• Multimedia presentations
• Additional materials posted on the e-learning platform
• Webinar
• Lecture combined with discussion, group work
• Case study</td></tr>
<tr><td colspan="2">Methods of educational effects verification</td><td colspan="3">Exam</td></tr>
<tr><td colspan="2">Credit form and conditions</td><td colspan="3">Oral exam or single-choice test</td></tr>
<tr><td colspan="2">Literature</td><td colspan="3">1. Internet
2. D.Tapscott, A.Tapscott, (2018) Blockchain Revolution: How the Technology Behind Bitcoin and Other Cryptocurrencies Is Changing the World, Penguin Lcc Us.</td></tr>
</table>

* prepared based on F2.
Source: own elaboration.

APPENDIX D. QUESTIONNAIRE

We would like to invite you to participate in a survey on Blockchain technology. Its aim is to identify the level of knowledge, competencies and opinions of academic economic environments related to Blockchain and its implementation in the curriculum for students of economics and management faculties. The survey results will be used to create an effective educational model and will allow to increase the potential of future graduates of these faculties in the labour market. Additional benefits will be gained by academic teachers, as they will obtain a tool enabling the acquisition of new and balanced knowledge and skills. The survey will be conducted in six EU countries: Portugal, Germany, the Netherlands, Ireland, Denmark and Poland. Its results will have an international dimension.
The survey will be conducted within the "Generation Blockchain" project funded by the EU under the programme Erasmus+.
It is fully anonymous and voluntary. In case of any comments or doubts, please contact us via e-mail: piotr.gutowski@usz.edu.pl

DEMOGRAPHICS

1. Country (of profession or practice)
☐ Portugal
☐ Germany
☐ Netherlands
☐ Ireland
☐ Denmark
☐ Poland
☐ other

2. Professional experience (university work)
☐ less than 5 years
☐ 5 to 10 years
☐ 11 to 15 years
☐ 16 to 20 years
☐ more than 20 years

3. Topics of conducted lectures (more than one answer may be selected)
☐ economics
☐ management
☐ IT
☐ other

I. KNOWLEDGE ABOUT BLOCKCHAIN

1. When did you first hear about Blockchain?
☐ before 2009 years
☐ between 2009 – 2014
☐ 2015 – 2018

☐ 2019 – 2022
☐ never
☐ I don't remember

2. Do you know of examples of Blockchain applications in the following areas (multiple answers allowed)?

area/issue	yes	no
public records and registries, e.g., land records, lists of prosecuted offenders, or civil registry records		
private records and registers, e.g., medical records, electronic gradebooks, or work experience records		
transactions and banking, e.g., payments and micropayments or buying and selling stocks, digital securities		
authentication and smart contracts, e.g. conclusion of a contract only after the parties meet certain requirements, elimination of the need for an intermediary authentication institution such as a notary		
currency function, e.g., cryptocurrencies, decentralized finance (DeFi)		
personal and entity identification, e.g., confirmation of identity at an election, verification of a driver's license or authentication of a company against a debtor register		
increase in the safety and security of electronic information exchange		
creation of secure and trustworthy documentation		
authentication of goods and services, e.g., confirmation of car mileage, origin and shelf-life of foodstuffs or elimination of counterfeit medicines from circulation		
protection of intellectual property, e.g., patents or trademarks		
new funding opportunities for startups and charity fundraising, new financial models		
physical security, e.g., access to an apartment or hotel room		
NFT (non-fungible token)		
tokenization of assets		
other		

3. Please rate on a scale of 1 to 5 (1-very poor, 5-very good):

evaluation	1	2	3	4	5
your general knowledge of Information and Communication Technology (ICT)					
theoretical technical knowledge about Blockchain					
knowledge of the potential applications of Blockchain in economics, economy and management					
knowledge of non-economic possibilities as regards the use of Blockchain					

4. Please mark the Blockchain-related terms with which you are familiar (multiple answers allowed):

peer-to-peer (P2P)	
tokenization	
Crowdfunding	
NFT	

Satoshi Nakamoto	
DAO	
EEA	
GPU	

distributed networks			Halving	
hashing			Hyperledger	

II. PRACTICAL COMPETENCES RELATED TO BLOCKCHAIN

5. Please rate on a scale of 0 to 5 your practical competence (0-none, 1-very poor, 5-very good)*

*Due to the fact that the questionnaire is addressed to academic teachers specializing in economics/management, and the subject of this question focuses on technical IT issues, it was decided to introduce a zero position in the evaluation scale to indicate the lack of skills in this area.

