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Design of a Blockchain Technology Competence Model for Interdisciplinary Curricula Development

Vladislav Fomin

Vilnius University, Lithuania
vladislav.fomin@knf.vu.lt
https://orcid.org/0000-0001-8423-2500

Tan Gürpinar

Quinnipiac University, United States
Tan.Gurpinar@quinnipiac.edu
https://orcid.org/0000-0003-0176-0338

Dovilė Balevičienė

Vilnius University, Lithuania
dovile.baleviciene@knf.vu.lt
https://orcid.org/0000-0002-4948-0477

Abstract. *Contribution.* This study identifies blockchain-related competences essential for professionals involved in blockchain projects and develops a blockchain technology competence model for interdisciplinary curricula development. *Background.* Amidst the surge in blockchain implementations, a gap exists in systematic knowledge about the skills required from blockchain professionals. While the number of new blockchain implementation cases is growing, there are no systematic reviews on the success factors or the skills required from blockchain professionals. Lack of systematic information on blockchain projects and their implementers presents a substantial obstacle to the development of new competence-oriented academic and professional educational programs, as well as for guiding recruitment for blockchain projects. *Research Question.* This research investigates the necessary knowledge and skills to leverage opportunities and adapt to changing employment trends in blockchain technology. The guiding research question of this study is, what knowledge and skills must be acquired in order to be able to exploit opportunities and to be prepared for changes in employment trends in the context of blockchain innovations? *Methodology.* The study adopts exploratory multiple case analysis based on qualitative content analysis of job advertisement and expert interviews. *Findings.* The study develops a blockchain technology competence model for interdisciplinary academic and professional educational programs. The developed model can also be used for guiding the development of professional training, certification, and recruitment strategies and practice for blockchain projects.

Keywords: Blockchain technology; competence model; education; future jobs; interdisciplinarity; nascent technology

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Blokų grandinės technologijų kompetencijų modelio, skirto tarpdisciplininėms studijų programoms, sukūrimas

Santrauka. Šiame tyrime buvo nustatytos blokų grandinės technologijų profesionalams reikalingos kompetencijos ir sudarytas blokų grandinės technologijų kompetencijų modelis, skirtas tarpdisciplininėms studijų programoms kurti. Didėjant blokų grandinės technologijų vystymui ir diegimui, vis dar trūksta sisteminių žinių apie įgūdžius, kurių reikia blokų grandinės technologijų profesionalams. Sistemingos informacijos apie blokų grandinės technologijų projektus ir jų vykdytojus trūkumas yra iššūkis kuriant naujas, kompetencijomis pagrįstas akademinio bei profesinio mokymo programas, taip pat atliekant darbuotojų atranką blokų grandinės technologijų projektuose. Šiame tyrime analizuojamos darbuotojams reikalingos tarpdisciplininės žinios ir įgūdžiai, kurie leistų prisitaikyti prie besikeičiančių darbo rinkos užimtumo tendencijų blokų grandinės technologijų srityje. Pagrindinis tyrimo klausimas – kokių žinių ir įgūdžių reikia įgyti, jog būtų galima pasinaudoti naujomis galimybėmis ir pasiruošti darbo rinkos tendencijų pokyčiams blokų grandinės technologijų inovacijų kontekste? *Metodologija.* Tyrime pasitelkiama žvalgomoji kelių atvejų analizės strategija, naudojama darbo skelbimų ir ekspertų interviu kokybinė turinio analizė. *Rezultatai.* Tyrimo metu sudarytas blokų grandinės technologijų kompetencijų modelis, kuris skirtas tarpdisciplininėms studijų programoms. Kompetencijų modelis gali būti naudojamas kuriant profesinio mokymo, sertifikavimo, įdarbinimo bei praktikų strategijas blokų grandinės technologijų projektuose.

Pagrindiniai žodžiai: blokų grandinės technologijos; kompetencijų modelis; švietimas; ateities profesijos; tarpdiscipliniškumas; besiformuojančios technologijos

1 Introduction

Following the initial hype, investments in blockchain technologies (BCT) are ongoing, with the total number of funding dollars invested in blockchain start-ups exceeding $3.0 billion in 2019 (CBInsights.com, 2020). Amidst the surge in blockchain implementations, a gap exists in systematic knowledge about the skills required from blockchain professionals. This lack of systematic and reliable information on the new technology (Lumineau et al., 2020) and the specificities of tasks related to BCT innovation and implementation projects – hereafter referred to as blockchain projects – is believed to be one of the reasons for the reported failure rate of 92.5 percent (Forbes.com, 2019).

For the last several years, there was an ongoing discussion on how blockchain technologies could influence research, education, and innovation (Da Cunha et al., 2020; Glaser, 2017; Rossi et al., 2019; Themistocleous et al., 2020). Yet, there remained a paucity of empirical studies of blockchain and its implications for education and business development. To date, publications on blockchain would typically be limited to presentation of technical fundamentals of the technology.

