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BLOCKCHAIN IN CONTINUING EDUCATION – TAXONOMY FOR A NEXT-GENERATION TEACHING PLATFORM

Nathalie Alysha Meyer
University of St. Gallen, meyer.nathalie@outlook.de

Alexander Meier
University of St. Gallen, alexander.meier@unisg.ch

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Completed Research Paper

Nathalie Alysha Meyer, University of St. Gallen (HSG), St. Gallen, Switzerland, nathaliealysha.meyer@student.unisg.ch

Alexander Meier, University of St. Gallen (HSG), St. Gallen, Switzerland, alexander.meier@unisg.ch

Abstract

The constantly growing educational technology market and rising demand for comprehensive, lifelong learning in rapidly digitizing environments, offer significant potential for implementing decentralized blockchain systems in the context of continuing education. However, the continuing education sector underutilizes the promised value. This paper develops a multi-layer taxonomy based on a systematic literature review and expert interviews, which contributes to systematically delineating possible augmentations of continuing education management using blockchain-based technology. Applications include fraud prevention, intellectual property protection, efficient and secure data exchange by tokenizing personal documents and developing interoperable, smart educational institutions using smart contracts and IoT. The taxonomy incorporates descriptive knowledge and prescriptive guidance to researchers in educational technology, implementers, and instructors in continuing education, as well as institutional decision-makers on the benefits of blockchain, such as decentralized governance, data security, immutability, and anonymity, leveraged throughout the phases of educational program development in an institutional or company-internal context.

Keywords: blockchain, continuing education, education management, multi-layer taxonomy

1 Introduction

In 2021, blockchain added an estimated US$ 119 million to the education market and is expected to increase with a compound annual growth rate of almost 44% to over US$ 3 billion by 2030 (Business Research Insight, 2024). This development goes hand in hand with the increasing demand for digitization and smartification of learning and working environments for flexibility and efficiency purposes. Regarding the development of digitization in the educational sector, according to HolonIQ (2023), the quaternary sector, including adult and on-the-job education, is more than twice as oriented towards entering new markets and integrating new technologies than the tertiary sector, However, investigation concerning the use of blockchain in the former sector and emphasizing the benefits for teachers and institutions remains open. According to the Gartner 2019 CIO Survey (2019), implementing blockchain technology in the educational sector could promote the simplification of record keeping, verifying digitized certificates and their accreditation. In addition to increasing efficiency, blockchain adoption helps secure intellectual property and prevent document fraud. Furthermore, it can lead to entirely new business models, such as educational institutions "rely(ing) on blockchain and smart contracts as the basis of the relationship between learners and educators," as Moore states (2019). The increasing demand for digital transformation in education is not only driven by the need for efficiency and flexibility but also by pressing global challenges. According to Brownie et al. (2023), many learners face barriers to accessing quality education due to geographic, financial, or institutional constraints. These constraints reflect the dependencies between economic, regional and education development/offerings (Brownie et al., 2023). By addressing such systemic challenges by enabling transparent, decentralized certification processes, reducing reliance on intermediaries, and improving access to lifelong learning opportunities, blockchain can play a key role in bridging skills gaps and fostering equitable access to education.

Our systematic literature review revealed several proposals for implementing blockchain in education. Firstly, in the context of research and course development, Yano et al. (2022) propose building a blockchain network between researchers to openly publish and mutually peer-review their findings in an automated manner. Van Rossum (2017) further mentions that the latter could facilitate the publishing process of research papers by involving publishers in the network or replacing them by implementing smart contracts to set the standards for publishing. Moreover, Sychov and Chirtsov (2018), as well as Bhaskar et al. (2021), propose that teachers, in the second step, can use such a pool of peer-to-peer-reviewed data for the construction of their courses and incentivize authors when their content is reused. Regarding the quality of individual course content and overall course development, Garg et al. (2021) present their "Blockchain-based Online Education Content Ranking" model. This model enables subject matter experts (SMEs) from diverse fields of interest to participate on the platform and evaluate online courses' content, quality, and overall efficacy. Furthermore, Guo et al. (2020) propose a "blockchain-enabled digital rights management system" (p. 974) involving multiple institutions. Each of these institutions has a private blockchain network for their direct participants, and these networks are part of a more extensive public blockchain network. According to Guo et al. (2020), this combination should secure the trustworthy sharing and management of multimedia courses and contents. Thirdly, regarding the specific course execution, Sharples and Domingue (2016) also refer to a blockchain-based motivation and learning management system. It allows educational authorities to implement so-called Kudos, a type of fungible token, in their Learning Management System (LMS) to track, motivate, and reward learners with coins that can be reused (Sharples & Domingue, 2016). In addition, the implementation of micro-credentials plays a crucial role in the fourth step of evaluating and certificating learning outcomes and handling subsequent diploma management. In partnership with MacArthur Foundations, Mozilla has been developing and disseminating its so-called Open Badges in 2010, allowing micro-credentials from courses to be accredited. Those badges are used to represent the successful completion of various learning or further training activities, thus promoting the lifelong learning process (1EdTech Consortium Inc., 2023; Cheriguene et al., 2022; Mikroyannidis, 2020). Since then, several other initiatives have been emerging, such as Cert4Trust, launched by the IHK Munich (2023); MyEduLife, an initiative from the Dresden University of Technology (2021); QualiChain, initiated by the National Technical University of Athens (NTUA) in 2020, or EduChain (2021). All those programs propose similar solutions for elaborating digitized certificates, all stored as NFTs on a private or public blockchain.

The systematic literature review shows that using blockchain in an educational context is a widely discussed topic. However, the gathered literature focuses on the higher education sector rather than adult education. Consequently, in combining literature findings with the importance of life-wide learning according to the philosophies of education of Dewey (1916), Klafki (1962), and Reischmann (2017), this paper aims to develop an overview of blockchain use cases holistically over all the continuing education management phases. Thus, the development of the taxonomy in this paper aims to answer the following research question:

Where can blockchain technology be integrated to enhance and transform the management of continuing education phases considering current blockchain use cases?