evaluation	0	1	2	3	4	5
general ICT skills (e.g. operation of office packages)						
ability to operate Blockchain-based applications and systems						
ability to quickly adopt new ICT solutions (e.g. learning to use a new program)						
programming in any language						
advanced use of specialized software (e.g. operation and administration of an ERP system)						
writing new or reprogramming existing Blockchain code						
ability to technically implement Blockchain in an information system						
ability to administer and manage an information system based on Blockchain						
ability to create a token, e.g., a NFT						
ability to set up a wallet						
ability to write a smart contract						

III. EXPERIENCE RELATED TO BLOCKCHAIN

6. Are there any lectures on cryptocurrency markets at your university?

☐ yes
☐ no
☐ I don't know

7. Have you ever used a Blockchain-based technology or service in practice (e.g., making a transaction, securing documents, etc.)?

☐ yes
☐ no

8. Have you addressed Blockchain-related topics or cited examples of its implementations, business models, projects, etc. while conducting lectures?

☐ yes
☐ no

9. Have you conducted a dedicated subject/course related to Blockchain?
☐ yes
☐ no

10. Have you participated in a research project, training, workshop, or other activity not directly related to teaching in which you encountered Blockchain (multiple answers allowed)?
☐ yes, in a project
☐ yes, at the workshop
☐ yes, at training sessions
☐ yes, at the conference
☐ yes, during other activities
☐ no

IV. ATTITUDES AND OPINIONS

11. Please rate on a scale of 1 to 5 whether you support/agree with the issue or not (1-definitely not, 3-no opinion, 5-definitely yes):

evaluation	1	2	3	4	5
Blockchain is future-proof					
Blockchain has great potential for development					
Blockchain issues should be one of the key topics in economics and management education					
Blockchain knowledge in the context of economics and management is a factor that gives graduates a competitive advantage in the job market					
Should universities use third-party commercial Blockchain providers to prepare content and create appropriate educational environments?					
teachers, who will be teach Blockchain-related classes, should attend a professional preparation course					
Blockchain-related educational environment operating in a university should be based solely on open source software and materials					

12. To what **technical** extent should universities of economics and management educate their students in the context of Blockchain?
☐ basic IT (Blockchain) knowledge
☐ advanced IT (Blockchain) knowledge
☐ basic IT (Blockchain) knowledge and basic IT (Blockchain) skills
☐ advanced IT (Blockchain) knowledge and basic IT (Blockchain) skills
☐ advanced IT (Blockchain) knowledge and advanced IT (Blockchain) skills
☐ none

13. Which teaching methods do you consider to be appropriate for teaching Blockchain economics and management studies? (multiple answers allowed)?
☐ exercises
☐ lectures

☐ case studies
☐ design experiments
☐ laboratories
☐ other

14. At what educational level should Blockchain-related classes be conducted in economics and management faculties (multiple answers allowed)?
☐ bachelor degree studies
☐ master degree studies
☐ doctoral studies
☐ should not be conducted
☐ I don't know

15. In your opinion, should Blockchain knowledge be profiled relative to specialization (adapted to the specialization) or be the same for all students of the faculty?
☐ should be adapted to the specialization
☐ should be general, not adapted to the specialization
☐ I don't know

16. Please rate on a scale of 1 to 5 how important for students of economics/management is the knowledge in the field (1-not important, moderately important, 5-very important):

evaluation	1	2	3	4	5
cryptocurrency markets					
implementations Blockchain in uneconomic projects					
implementations Blockchain in economic projects					
technical and IT knowledge related to Blockchain					
business models based on Blockchain					
innovative projects and startups related to Blockchain (examples of such project and startups)					

17. Please rate the most important infrastructural barriers which may inhibit the implementation of Blockchain into the education system in your institution (scale of 1 to 5, 1-not important, 3-moderately important, 5-very important):

evaluation	1	2	3	4	5
lack of proper computer laboratories					
lack of proper software					
lack of bandwith					

18. Please rate the most important managerial barriers which may inhibit the implementation of Blockchain into the education system in your institution (scale of 1 to 5, 1-not important, 3-moderately important, 5-very important):

evaluation	1	2	3	4	5
lack of incentive (financial, recognition, HR policy)					
lack of interests from superiors					
lack of clarity how Blockchain fits into the existing or future curriculum					

lack of need					

19. Please rate the most important competency and psychological barriers which may inhibit the implementation of Blockchain into the education system in your institution:

evaluation	1	2	3	4	5
lack of knowledge					
lack of skills					
fear of new concepts					
fear of appearing to lack expertise to colleagues					
fear of appearing to lack expertise to students					

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