The growing prominence of BCT and the lack of people with appropriate and adequate knowledge and skills to work on blockchain projects must be creating a fertile ground for spouting domain-specific educational programs. However, by 2020 only a few dozen of universities worldwide were offering blockchain-oriented courses or programs (Themistocleous et al., 2020). Slow uptake in blockchain-oriented program development is at odds not only with the contrasting duplet of the high market expectations towards BCT and the high failure rate of blockchain projects, but also with the overall low awareness about the technology among nonengineering communities (Themistocleous et al., 2020).

This research investigates the market required knowledge and skills to leverage opportunities of and adapt to changing employment trends in blockchain technology. At the backdrop of what can be best described as a "blurred landscape of BCT implementations," high overall failure rate of BCT projects and the call to educators to develop new teaching and training programs and courses (Glaser, 2017; Rossi et al., 2019; Themistocleous et al., 2020) which can help prepare professionals capable of coping with "broader complexity for technology-powered change" (Forbes.com, 2019), this paper reports on design of domain-specific competence model for interdisciplinary blockchain curricula development. The question guiding this research was, *what knowledge and skills are required in order to be able to exploit opportunities and to be prepared for changes in employment trends in the context of blockchain innovations*? The resulting blockchain competence model provides the required information on topics and the levels of cognitive learning for the development of academic and professional programs and courses on blockchain technology and its application in different business environments (CC2020 Task Force, 2020; O'Neill, 2010, p. 63).

2 Design of Competence Models for Educational Programs

2.1 The basic principles of new curricula development

The word "competence" refers to the ability to do something successfully or efficiently. Not surprisingly, in academia, the term has evolved into a key concept of educational research (Klieme & Leutner, 2006), as it establishes teleological link between the educational and the market domains: to have the competence to perform job successfully, a person must possess a range of relevant to the job *skills* and *knowledge* (Roberts, 1997; Blanka et al., 2022, p. 10).

Orientation of educational programs to expected skills, or competences, have become an established practice in Europe (Biggs, 2011; Finster & Robra-Bissantz, 2020) and globally (CC2020 Task Force, 2020; Topi et al., 2017). For example, there are national and international guidelines with recommended competences for IS (Topi et al., 2017) and business degrees (AACSB, 2020) and accreditation agencies require from the universities to explicate and justify the list of competences found in the educational programs (Finster & Robra-Bissantz, 2020).

At the same time, the process through which the universities identify the market-required skills and knowledge is usually internalized (O'Neill, 2010, pp. 62–63). As a result, there is a paucity of published examples on how to identify the skills or operationalize the competences the future professionals must possess for successfully dealing with nascent technologies.

Given that the process of new curricula development is university- and program-specific (Gudonienė & Rutkauskienė, 2015), and that different approaches to curricula development exist, the effort becomes a "local phenomena" which can hardly be externalized. At the same time, if the competences the graduates must possess were identified in a systematic manner (Diamond, 1998), they can be treated as a "global reference point" for any university world-wide, as identification of skills is a common element of most curricula development models (O'Neill, 2010, p. 63).

This is definitely true for world's and Europe's most popular (O'Neill, 2010, p. 63; Ornstein & Hunkins, 1988) approach to curricula development – rooted in Tyler's (1949) "product model" – which is focused on learning objectives (LOs) (O'Neill, 2015, p. 27). A more specific implementation of the product model – that of "backward design" model - defines three consecutive stages in the curricula development: identification of learning goals, identification of required knowledge for the assessment of learning, and devising the learning activities (G. Wiggins & McTighe, 2010; G. P. Wiggins & McTighe, 2012).

This paper caters to the goals of the first stage of curricula design process, which is focused on answering the question "what do we ultimately want students to know, understand, or be able to do?" (G. P. Wiggins & McTighe, 2012). Specifically, the primary aim of this research was to identify factual knowledge and skills (Schwieger & Ladwig, 2021, p. 170) relevant to BCT implementation projects.

To facilitate the applicability of the research findings for the consecutive stages of curricula development, the identified skills were mapped into *a competence model*, featuring four commonly used competence categories (Finster & Robra-Bissantz, 2020). The interface to the subsequent stages of curricula development process, during which masters of particular programs will be defining discipline-specific learning goals and measurable LOs according to university- and program-specific requirements and formats, is established by complementing each of the identified skill with the "statements of what we expect or intend students to learn as a result of instruction" (Krathwohl, 2002) according to the revised Bloom's taxonomy of educational objectives (Bloom, 1956; Krathwohl, 2002).

2.2 The task of competence modeling

The task of developing program- and course-specific LOs requires that learning goals are meaningfully anchored to the theoretical and empirical domains of knowledge (Kollee et al., 2009). Accordingly, identifications of required skills for future technology professionals is performed in connection with a specific domain (Campion et al., 2011; Nickolaus & Seeber, 2013). As different jobs may require specific clusters of skills (Jerman et al., 2018), educational research is concerned with developing the description of the respective competences and their clustering – the task referred to as competence modeling (Campion et al., 2011; Klieme & Leutner, 2006; Nickolaus & Seeber, 2013).

Scholars distinguish different types of competences: professional (or technical), social, self- (or personal) (Roth, 1971), and methodological competences (Reetz, 1999). Technical competences cover all job-related knowledge and skills, while methodological competences represent all skills and abilities for general problem solving and decision making. Social competences describe all abilities and skills as well as the attitude towards cooperation and communication with others. The personal competences encompass the social values, motivations and attitudes of an individual (Hecklau et al., 2016, p. 4).