The taxonomy development process follows the approach of Nickerson, Varshney, and Muntermann (2013) and is based on a systematic literature review and 15 expert interviews. Our results extend the current state of literature by making theoretical and managerial contributions in 1) relating all phases of continuing education management to blockchain and 2) providing a guideline for professors, teachers, knowledge managers, coaches, and others on using blockchain implementation to leverage its opportunities throughout continuing educational program development in an institutional or company-internal context. The remainder of the paper is structured as follows. First, we introduce a theoretical foundation on philosophies of education and blockchain technology. After achieving a detailed understanding of these concepts, we present our research methodology, followed by a detailed description of the resulting taxonomy. Finally, we discuss the resulting taxonomy, its contributions, and limitations.

2 Theoretical Background

The following chapter provides the fundamentals for understanding the dimensions and relevance of the subsequently elaborated taxonomy in the context of continuing education and blockchain technology.

2.1 Continuing Education

Lehner (2019) and Seufert (2013) distinguish the primary and secondary sectors of pedagogy as crucial mediators of cultural principals from the tertiary sector as a professional academic pedagogy. They also define the quaternary sector as addressing the lived realities in qualification-related jobs in continuing education and further training. This work focuses on discussing relevant aspects concerning pedagogy in relation to the quaternary sector at the macro, meso, and micro levels. Wolfgang Klafki's philosophy of categorical education, with its double sense of material and formal philosophy of education (Klafki, 1962), as well as Dewey's philosophy of intentional and incidental learning (Dewey, 1916), led to the modern understanding of "life-wide learning" according to Reischmann (2017). These philosophies promote the importance of holistic and lifelong learning, not only including the constant gain of theoretical knowledge but also of values, skills, and attitudes. Such a wide range of knowledge should be provided by further training supported by institutions and companies. The field of andragogy in corporate and business education represents a subset of economic education (Seufert, 2013) that distinguishes between two specific types of learning in the corporate environment for adults, namely upskilling and reskilling. According to Holleis (2022), Upskilling is the acquisition of new competencies in the employee's current role, while reskilling focuses on developing new skills to perform entirely new roles. Companies and public institutions apply the phases of continuing education management proposed by Dehnbostel (2020) to offer employees wide-ranging and impactful further training programs. The mentioned phases originally included three steps: "planning, implementation, and evaluation" (Dehnbostel, 2020, p. 16). These address the elaboration of the matching institutional framework for courses, their conceptualization, their methodological and practical execution, and the evaluation and certification depending on the respective participants. In the context of holistic education and from the perspective of educators and instructors, however, these three steps should be enriched by two more dimensions to cover the phases holistically. Adding Research & Development and Distribution leads to the five-step, end-to-end process of continuing education management shown in Figure 1. All these steps provide numerous characteristics that can be connected to blockchain technology, and therefore, will build the foundation of the following taxonomy.

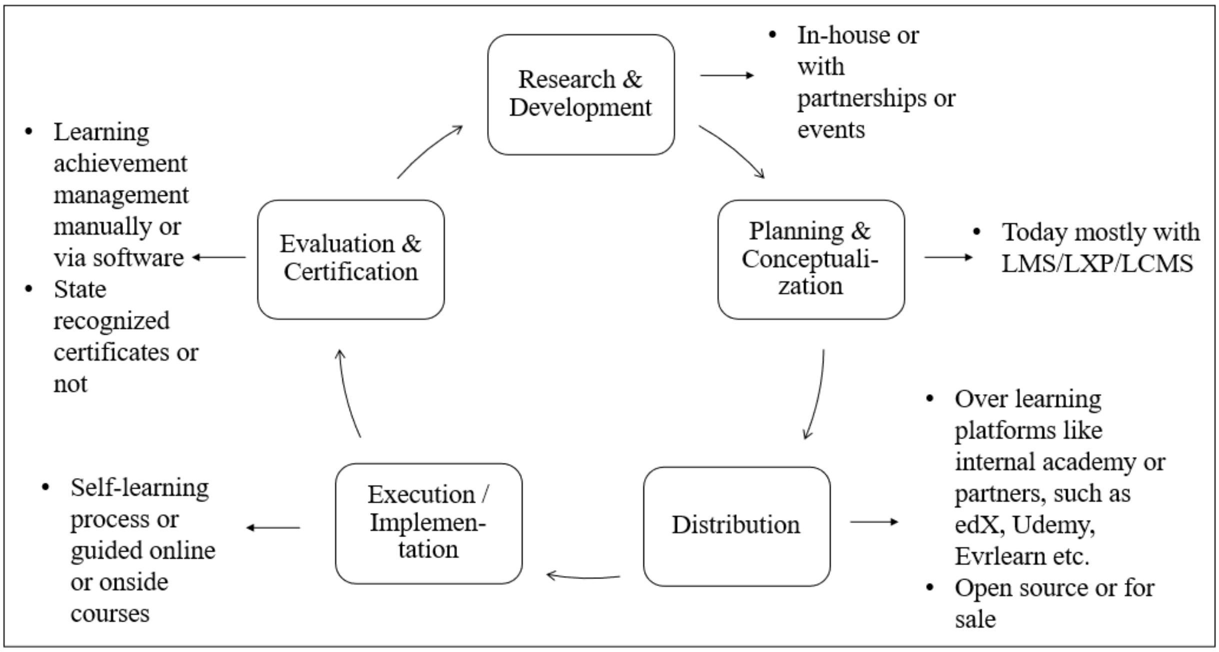

Figure 1. Phases of Continuing Education Management (own representation).