Identification and justification of the aforementioned categories of competences is also required for accreditation of educational programs (Finster & Robra-Bissantz, 2020).

Modelling the competences according to traditional to educational system four basic categories (Janjua et al., 2012; Nyikes, 2018) helps overcome the critique of overly prescriptive lists of skills being produced under the product model of curricula development (Hussey & Smith, 2003, p. 367) on the one hand, and empowers students to choice (or flexibility) with regard to what they want to learn (O'Neill, 2015, p. 36) on the other hand. To date, no domain-specific competence model has been developed for blockchain technologies. The blockchain competence model reported here establishes a universal reference for educators aiming at developing blockchain-oriented programs which are expected to meet job market needs (Finster & Robra-Bissantz, 2020; Kachalov et al., 2015; Zeidmane & Cernajeva, 2011).

3 Research Design

The extant academic research (Fill & Haerer, 2018; Glaser, 2017; Janaviciene & Fomin, 2019; McAbee et al., 2019; Rossi et al., 2019; Schlecht et al., 2020), blockchain implementations (CBInsights.com, 2020; Forbes.com, 2019; FT.com, 2019), projections for the future development of technology (Schlecht et al., 2020; Themistocleous et al., 2020), and currently recognized obstacles to wider technology adoption [(Levi & Lipton, 2018; Politou et al., 2019; Raskin, 2017), all speak of transboundary (or interdisciplinary) scope of blockchain projects. Interdisciplinarity seems to be one of the certain things about the otherwise blurred development landscape for blockchain.

At this background, this research followed the guidelines reported by Lansu et al. (2013) for the design of competence-oriented courses: "first, the curriculum design should be directed towards the acquisition of transboundary competence. Second, competence development should be a holistic rather than a fragmented approach" (Lansu et al., 2013, p. 125).

While literature on curricula development does not prescribe any specific "holistic method" for identification of transboundary competences for future graduates, scholars generally agree that a systematic approach to the discovery process must be taken (Lansu et al., 2013; Rompelman & De Graaff, 2006). Accordingly, this research was designed with the aim to conduct an exploratory case study (Eisenhardt, 1989) on blockchain-related competences. To cater for the acquisition of transboundary competences, data collection was set to encompass different business domains.

The study used job advertisements and expert interviews as data sources for identifying domain-specific competences for future blockchain professionals. The main research question was formulated as the following:

- *Which blockchain-related competences are seen relevant by practitioners for coping with future blockchain projects?*

Within the main research question, the following questions were formulated:

- *Which competences are necessary for employees involved in blockchain operations?*
- *Which competences are the most important, and why?*

Given the interdisciplinary scope of BCT application, this study also investigated which team members were involved in blockchain projects and which methods were used for interdisciplinary work. Thus, the following question was formulated:

- *How an interdisciplinary team composition may influence blockchain operations?*

3.1 Research method

To obtain valid and generalized findings, this study followed a three-phase approach suggested by Yin (2011): 1) the development of a data collection protocol and the selection of cases; 2) collection of data on the basis of the protocol and 3) per-case and cross-case analysis leading to research conclusions. To ensure that a comprehensive set of competences is identified, and taking into account the reported transboundary nature of BCT and its applications (Forbes.com, 2019; Lumineau et al., 2020), cases from different industries were analyzed and experts with diverse backgrounds, with both technical and nontechnical expertise were interviewed to ensure that transboundary competences are properly identified (Lansu et al., 2013, p. 123).

Following a hierarchical approach to the development of competence models (Lucas, 2020), under which the definition of higher-level competence areas is followed by identification of lower-level competences for each area (Topi et al., 2017), technical, social, methodological, and personal competences were adopted as the higher-level categories, as previously suggested by experts of educational domain (Reetz, 1999; Roth, 1971). For identification of the lower-level categories two rounds of data collection were done in 2018: the text analysis of job advertisements (Föll et al., 2018), and expert interviews.

Job ads were collected through online portals of the three largest recruiters in Lithuania, Germany, Estonia and Denmark. Additionally, the pan-European job advertising database has been queried and industrial partners of the involved universities were asked to refer to their recent blockchain-related job positions. The template for collection of job ads included, among other, title of position, market segment, field of the position, skill demand (requirements for position), and responsibilities. The search process resulted in 85 job advertisements: 12 from Lithuania, 34 from Germany, 15 from Estonia, 1 from Denmark, and 23 from the pan-European online job database. Each job advertisement was thoroughly reviewed, the job skills extracted and classified according to the four top-level categories.

When nascent technologies and their novel applications are considered, Lansu et al. (2013, p. 123) argued for the importance of "interaction with the workfield" in ensuring that transboundary competences are properly identified. This approach is in line with the "backward design" model of Wiggins and McTighe (2010), which sets focus on "knowledge requirements in the field of study" (Schwieger & Ladwig, 2021, p. 170).

Accordingly, expert interviews were conducted to refine, validate and expand the results obtained through the job ads analysis (Ridder, 2019). A semistructured interview guideline was followed (Tables V and VI in the Appendix). The aim was to find a balance between asking the intended questions and allowing the interviewees to elaborate based on their own experiences (Runeson et al., 2012).