2.2 Blockchain

Blockchain is primarily known because of the introduction of the cryptocurrency Bitcoin in 2009 (Nakamoto, 2008). Today, the technology is the foundation for many use cases based on smart contracts and data tokenization. Blockchain technology represents only one scope of Distributed Ledger Technology (DLT), which is a system to store and update digital data decentrally distributed over and accessible via every computer that is part of the system (Ma & Fang, 2020; Belotti et al., 2019). This distributed system of single computers, also called nodes, acts as processing and peer-to-peer (P2P) reviewing instances, providing a global virtual network for transactions with data structures, so-called distributed ledgers. Like that, a complex platform of bilateral programming transmitting encrypted values of different forms between two parties is developed without any intermediate institutions needed for the transaction (Belotti et al., 2019). With blockchain technology, such decentralized transactions are stored in blocks that are cryptographically linked in a chain via so-called hashes representing individually created encrypted numbers based on mathematical hash functions for every single transaction. Hashes are individually time-stamped, irreversible, immutable, or at least mutable with considerable calculating and computing power (Nakamoto, 2008; Hofmann et al., 2018). Overall, the Blockchain system is an entirely self-controlled network that enables decentralization of data and their transmission as well as transparency and authenticity, immutability, and, most importantly, with an increasing number of users/nodes, also an increasing authenticity and security (Liashkevych et al., 2021; Belotti et al., 2019).

2.3 Blockchain-based Augmentation

Blockchain, as an underlying or supplementary technology, brings beneficial impacts concerning storing, tracking, and transferring data types for augmenting the phases of holistic continuing education (Sunny et al., 2022; El Koshiry et al., 2023). Especially, the Internet of Things (IoT), i.e., the data exchange and communication between technical objects based on the Internet, seems to benefit from blockchain augmentation regarding the machine-to-machine communication (M2M) and "smartification" of environments (Viriyasitavata et al., 2019, p. 25ff.). Such use cases are based on implementing smart contracts that are digital, distributed, and immutable agreements based on computer programs implemented in the blockchain code. Smart contracts build the fundament for cryptographic tokens, representing digitalized, encrypted values replacing tangible or intangible sensitive data, such as information about learning achievements, that are either fungible (interchangeable) or non-fungible (unique) (Oliveira et al., 2018; Hartwich et al., 2023). Regarding the smartification of environments, smart contracts are also used to build so-called Decentralized Autonomous Organizations (DAOs). DAOs are "collectively owned, blockchain-governed organizations working towards a shared mission" (Wang et al., 2019, p.870). On a higher level, previous research claims that DAOs have the necessary organizational structure to build smart (educational) institutions. Smart institutions enable new forms of collaboration by augmenting different processes by integrating numerous new technologies besides blockchain, such as artificial intelligence (AI), virtual reality, gamification, IoT, and cloud computing (Agarwal et al., 2021; Chaiyarak et al., 2020; Chen et al., 2023; Hsu et al., 2022).

The conducted systematic literature review showed that, along the five steps of continuing education, blockchain has recently been implemented mainly in diploma and performance management which represents the step of evaluating learning achievements (Sharples & Domingue, 2016; Grech & Camilleri, 2017; Ma & Fang, 2020; Bhaskar et al., 2021). Regarding the first phase, Research & Development, Bhaskar et al. (2021) and Van Rossum (2017) suggest that blockchain technology may help researchers enhance their searches and development processes. By enabling decentralized, public, or private networks, blockchain technology offers individuals, groups, or institutions a platform to collaborate with their test subjects. This network of research sources can then be used to conceptualize new course structures and content. Sun et al. (2018) also note that blockchain-based smart contracts offer benefits for creating a massive "resource-sharing platform" (p.6). As mentioned in the introduction, several researchers (Guo et al., 2020; Garg et al., 2021) also examine the quality and digital rights management of data published in a blockchain network, which is especially important for teachers in the course development and distribution phase. Concerning the use and emission of literature or even entire courses, Guo et al. (2020) claim that their "blockchain-enabled digital rights management system" (p. 974) safeguards intellectual property of researchers and teachers. Only contents that have been watermarked (verified for digital rights) will be stored and made public in the blockchain network. Regarding the course execution phase, blockchain can can support smart educational institutions by enabling seamless integration of various technologies and M2M communication. This allows teachers to implement their curriculum digitally, linking tasks to certain digital applications or functions. Such integration not only enhances learners' motivation, for example, through gamification but also enables tracking their learning process, even in group tasks, while providing personalized feedback (Bdiwi et al., 2018; Chen et al., 2018; Fedorova & Skobleva, 2020; Haque et al., 2022). Here, Kudos (Sharples & Domingue, 2026) or other types of micro-credentials, technically spoken fungible or non-fungible tokens, also play a crucial role. Those micro-credentials not only incentivize students but simultaneously indicate the course or curriculum quality, as Duan et al. (2017) emphasized. Lastly, also the phase of evaluation and certification can be augmented by blockchain. As a result, the technology is used to create, store, and manage non-fungible certificates in a trustworthy and tamperproof manner. Typically, this involves the elaboration of an individually managed digital wallet, also known as an academic passport, for each learner, into which the institution can insert the issued certificate (Agarwal et al., 2021; Chen et al., 2018; Deenmahomed, 2021; a.o.). In summary, the SLR reflected numerous use cases for augmenting the holistic phases of continuing education management with blockchain. However, the discussed use cases in literature mainly focus on the learner's perspective and the benefits of using blockchain in higher education rather than in continuing educational contexts. These selectively thematized use cases include, among others, a simplified enrolment in university courses with a digital identity, the payment of tuition fees with digital currency, the collection of learning achievements in the form of micro-credentials, such as coins or badges, in a personalized digital wallet, and the receipt of digital certificates, all stored on the blockchain of an institution and accessible to selected stakeholders. Despite these advancements, most studies neither take an integrated approach to evaluating blockchain applications across the entire education management process nor consider benefits from the teacher's perspective. Additionally, we expanded the education management process to incorporate specific requirements and characteristics of lifelong learning and continuing training. Based on the findings from the SLR and interviews, the taxonomy developed and presented in this paper is, to the best of the authors' knowledge, the first to address these perspectives.