For the interviews, a combination of purposive and snowball sampling techniques was used for the interviewing. The choice of the purposive sampling was justified by the overall small number of known companies (Edgar & Manz, 2017, pp. 106–107) involved in or considering BCT projects. Companies which agreed to be interviewed were asked to refer to potential other interviewees (Edgar & Manz, 2017, p. 107).

The interviewed experts were project leaders, managers, and other blockchain project staff representing 12 different industries with variating project maturity stages, and several blockchain solutions (Hyperledger, Corda, Multichain, different public blockchains, and self-constructed solutions) (Tables VII and VIII in the Appendix). Interviews lasted from 45 to 90 minutes, were recorded and subsequently transcribed.

Qualitative content analysis was deployed on the interview and job advertisement data. Specifically, summary content analysis was used (Mayring, 2020). Under this method, the material is reduced to a manageable short text by preserving only essential content through four steps of abstraction: paraphrase, generalization, first reduction, and second reduction (Mayring, 2020).

Spreadsheet tables were used for the compilation and interpretation of the results. For "paraphrase," the text from the transcript was paraphrased (simplified, streamlined) according to the researcher's own understanding. At this step, it must be ensured that the own words do not stray far from those originally stated, and the intended semantics are preserved. For "generalization," the general ideas and concepts stated in the interview were identified and recorded in a succinct form in one or two sentences to the spreadsheet. At this step, it must be ensured that the generalization falls in line with the initially stated ideas. The generalized content was further reduced into categories and subcategories, which represented the final result of the analysis (see example in Table IX in the Appendix).

Validity of the analysis was ensured by employing cross-checks of the results in peer-debriefings with a group of experienced blockchain researchers (Kuckartz, 2019) seeking the consensus (also referred to as inter-rater agreement (IRA) (Gisev et al., 2013)) among the researchers on the meaning and categories of skill items. Validity of the findings on the other hand was ensured by triangulation (use of different data sources, methods, different types of informants, industries, and different job advertising sites) and by obtaining feedback on the analysis results from select experts from industry and academia. Consultations with experts are considered to be essential tool for curricula design in nascent and interdisciplinary domains of knowledge (Lansu et al., 2013, p. 125; Schlecht et al., 2020; White, 2017; Fomin et al., 2008).

Finally, following the clustering and grouping tasks, each of the identified skill items was ascribed a specific level of expected knowledge, according to the revised Bloom's taxonomy[1] (Krathwohl, 2002) to facilitate the development of learning objectives, educational content and assessment methods in the subsequent curricula development stages (Column (8) in Table X in the Appendix).

4 Analysis of findings

4.1 Domain-specific competence model for blockchain implementation projects

In seeking answers to the first research question "which competences are necessary for employees involved in blockchain operations?," analysis of job ads was performed.

This involved careful reviewing of each text, extraction of the job skills and classification of these skills to the four highest-level categories of the competence model. In total 61 blockchain skills were elicited and classified to professional (31 skills), social (11 skills), personal (self-competence) (9 skills), and methodological (10 skills) (see Table X in the Appendix). These skills are observed in different work-related areas including information technology sector (found in 28 advertisements), financial (in 10 advertisements), crypto-currency trading sector (in 9 advertisements), consulting (in 7 advertisements) and other (e.g., automotive, banking, client innovation, education, energy, engineering, law, sales, supply chain management and tourism).

The job ads analysis helped develop interview protocol for the following stage of data collection – the expert interviews. The largest part of the interviews was used to answer the first two research questions: "what competences are necessary for employees involved in blockchain operations," and "which ones are deemed the most important and why?". Responses indicated 246 categories of skills, of which the number of blockchain-specific items was 110.

A recursive discussion within the research group sought to eliminate redundancies and inconsistencies (Hecklau et al., 2016) among the identified skills, aiming to establish validity of findings through inter-coder agreement (Gisev et al., 2013; Lincoln et al., 1985). The resulting final list contained 87 skills (see Table X in appendix X). Grouping

[1] Categories of the revised Bloom's taxonomy refer to the cognitive domain of learners and allow developing methods to assess whether the degree of knowledge of a learner corresponds to the learning objectives defined by the educator. The lowest category (1) "Remember" (originally: "Knowledge") refers to the knowledge of basic elements of the phenomenon. It requires from the learner ability to remember, describe, relate a phenomenon. The "Understand" (originally: "Comprehension") category (2) is about conceptual knowledge on interrelationships between the basic elements of a larger phenomenon. The learner is expected to be able to explain the phenomenon. The "Apply" category (3) concerns how the knowledge is applied in relevant situations, where the learner is expected to solve a problem using the received knowledge. The "Analyze" category (4) deals with the breaking down the ideas and objects into the smaller and more simpler components thus helping to find evidences for the generalization. The learner is expected to be able to differentiate between the concepts and components of the phenomenon, provide a critical assessment, make associations. The "Evaluate" (originally: "Synthesis") category (5) is about compiling the different ideas into a new whole or alternative solution. The learner is expected to be able to justify the choices, prioritize alternatives. Finally, the "Create" (originally: "Evaluation") category (6) is about subject-specific skills and techniques which allow designing new solutions based on the received knowledge.

the identified skills in predefined four competence clusters allowed to ensure clarity and transparency of the emerging model (Leinweber, 2013). Each skill was ascribed a degree of expected knowledge according to Bloom's taxonomy[1] to facilitate operationalization of learning content and assessment methods in the subsequent stages of curricula development (Diamond, 1998; Kirschner & Van Merriënboer, 2008; Lansu et al., 2013; Michael & Libarkin, 2016; Schwieger & Ladwig, 2021).

Figure 1. **Domain-specific competence model for blockchain implementation projects**

The resulting domain-specific competence model for blockchain implementation projects (Figure 1) features twelve skill clusters, each of which describes the necessary competences for future blockchain experts in the interdisciplinary blockchain environment. Five clusters were discovered in the area of technical competences, three in the area of methodological competences, two in the area of social competences, and two in the area of personal competences.

Among the most frequently mentioned skills in the technical competences cluster (Table I, also see Table X in the Appendix) is the general knowledge about the foundations, the functionality, architecture, components, and the principles of the blockchain technology. Therefore, possession of this knowledge is an essential skill for all future blockchain project professionals, and this competence must become a decisive part of our future educational program. The demand for programming skills also appears to be of central importance.

Table I. **Technical competences**

Skill cluster 1: Technical BCT basics. Be able to explain the general BCT capabilities and functionalities of smart contracts. Be able to compare and explain different BCT solutions and platforms
Skill cluster 2: Business, economics, and finance Be able to explain processes in Business, Economics and Finance and understand the impact of BCT
Skill cluster 3: Supply chain management Be able to explain processes in SCM and within corporate networks and understand the impact of BCT
Skill cluster 4: Computer science and application development Be able to explain the functionalities of the technical elements BCT consists of and understand development requirements in BCT environment
Skill cluster 5: Security Engineering and Privacy Management Be able to explain the impacts that BCT applications have concerning security and privacy management

In the area of methodological competences (Table II), the analytical ability to solve problems can be emphasized. Besides, employees in the blockchain area are expected to master innovative application development methods and be able to develop creative solutions. Finally, the ability to prioritize and structure one's own work well is highlighted as relevant.

Table II. **Methodological competences**

Skill cluster 6: Efficiency orientation Be able to work efficiently in a BCT project
Skill cluster 7: Creativity Be able to use creative approaches in BCT projects
Skill cluster 8: Problem-solving and decision making Be able to find the right decision and solve problems in BCT projects

The most important social competences (Table III) are the ability to lead and manage a team, followed by the ability to lead international and interdisciplinary teams. The importance of good communication and, consequently, the ability to communicate well, both in written and verbal form, is stressed. The most important personal competences (Table IV) identified are willingness to learn and the ability to work effectively and ability to adapt to new settings.

Table III. **Social competences**

Skill cluster 9: Leadership and collaboration Be able to lead a team and network to run a BCT project successfully
Skill cluster 10: Communication Be able to communicate well in order to run a BCT project successfully

Table IV. **Personal competences**

Skill cluster 11: Willingness to learn Be able to learn effectively in order to run a BCT project successfully
Skill cluster 12: Ability to work effectively Be able to work effectively in order to run a BCT project successfully

In the interviews, some skills were also mentioned, which were not included in the final skill list, as they did not represent competences in the classical sense. The most critical point in this respect is experience. Many interview partners emphasize that they perceive it as a great advantage if people in blockchain projects already have experience from other blockchain initiatives. Also, in the interviews, there were auxiliary properties or traits mentioned, which are vital by all means but are too granular or general to be included as a single property. An example would be mathematical basics – a good understanding of linear algebra for computer scientists.

4.2 Blockchain and Interdisciplinarity

Acknowledging the novelty of blockchain technology (CC2020 Task Force, 2020), the high failure rate of BCT projects (Forbes.com, 2019), as well as the broad scope of BCT application (Friedlmaier et al., 2018; Lindman et al., 2017; McAbee et al., 2019), one of the research questions was targeted at investigating the soft skills required for BCT professionals – namely, methodological competences for working in transboundary knowledge environment (Boland & Tenkasi, 1995; Lansu et al., 2013).

The analysis of the interviews shows that teams working in the blockchain environment are indeed heterogeneous, consisting of members with different backgrounds such as computer science, business administration, engineering, supply chain management, natural science, finance, law, insurance, etc. (Tables VII and VIII in the Appendix). Overall, across fourteen studied cases, project teams had computer scientists and experts of eight other fields. In the organization of work in these interdisciplinary teams, constant ongoing communication was reported to have a decisive importance. The most common communication was face-to-face, also supported by technical tools such as email, messengers, or video conferences. Occasionally, methods such as sharing the display content or collaborative work on the code were mentioned.