3 Methodology

Building on the existing corpus of theoretical background, the following section explains the overall process of our taxonomy development, as represented in Table 1.

Research Phase	Method	Activities
1 Taxonomy Database Creation	Systematic Literature Review and Semi-Structured Expert Interviews (Webster & Watson, 2002; Glaser & Strauss, 1967)	1. Analysis of the literature on transferability on and relevance for the quaternary educational sector 2. Coding of interviews to extract relevant information
2 Taxonomy Development	Taxonomy Development (Nickerson et al., 2013)	1. Definition of the meta-characteristic 2. Definition of ending conditions 3. Selection of an empirical approach for each iteration 4. Checking if the ending conditions are met after each iteration
3 Taxonomy Evaluation	Taxonomy Evaluation (Nickerson et al., 2013)	1. Evaluation of layers, dimensions, and characteristics according to ending conditions in open, iterative feedback sessions with experts

Table 1. Overview of the Three Research Phases adapted from Weber et al., 2021.

3.1 Phase 1: Systematic Literature Review and Interviews

We conducted a systematic literature review (SLR) following the conceptual approach according to Webster and Watson (2002). Due to the subject area, which was narrowed down to Education and Computer Science, the databases Web of Science and Computer Source in combination with ERIC database were chosen. As shown in Figure 2, the keyword search filtered for English-language content, articles and reports, peer-reviewed academic journals and the exclusion of duplicates from the two databases used resulted in 44 relevant articles. Keywords, such as 'continuing education' or 'upskilling', did not yield matching results, while the term 'DLT (distributed ledger technology)' has not been used because, as mentioned above, blockchain only is a subset of DLT. The latter keywords have, therefore, not been included in the SLR. After the full-text screening of the 44 articles, we further filtered them by thematic relevance and enriched them with results through a backward search. Finally, the remaining articles contain not only proposals of applications transferable to the quaternary sector but also proposals addressing the teachers' perspective to close the research gap. Nevertheless, only a few articles were found that described the possible impacts and use cases of blockchain technology on the specific field of continuing education. Therefore, we also conducted 15 semi-structured, open-ended expert interviews. The conduct and coding of the interviews were based on the grounded theory and theoretical sampling developed by Glaser and Strauss (1967). This enables the researcher to collect, codify, and evaluate data simultaneously in a reciprocal research process (Glaser & Strauss, 1967; Zaynel, 2018). The group consisted of Swiss, Germans, and Austrians aged 30-55, including two women and 13 men. This group of interviewees was selected according to the principle of purposive sampling, which represents a "systematic choice" (Glaser & Strauss, 1967, p. 9) of a homogeneous sample. We decided for this approach due to access and language considerations. Nevertheless, we engaged with experts who have recognized expertise in (continuing) education, blockchain, or both, and who are mostly involved in blockchain-related projects in the DACH region. To reduce potential bias and to determine unique requirements of the continuing education sector, we ensured representation from different types of institutions - including universities, vocational schools and corporate training departments. Furthermore, we balanced our interview findings with the literature review, that incorporates international sources and perspectives.

Before the interview, each respondent received their personalized interview guideline to give them a first insight. The interview structure and the open-ended questions were based on the overall guidelines for qualitative interviews in research by Myers and Newman (2007). According to them, the four steps of the opening, a mutual presentation of the interviewer and interviewee, a brief introduction to the topic, some key questions as well as the closing, like asking for potential further interviewees were incorporated in our final questionnaires (Myers & Newman, 2007). Following the transcription of the interviews, they were uploaded into Atlas.ti for single-author deductive-inductive coding (Goulding, 2002). Core categories were predefined based on continuing education phases, namely research, course conceptualization, distribution, execution, and evaluation. However, additional categories, such as institution type, addressees, governance/regulations, teaching process, and blockchain infrastructure, emerged inductively. Most codes were mutually exclusive, though some codes overlapped during axial coding. To maintain manageability in the number of codes, broader labels were used, such as megatrends/market changes under research and plagiarism prevention/intellectual property, relevant across multiple areas. Concerning selective coding, the category blockchain infrastructure was selected as the center of the coding process because of its summarizing nature concerning the relevant underlying technological characteristics and infrastructure.

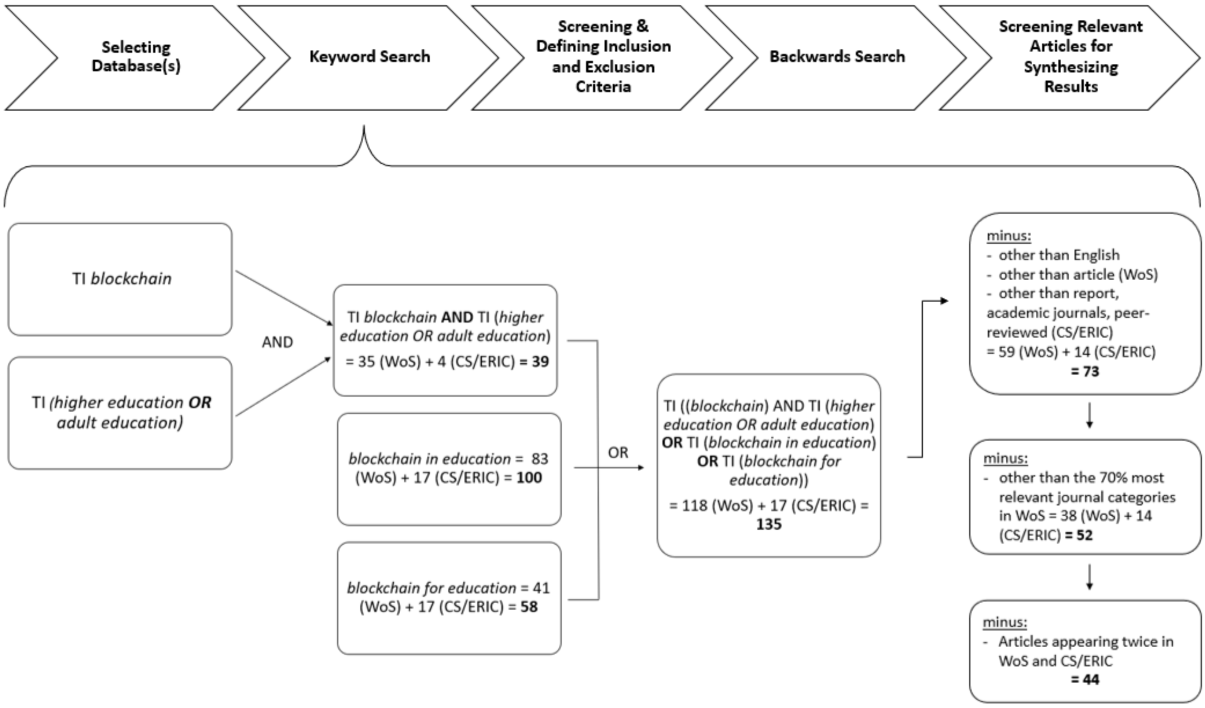

Figure 2. Overview of our Systematic Literature Review (own representation).

3.2 Phase 2: Taxonomy Development

According to Nickerson et al. (2013), taxonomy is a term among interchangeably used others, such as framework, typologies, and classification, that describes a "system of grouping (data) that are derived conceptually or empirically" (p. 338). The overall taxonomy development process is based on the research phases represented in Table 1.

In this paper, the meta-characteristic of the taxonomy is "to guide implementers, teachers, and institutional decision-makers on using blockchain implementation to leverage its opportunities throughout the holistic phases of educational program development in an institutional or company-internal context." This meta-characteristic addresses the target group of persons responsible for the holistic implementation of training programs with adequate standards and qualifications. This target group includes professors, teachers, coaches, HR professionals and knowledge managers. They belong to three main types of institutions. The first type consists of corporate HR departments responsible for the training of employees. The second type includes private companies that develop and implement training programs for client companies. The third type is represented by independent public institutions funded by government or other investors. The ending conditions were not modified except for the predefined conditions of Nickerson et al. (2013) so that the iterations end when the subjective and objective ending conditions are met.

For the first iteration, an empirical-to-conceptual approach was chosen. Thus, the first draft of the taxonomy was developed based on the findings from the literature review. The layers were developed following the elaborated steps of the process of further education management as mentioned in chapter 2.1. The taxonomy refers to them as Research & Development, Planning & Conceptualization, Distribution, Execution & Implementation, and Evaluation & Certification. Based on the selectively discussed use cases of blockchain in education in the literature consulted, a first set of dimensions as sub steps and corresponding characteristics related to the defined layers has been identified, complementing the first state of the taxonomy. This first iteration did not meet most of the ending conditions and was not a collectively exhaustive classification, so that a second iteration was necessary. The second iteration involved implementing the dimensions and corresponding characteristics based on the information gathered from the first ten expert interviews. Thus, an empirical-to-conceptual approach was used again, resulting in the second draft of the taxonomy. This version was discussed with two IS researchers, who revealed discrepancies and incompleteness regarding the characteristics of the specific dimensions. Especially, the substantial number of dimensions considered important by the various interviewees, exceeded the focus of the five predetermined layers. Therefore, the third iteration served the implementation of the researchers' feedback. Consequently, the number of dimensions was reduced to represent only those that could be actively influenced by and occupy the target group in their daily work, displaying the management of the holistic education phases. The developed third draft of the taxonomy was again reviewed with three interview partners, that affirmed the developed dimensions and characteristics with minor suggestions on the wording. The fourth iteration, then only involved updates to the taxonomy to make it more precise and holistic. That included finding and using more specific and meaningful labels for the dimensions and characteristics affected. At the end of this iteration, the final taxonomy represented a multi-dimensional classification system of the collected data from the SLR and the semi-structured interviews, which was precisely addressed to the identified target group.

3.3 Phase 3: Taxonomy Evaluation

To evaluate if "the user's purpose (can) be satisfied with the taxonomy" (Nickerson et al., 2013, p. 347) we chose the qualitative and iterative evaluation of the taxonomy. Therefore, we interrogated teachers and blockchain experts to get direct feedback regarding the implementation of blockchain to the represented end-to-end phases of continuing education management. In August 2023, the evaluation took place via semi-structured online sessions of around 45 minutes each, with five respondents who had the chance to view the taxonomy beforehand. The respondents are male and aged between 30 and 55 years old, teachers at universities, in executive educational programs, or companies, each with a background in either taxonomy development or blockchain application. Two of these feedback sessions already took place during the taxonomy development process after the second iteration with respondents I4 and I5. In contrast, the other three interviews with I13, I14, and I15 were conducted at the end of the process. This iterative feedback process was chosen to identify weaknesses of the taxonomy at an early stage and to be able to implement the respondent's feedback in time. As presented in the previous paragraph, this approach helped check the taxonomy's explanatory power, stage, and preciseness after each of the iterations. In summary, the step-by-step feedback and improvement facilitated and made the development process more transparent, enabling it to end with an accurate, understandable, and complete taxonomy for the identified target group.