Besides the importance of good communication, the negative impact of poor communication was also emphasized. For example, interviews mention that a common understanding is not given in some instances. Analysis of methodological competences finds strong support for the need of interdisciplinary education on BCT. Following Lansu et al. (2013, p. 125) definition of transboundary competence as a "multi-competence including the communication competence, collaboration competence and competencies that enable people to deal with different situations … in their professional lives," four of 11 methodological competences can be defined as directly pertaining to boundary-spanning, or interdisciplinarity (see Table X, columns (4) and (7)): ability to transfer knowledge to internal (e.g., colleagues, developers, testers, etc.) and external (e.g., customers, support teams, etc.) stakeholders, ability to organize interdisciplinary work, knowledge of new interdisciplinary working methods, and apply critical thinking.

5 Discussion

Most studies found today on blockchain education focus on the technology fundamentals. Good knowledge of blockchain fundamentals is indeed required due to the complex nature of this technology (Mulligan et al., 2018). The lack of understanding of the complexity of blockchain projects was argued to be one of the reasons for the high rate of their failure (Forbes.com, 2019; Lumineau et al., 2020). On the other hand, findings of this study demonstrate that familiarity with technology fundamentals is but one of many skills forming the competences for future blockchain professionals. Blockchain professionals must also possess good knowledge on business processes in relevant application domains, be open-minded, learn quickly, and be capable of working in international and interdisciplinary teams. The results of this study support the conjecture that an interdisciplinary approach to blockchain education will allow students to better understand "the rules of the blockchain game" and help companies better address their staffing challenges for current and future projects (Themistocleous et al., 2020).

The importance and currency of our findings can be corroborated by the 2023 Future of Jobs Report (WEF, 2023). While the utterly comprehensive 300 pages report does not in any way focus on blockchain professionals, it validates the findings of our work in a number of ways. To start with, the WEF report shows the general trend for the increasing importance of technologies in the creation of jobs and technology literacy as a skill required from workers. Second, "Blockchain developers" and few other BCT-relevant jobs (such as "Information Security Analysts," "FinTech Engineers," and "Digital Transformation Specialists") are listed among jobs with the highest growth in 2023–2027, with over 25% projected growth. (WEF, 2023, p. 30). Finally, the report supports our thesis on the need for professional workforce to develop other than technology basics competences for the successful implementation of technology projects. So, additionally to "Technological literacy," "Analytical thinking" and "Creative thinking"[2] are reported

[2] These two "core skills" find a perfect match in our model's "Methodological competences" competence cluster. Specifically, see the following skills entries in Table X: #46 Ability to transfer knowledge to internal (e.g., colleagues, developers, testers, etc.) and external (e.g., customers, support teams, and etc.) stakeholders; #50 Sketch/imply creative solutions; #51 Apply innovative application development methods; #52 Practice creative solutions;

to be the top 3 "core skills" in importance to their workers in the next five years (WEF, 2023, p. 38).

6 Conclusions

Research reported in this work responds to the call for blockchain-focused research (Da Cunha et al., 2020; Glaser, 2017; Rossi et al., 2019; Themistocleous et al., 2020) and contributes to ongoing debate on quality and relevance of academic and professional educational programs through competency-focused design (Rompelman & De Graaff, 2006; Lansu et al., 2013; Lucas, 2020; Schwieger & Ladwig, 2021).

Through an exploratory study of blockchain implementations in different business domains, this research identified the competences – the skills and the associated degrees of knowledge according to Bloom's taxonomy– required for work on (future) blockchain projects.

The identified competences were clustered into what to the authors' best knowledge is the first comprehensive domain-specific competence model for the blockchain implementation projects. The presented blockchain competence model can be seen as the output of the first stage of "product model" curricula development process with its focus on learning outcomes (Ornstein & Hunkins, 2004), and as the input to the subsequent stages of the curricula development – the university- and program-specific courses development (G. P. Wiggins & McTighe, 2012). The produced model in general and its emphasis on interdisciplinarity are expected to contribute to filling the void of educational programs on BCT and eventually contributing to boosting innovation potential (Penttilä et al., 2014) of blockchain projects. The model also operationalizes the first step "Preliminary Evaluation" of the six-step blockchain integration roadmap suggested by Gürpinar et al. (2024, p.4542). The developed competence model can help companies evaluate their readiness and "strategic orientation" for implementation of blockchain projects.

Given the reported lack of understanding on key benefits of blockchain technology among industry (Forbes.com, 2019), academia (Schlecht et al., 2020), and lay people (HSBC, 2017), identification of the competences required for blockchain professionals is not a trivial task, without accomplishing which, however, education and training of future professionals is not possible. In this light, the second major contribution of this work is the description of a systematic method for skills identification for nascent technologies and future jobs – the process common to most curricula development models but rarely reported in literature.

#53 Knowledge of new interdisciplinary working methods; #54 Apply analytical methods to solve problems; #56 Apply critical thinking.