No.	Respondent's Position	Age (rounded), Gender	Duration of Interview
I1	Professor Executive Education	~ 45, male	~ 45 min
I2	Professor Executive Education	~ 50, male	~ 45 min
I3	Professor Executive Education	~ 55, male	~ 30 min
I4	Research Professor & IS Researcher	~ 40, male	~ 40 min
I5	Research Associate & IS Researcher	~ 30, male	~ 40 min
I6	Teacher	~ 50, female	~ 45 min
I7	Lawyer, Compliance Officer & Trainer	~ 45, female	~ 55 min
I8	Group Global Head of Knowledge and Education	~ 40, male	~ 60 min
I9	Editorial Director at a large Scientific Publisher	~ 55, male	~ 50 min
I10	Executive Director Global SAP UCC (university competence centers)	~ 55, male	~ 60 min
I11	Director of Education & Governance Initiatives at a Web3 Company	~ 40, male	~ 30 min
I12	Innovation & Digital Strategy Coach at IHK	~ 35, male	~ 45 min
I13	Manager at a Blockchain Research Center & Professor	~ 40, male	~ 35 min
I14	Scientific Director at a Blockchain Research Company & Professor	~ 55, male	~ 30 min
I15	Economist of Education & Data Scientist	~ 30, male	~ 40 min

Table 2. Overview of conducted Interviews (own representation).

4 Result: Multi-Layer Taxonomy

The developed taxonomy contains five layers, 14 dimensions, and 46 characteristics, representing the phases of continuing education management as described in Chapter 2.1. This multi-layer taxonomy, according to its meta-characteristics, provides teachers with a structured orientation for the development and implementation of blockchain in the corresponding steps. Table 2 shows that the taxonomy tries to holistically represent blockchain use cases over the continuing education management phases. Nevertheless, representing the entire process also includes parts of it that may not directly be linked to blockchain. These specific steps are marked as grey-shadowed fields in Table 3.

	Dimensions	Characteristics						
Research & Development	Execution	Fully in-house	With Partners	No internal R&D				ME
	Publication	Over DAPO (Distributed Autonomous Publishing Organization)	Over Academic Publisher	No Publication				ME
Planning & Conceptuali-zation	Educational Resource Compilation	Compilation of own material	Enriching internally developed material with external material	Purchase of external material				NME
	Quality Management	User-Feedback	SMEs					NME
	Tokenization	Tangible	Non-fungible	Intangible				NME
Distribution	Marketing	Word-of-mouth	In-Person Events	Social Media	Own Website			NME
	Channel	In-house Academy	External Platform					NME
	Compensation	Non-monetary Royalties	Cryptocurrency	Fiat-Money	No Compensation			NME
Execution & Implemen-tation	Instructional Format	Frontal Teaching	Seminar	Keynote/Speech	Self-Study	Workshop/ Groupwork	Flipped Classroom	NME
	Instructional Method	Face-to-Face	Blended teaching/learning	Online (via LMS and/or Platform)				NME
	Technological Integration	Artificial Intelligence	Gamification	Smart Contracts	Virtual Reality			NME
Evaluation & Certification	Course Ealuation	Quantitative	Qualitative					NME
	Incentive Rewarding or Issuing	Coins	Badges	No Reward				ME
	Certification Issuing	Micro-credential	Digital Certificate					ME
	State Recognition	Yes	No					ME

Legend:
orange border = based on literature
orange dotted border = based on interviews
ME = mutually exclusive characteristics
white fields = blockchain augmented
grey fields = not blockchain augmented
NME = not mutually exclusive characteristics

Table 3. Multi-layer Taxonomy of Blockchain in the Phases of Continuing Education Management.

The following part is structured as going through the layers and associated dimensions of the continuing management phases one after another and explaining the respective potential of blockchain augmentation. Additionally, to provide the best understanding of the application of the taxonomy, for each step, we consider an exemplary use case applying to the Industrie- und Handelskammer (IHK) in Germany. The IHK is a government-supported institution that exists in several European countries and represents the interests of businesses, particularly craft businesses. The IHK supports such companies by offering re-training and upskilling programs for distinct groups of employees.

Research & Development: The first layer, *Research & Development*, deals with the necessary research to identify new relevant topics as a basis for course content. This layer includes the processes of *Execution* and *Publication*. The three characteristics, *Fully in-house*, *With Partners*, and *No internal R&D*, describe where and how the target person and the employing institution conduct their research or whether they only rely on external sources. Findings and developed material from cooperating research partners can be uploaded, openly discussed, and mutually peer-reviewed in a blockchain-enabled network of researchers (Bhaskar et al., 2022; Van Rossum, 2017; Yano et al., 2022). Such a massive "resource-sharing platform" (Sun et al., 2018) benefits from blockchain-based smart contracts' high security and efficiency standards. In addition, the *Publication* dimension, which includes the characteristics *Over DAPO* (Distributed Autonomous Publishing Organization), *Over Academic Publisher*, and *No Publication*, allows the target person to decide where, how, or even whether the developed research insights are published. The characteristics of both dimensions are mutually exclusive, According to I12, the R&D process at IHK takes place with numerous partners, such as the Fraunhofer Institute, the Heinrich Piest Institute for Crafts Technology at the University of Hannover, or the German Aerospace Centre (Deutsche Luft- und Raumfahrt (DLR)) to develop new course formats. The partners could benefit from interoperable blockchain networks as transparent database, research and experimentation environments. On the part of the IHK, a subsequent Publication of research results only appears in the figurative sense of processing the developed insights into new course formats, which are published through distribution to the customers.

Planning & Conceptualization: The second layer *Planning & Conceptualization* shows the development of specific training materials, content, and entire courses or programs. The layer contains the dimensions of *Educational Resource Compilation, Quality Management*, and *Tokenization*, all of which benefit from an underlying blockchain network. The *Educational Resource Compilation* dimension, with its characteristics of *Compilation of own material, Enriching internally developed material with external material*, and *Purchase of external material*, represents the step of selecting and collecting materials for the course development. This dimension is mutually exclusive. The phases of enriching one's material or purchasing external material can be augmented by blockchain through a material pool, as mentioned in the previous paragraph, containing peer-reviewed data accessible to teachers. The IHK uses the previously developed research results as material to conceptualise its programs, but according to I12, additional scientific research is carried out to find relevant content, what corresponds to the characteristic *Enriching internally developed material with external material*. *Quality Management* includes the characteristics of *User Feedback* and *SMEs* (Subject Matter Experts), which are not mutually exclusive. The quality of the course material and the whole program can be elevated by asking for users' feedback at the end of the course's implementation. Garg et al. (2021) present their "Blockchain-based Online Education Content Ranking" (p.1) model that enables SMEs from diverse fields of interest to participate on a blockchain platform and evaluate online courses' content, quality, and overall efficacy. According to I12, at IHK the developed course is tested for its effect and quality by its execution with several test groups of about 10 persons giving their feedback on the contents. The tested program then has to be brought into a distributable form through its *Tokenisation.* In other words, it is digitised and becomes an *Intangible*, *Non-fungible* material, because it has been independently developed by the IHK itself. In the case of confidential or personalized material, it is desirable to create non-fungible tokens out of the data. Again, the blockchain network plays a crucial role in protecting sensitive data. A fungible form of the developed material is generally not intended by the teacher or researcher because the data is individually developed and, therefore, should not be easily replaceable. According to respondent I2, the target person owns the intellectual property rights and wants to make money from them or earn scientific credits for their work. Nevertheless, not all the material necessarily has to be in a digital, intangible form. There may be aspects or situations where tangible material is valuable, and no blockchain augmentation is necessary. As explained above, the characteristics of *Tangible, Non-fungible*, and *Intangible* are not mutually exclusive. Teachers may own the material in different forms at the same time.

Distribution: The *Distribution* layer deals with the prerequisites, execution, and compensation in bringing the developed course to the public. The layer includes the dimensions of *Marketing, Channel*, and *Compensation*. The *Marketing* dimension includes the characteristics *Word-of-mouth, In-Person Events, Social Media*, and *Own Website* representing direct and indirect ways of promoting one's programs, which can be applied reciprocally but do not have to be directly linked to blockchain augmentation. IHK uses a mix of those marketing measures and could track their performance by the institution's underlying blockchain. With the dimension *Channel* the target person can decide where to share their material and at what price. As the characteristics of *In-house Academy* and *External Platform* show, the material can only be accessible within the company to enrich the internal academy, or the target person can only or additionally publish their program on an external platform. In case of IHK, I2 explained that the distribution of their courses primarily takes place via their in-house academy, which is open to any type of adult interested in education or further training. Both ways of distribution can be augmented by an underlying private or a public blockchain network. According to Guo et al. (2020), the combination of both should facilitate and secure the trustworthy management and sharing of course content with attendees as well as partners. The *Channel* dimension, as well as the *Compensation* dimension, are not mutually exclusive. The latter shows the different types of compensation the teacher may receive for developing and distributing their content. It includes the characteristics of *Non-monetary Royalties, Cryptocurrency, Fiat Money*, and *No Compensation*. The first two characteristics are directly linked to blockchain as digital tokens. It is not excluded that teachers may receive more than one of these types of compensation, depending on the combination of channels used for distribution. Overall, in the distribution step, an underlying blockchain network would provide a transparent and secure environment for sharing the developed materials and receiving payments. However, as the courses of IHK are not sold, but distributed and delivered mostly free of charge, the institution does not receive any direct compensation for offering and delivering a course. **Execution & Implementation:** The fourth layer, representing the phase of *Execution & Implementation*, includes the three dimensions *Instructional Format, Instructional Method*, and *Technological Integration*. It deals with all the decisions concerning implementing the developed course in a specific environment. The first dimension, *Instructional Format*, represents diverse ways of designing and delivering a teaching lesson, considering influencing factors, such as the location, the size of the group to be taught, their background, the content of the program, and much more. The dimension with its characteristics of *Frontal Teaching, Seminar, Keynote/Speech, Self-Study, Workshop/Group Work*, and *Flipped Classroom* usually are not directly augmented by blockchain. The dimension *Instructional Method* focuses on the environment in which the program takes place. As the characteristics show, such a course can be delivered *Online* or *Face-to-Face*, or the target person can offer parts of it online and others on-side, referred to as *Blended Teaching/Learning*. In the online environment, an LMS or other platform plays a crucial role in organizing the tasks, the degree and type of involvement of the learners, and tracking their achievements. Respondent I3 referred to the LMS as the "central instrument of communication with the student." Also, the IHK uses the LMS of Moodle to communicate relevant information to the course participants and to give them a platform for relevant literature, videos, or tasks. Such an LMS could be implemented on a blockchain network to provide more transparency and security. With the characteristics of *Artificial Intelligence, Gamification, Smart Contracts*, and *Virtual Reality* as part of the step of *Technological Integration*, various other technological applications may be used and added to the courses. I12 gave several examples of courses that have already been developed at IHK, or are in the process of being developed, using recent technologies to deliver content. A specific one is a course where participants learn new welding techniques in a *Virtual Reality* environment before their practical lessons and examination. This combined use of different technologies augmented by an underlying blockchain leads to the already mentioned smart education institutions. All the characteristics of the three dimensions mentioned in this layer are not mutually exclusive, as the teacher is free to combine them as considered appropriate.