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Appendix

Table V. **Semistructured interview guideline**

Section A: Instruction for interviewers
Section B: Interview questions
Section C: Evaluation of the interview
1. General questions on the interviewee
2. General questions on the blockchain project
3. Questions on competence requirements
4. Questions on interdisciplinarity

Table VI. **Interview questions**

1.1 Institution name, sector/industry (only if not already clear) 1.2 Interviewee role, department, years of tenure in position / institution 1.3 Company facts & figures (no. of employees, turnover, …) (only if not already clear) 1.4 Business model of the company, their geographical scope of operating
2.1 Do you have BCT implementations, preparations, or plans to implement BCT in the future? 2.2 Why are you interested in BCT? What is your intention and aim in utilizing BCT? 2.3 Can you give us some general information about the Use case? 2.4 Which business processes are (would be) affected by the implementation? 2.5 What kind of Blockchain solution / framework is used (or would be appropriate)?
3.1 Which roles/responsibilities exist among the team members of your blockchain project? 3.2 Which professional skills are necessary for them? Why are they important? 3.3 Which skills other than professional skills are necessary for them? Why are they important? 3.4 Which skills do you see particularly important for the fields Business / SCM / Computer Science / IT Security? 3.5 Which skills do you feel university graduates lack when they start work in a BCT role?
4.1 Which (professional / academic) fields do team members of the Blockchain project come from? 4.2 How is the cooperation between the team members organized? 4.3 What can/should be improved in team collaboration to increase project success? 4.4 Which methods are already used to enable good cooperation between team members?

Table VII. **Conducted interviews**

Industry
Technical wholesale (1), Social security services (1), Timber (1), Agriculture (1), Fashion (1), Energy (1), Blockchain consulting (1), IT security (1), Cryptocurrencies (3), Mobility (1), Digital identities (1), Blockchain for digital twins (1)
Interviewee role
Manager (7), IT specialist (4), Consultant (4)
Interviewee function / department
Management (2), Procurement (1), IT implementation (3), Corporate Social Responsibility (1), Research (1), Consulting (2)
Project stage/ maturity
Implementations (8), Preparations (5), Plans (1)
Blockchain solutions used
Hyperledger (2), Corda (2), Multichain (2), Public cryptocurrencies (2), Self-constructed solutions (3)

Table VIII. **Blockchain and interdisciplinarity**

Professional fields of team members	
14	Computer science
8	Business administration
8	Engineering & Supply Chain Mgmt
3	Natural sciences
3	Marketing
2	Sales
2	Law
2	Finance
1	Insurance
How work is organized	
5	Ongoing constant communication
5	Meetings
4	Mail/Phone/Messenger
3	Face-to-face communication
3	Desktop sharing
2	Video/Phone conferences
1	Document sharing
1	Workshops
1	Seminars
1	Shared code revision control
1	Following a concrete work plan and steps
What can be improved	
1	Better communication
1	Common understanding
1	Problems between disciplines / different team members

Table IX. **Examples of the empirical content analysis**

Question	
Q1.3.2	What competences are necessary in addition to professional skills to successfully run blockchain projects in an enterprise setting?
Transcript	
T1.3.2	The people in charge of the project definitely have to be team players – to a gre-at degree. You have to be a people person because you have to deal with many different types – internally as well as externally. You have to take everyone as they are, which is a basic characteristic that many people don't have.
Paraphrase	
P1.3.2	Ability to work in a team, be a people person, and respect other people as they are.
Generalization	
G1.3.2	Team work
G1.3.2	Leadership and collaboration
Category	
C1.3.2	Social competences

Table X. **The complete list of skills, clusters, and the level of knowledge required**

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Top category	**Competence cluster**	**Definition of com-petencecluster**	**Frequently mentioned**	**Interdiscipli-narty**	**#**	**Skill item**	**Bloom's level**
Technical competences	Technical BCT Basics	Be able to explain the general BCT capabilities and functionalities of smart contracts. Be able to compare and explain diffe-rent BCT solutions and plattforms.	x		1	Knowledge of the foundations, general functionality, architectu-re, components, principles (e.g., cryptocurrencies, wallets, smart contracts, separate platforms) of blockchain systems	1
				x	2	Explain trust management principles	2
					3	Define ways to maintain blockchain-based systems	1
				x	4	Demonstrate blockchain technology capabilities and apply them to business-related challenges	3
					5	Compare blockchain platforms to enable understanding of different system design choices	2
			x		6	Discuss and compare different blockchain models, scheme and solu-tions with constructed/illustrated application (suggestions, proposals, methods for blockchain use in economics, business and finance)	2
					7	Comprehension of BCT application development	2
				x	8	Knowledge of BC Use Cases and different application fields	1
	Business, Economics and Finance	Be able to explain processes in Busi-ness, Economics and Finance and understand the impact of BCT.			9	Knowledge of auditing, accounting and taxation processes as block-chain application fields	1
			x		10	Knowledge of financial operations, sales, payments, and transactions impacted by blockchain solutions	1
			x		11	Knowledge of regulatory standards, rules, laws, regulations, manage-ment standards relevant for blockchain implementations	1
			x		12	Knowledge of economic efficiency and the profitability of BCT	2
					13	Comprehension of market and customer needs in order to apply bloc-kchain solutions	2
				x	14	Ability to apply process designing methods (e.g. CMMN & BPMN)	3
					15	Comprehension of Risk Management in BCT operations	2
	Supply Chain Management	Be able to explain processes in SCM and within corpo-rate networks and understand the impact of BCT.	x		16	Knowledge of the general capabilities of blockchains in SCM	1
					17	Explain the interoperability of blockchain technology and possible collaboration between unknown or untrusted parties in SCM	2
					18	Demonstrate blockchain capabilities and apply them to counterfeit and fraud prevention problem statements	3
					19	Demonstrate blockchain capabilities and apply them to provenance and track&trace problem statements in SCM	3
				x	20	Analyze how information asymmetry in corporate networks can be addressed by the blockchain-based applications	4
			x		21	Comprehension of Supply Chain Management	2
					22	Ability to design a concept for the use of BCT in SCM	5
	Computer Science and application development	Be able to explain the functionalities of the technical elements BCT con-sists of and unders-tand development requirements in BCT environment.			23	Comprehension of development processes for blockchain solutions	2
			x		24	Knowledge of system architectures, frameworks, different layers	1
					25	Discuss software quality goals and their impact on blockchain system development	2
					26	Describe the software requirements elicitation and engineering process of blockchain systems	2
					27	Develop and manage databases using data management systems (also use of SQL, etc.)	5
					28	Knowledge of network protocols	1
			x		29	Apply different programming languages (e.g. P2P Programming)	3
					30	Develop a testing plan for concrete blockchain solutions	5
				x	31	Knowledge of Cryptocurrencies & Cryptocurrency Coding	1
					32	Ability to apply methods of systems engineering	3