Evaluation & Certification: The final layer, *Evaluation & Certification*, represents dimensions and characteristics related to decisions that influence participant satisfaction through rewards, certification and feedback to the target person. The dimensions include *Course Evaluation, Incentive Rewarding or Issuing, Certification Issuing*, and *State Recognition*. The *Course Evaluation* step allows the teacher to get feedback for improving the program or as basis for new developments by carrying out a qualitative or quantitative questionnaire at the end of the course. In the case of the IHK, the courses are additionally evaluated by external bodies, that I12 referred to as "third-party certification" (2023) which is mandatory for all IHK programs. The *Qualitative* and *Quantitative* characteristics are not mutually exclusive. During the course, or at least at the end of it, the target person must decide on giving incentives or rewards to their participants. The similarly named dimension, *Incentive Rewarding or Issuing*, has characteristics such as *Coins, Badges*, and *No Reward*. Coins and badges, in this case, refer to fungible and non-fungible tokens on the blockchain, which are mutually exclusive due to their characteristics. As explained in Chapter 2.2.2, Sharples & Domingue (2016) propose implementing Kudos allowing the teacher to track, motivate, and reward learners with coins that can be reused (Sharples & Domingue, 2016). The IHK has not implemented a blockchain, nor is it currently part of another blockchain that would allow the implementation of such digital fungible tokens. Thus, they do not reward their participants with digital incentives, yet. Nevertheless, respondents I3 and I4 stressed that the Evaluation & Rewarding process is a two-sided dimension that deals with the issuing of rewards by the teacher on the one hand and the possibility of earning rewards by successfully running and completing a course as a teacher on the other hand. Similarly, the *Certification Issuing* dimension includes the types of certificates issued by the target person to the participants, such as a *Micro-credentials* or a *Digital Certificate*. These characteristics are not mutually exclusive. Micro-credentials can also indicate the quality of the course delivery by demonstrating the motivation of participants to complete the course and their success in the new work environment after attending the course (Williams, 2019). The latter can then be projected onto the course quality, as Duan et al. (2017) emphasize. Accordingly, the steps of *Incentivizing and Issuing Rewards and Certificates* are augmented by blockchain implementation. Finally, as respondent I5 emphasized, the teacher must decide or at least promote the issued certificates recognized by the country where the course takes place or even internationally. As a public and governmentally funded institution, the IHK is interested in developing programmes and certifications that are officially recognised by the state and country. The step *State Recognition* is not directly linked to the blockchain, even if a nationally underlying blockchain network could provide an anonymous, protected environment to issue, store, and manage educational certificates.

5 Contributions, Limitations, and Conclusion

Our taxonomy advances the existing literature by contributing theoretical and managerial insights in two key areas. Firstly, it connects all the phases of continuing education management with blockchain technology. Secondly, it presents an overview of possible blockchain augmentation to guide the target group, on using blockchain technology to optimize opportunities in the existing development and execution of educational programs, whether in institutional or internal company settings.

However, the use of blockchain in the educational context and the developed proposal are accompanied by several limitations. These are not only represented by the selected samples during qualitative research, but they also concern the scope and relevance of blockchain depending on the overall legal, societal, and economic developments in the future. The adult education sector depends on developing other education sectors, changing dynamic labor market structures, and political influences and regulations. Blockchain technology is widely discussed and often associated with numerous uncertainties regarding its ecological impact, its impact on integrity, international and cross-border transactions, and social interaction.

Overall, technological advances also influence industries societal sectors on which a scalable blockchain network depends. Thus, blockchain is increasingly implemented in various industries that define today's society, especially in the financial sector. However, in less apparent niches and markets, the technology is beginning to establish rapidly and with extensive growth, as shown by the expected growth rate of almost 44% in the market size of blockchain in education (Business Research Insight, 2024). Nevertheless, the adoption of blockchain in education faces several key limitations. First, technical challenges arise according to I10, because several applications related to the topic could already be solved by legacy systems, without a costly infrastructure modification to a blockchain system within an institution. In addition, interoperability issues between different blockchain provider and networks can hinder scalability, a concern also highlighted by Guo et al. (2020). Interoperability, implementation, and scalability are not only dependent on technical intersections, but also strongly rely on legal and regulatory standards adding complexity as decentralized governance leads to different national regulations, as I2 and I14 indicate. Political, societal, and psychological barriers further complicate the implementation, as decision makers must develop such new standards, enable users' large-scale adaption to emerging processes and overcome their change resistance due to uncertainty (Grech, Sood & Arino, 2021). Baur (Educa, 2023) also raises ethical concerns about the immutability of the blockchain, which, while ensuring security, may prevent necessary corrections to content that could lead to the spread of incorrect data and information. Baur further mentions, that trust and human interaction, as fundamentals of education, may be strongly disrupted by such security concerns. Regarding blockchain's pseudonymity, especially in private networks that requires participating nodes to be identified, transactions can still be traced back to individuals, posing privacy risks and data protection concerns (Conoscenti, Vetro & De Martin, 2016). Finally, also financial and environmental factors pose obstacles with direct high integration costs of blockchain in legacy systems as well as indirect costs concerning regulatory adaptions or blockchain's significant energy consumption as mentioned by I15.

The developed taxonomy shows that the quaternary sector of education could benefit from blockchain-augmented processes in terms of efficiency in the design of training programs and content development, transparency, protection of intellectual property rights, as well as fraud prevention of sensitive data. Especially in the steps of Research & Development as well as Evaluation & Certification of the continuing education management phases, blockchain augmentation brings benefits such as new forms of secure collaboration and sharing of data, as well as implementing micro-credentials and tokenization into diploma management. Thus, by closing the research gap and providing a guide on blockchain augmentation regarding the entire teaching process, the taxonomy answers the research question. Furthermore, it aims to reduce prejudices and insecurities concerning blockchain technology by using examples of use cases in education.

For future research it would be interesting to not only systematize blockchain use cases in the presented context as we did, but also assess those use cases on the fit and added value of blockchain rather than other technologies. For such an assessment, it would be very relevant to elaborate the technical details on developing and running an underlying blockchain network for an institution or company. The resulting benefits or limitations caused by specific technical aspect of blockchain itself and its interoperability could then be compared to those of other digital solutions and technologies. Studying these technological aspects would be an interesting consolidation of the topic for further research. Also, explaining how such a new system would be implemented into technological and infrastructural legacy systems on a mathematical, computational, and technological level poses a call for further research.

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