Technical competences					33	Comprehension of interface management	2
					34	Ability to apply formal abstraction	5
					35	Knowledge of the connection bewtween Data Science & BCT	1
					36	Abbility to programm smart contracts	5
	Security Engineering and Privacy Management	Be able to explain the impacts BCT applications have in relation to security and privacy management.	x		37	Describe privacy management principles using the blockchain solutions	2
					38	Explain identity management principles using the blockchain solutions	2
			x		39	Explain how data, information and processes can be secured by the use of the blockchain technology	2
					40	Recognise security countermeasure implications	2
					41	Explain access control (authentication, authorization and identity) models	2
				x	42	Describe transaction protection and validation principles	2
					43	Underline major encryption and signature schemes	2
					44	State major fair mining principles	2
					45	Identify security errors in smart contracts	2
Methodological competences	Efficiency orientation	Be able to work efficiently in a BCT project.		x	46	Ability to transfer knowledge to internal (e.g., colleagues, developers, testers, etc.) and external (e.g., customers, support teams, and etc.) stakeholders	6
			x		47	Demonstrate ability to prioritise and to have a good time-management	3
				x	48	Ability to organise interdisciplinary work	5
			x		49	Ability to structure ones own work well	4
	Creativity	Be able to use creative approaches in BCT projects.	x		50	Sketch/imply creative solutions	3
			x		51	Apply innovative application development methods	3
					52	Practice creative solutions	3
				x	53	Knowledge of new interdisciplinary working methods	1
	Problem solving and Decision making	Be able to find the right decision and solve problems in BCT projects.	x		54	Apply analytical methods to solve problems	3
			x		55	Apply evidence-based approaches for problem solving	3
				x	56	Apply critical thinking	3
Social competences	Leadership and Collobo-ration	Be able to lead a team and network to successfully run a BCT project.	x		57	Lead and manage the team	5
					58	Demonstrate strong (inter-) organisational networking skills	3
			x	x	59	Demonstrate ability to work in international and interdisciplinary teams	3
				x	60	Practice to support colleagues with expert knowledge	3
					61	Establish good social relationships with the customers	3
				x	62	Ability to allocate team members according to their specific competences in different BC tasks	3
					63	Ability to work effective and collaborative in a team	3
					64	Willigness to behave socially and ethically correct	3
				x	65	Ability to mediate between different team members and align the knowledge level of different team members	6
	Communi-cation	Be able to communicate well in order to successfully run a BCT project.	x		66	Demonstrate good written communication (documentation) skills	3
			x		67	Demonstrate good verbal communication skills	3
					68	Demonstrate ability to communicate complex and interdisciplinary problems	3
					69	Use social media means	3
				x	70	Demonstrate communication skills to internal and external stakeholders (colleagues, users, customers, advisors, and etc.)	3
					71	Demonstrate good presentation skills	3
				x	72	Ability to communicate within intercultural teams	3
				x	73	Ability to demonstrate negotiation skills considering different cultural background	3

Personal competences	Willingness to learn	Be able to learn effectively in order to successfully run a BCT project.	x		74	Ability to learn quickly	3
					75	Demonstrate Interest in new technology	3
					76	Demonstrate Interest in continuing learning	3
					77	Ability to accept and take into account feedback	3
			x	x	78	Apply new ideas and be open-minded	3
					79	Ability to educate oneself	3
					80	Willigness to work without existing partners/examples in the area of running BCT Projects	3
	Abilitiy to work effecti-vely	Be able to work effectively in order to successfully run a BCT project.			81	Demonstrate ability to work independently and self-organized	3
					82	Be proactive and take initiative	3
					83	Be responsible, trusted, and committed	3
					84	Ability to determine qualitative results	3
			x	x	85	Ability to act in a flexible manner and to adapt easily to new settings	3
					86	Demonstrate honest and correct business practices	3
					87	Demonstrate resilience and the ability to continue working on tasks despite difficulties	3