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Development and Validation of a Blockchain Literacy Scale

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Abstract

Background: The use of blockchain is increasing daily and has become a transformative technology across various sectors. The competent use of blockchain is becoming a fundamental skill. Although numerous studies have attempted to measure digital competencies, the absence of research specifically focused on blockchain literacy has left a significant gap.

Objective: The aim of this study is to provide a systematic review of digital literacy and blockchain measurement frameworks, comparing them with existing theoretical digital competence models.

Methods: Furthermore, we introduce a newly developed Blockchain Literacy Scale (BLS). The factorial structure of the BLS is assessed to explore its multidimensional nature. A sample of 591 Turkish college students completed a questionnaire to empirically test its reliability, validity and general applicability.

Results: Both Exploratory Factor Analysis (EFA) and Confirmatory Factor Analysis (CFA) supported a five-factor structure for the BLS, comprising: information access, information evaluation, economic literacy, legal literacy and risk literacy. The scale demonstrated strong internal consistency and reliability.

Conclusion: Directions for future research and the practical implications of the newly developed BLS are discussed in the conclusion.

Index Terms

Blockchain; Digital literacy; Online security; Legal regulations; Web 3.0.

1 INTRODUCTION

Web and internet technologies have continuously evolved since their inception. This evolutionary process is commonly described in three phases: Web 1.0, Web 2.0 and Web 3.0. Web 1.0 is characterized as the "read-only web", where users passively consume existing information. Web 2.0, on the other hand, is known as the "read-write web", allowing users to interact and contribute content. Finally, Web 3.0, often termed "read-write-execute", represents a semantic network that offers users diverse interaction possibilities (Hiremath & Kenchakkanavar, 2016; Shivalingaiah & Naik, 2008; Sing & Gulati, 2011). Each successive transformation has aimed to address the shortcomings of its predecessor while introducing novel features. Web 3.0 is envisioned as a system that fosters a more decentralized, secure and intelligent web environment through the integration of advanced technologies such as blockchain, smart contracts and artificial intelligence (Bharadiya, 2023). This new era of the web aims to establish a decentralized, transparent, secure and efficient information infrastructure. The incorporation of technologies such as wireless computing and semantic communication enables users to enjoy a more immersive, expedient and personalized web experience (Nath & Jana, 2023).

In this context, blockchain technologies play a crucial role in providing the infrastructure for a decentralized, transparent, efficient and secure information system in the realm of Web 3.0.

In parallel with the development of Web 3.0, the concepts of cryptocurrencies and blockchain have gained significant prominence in discussions surrounding the economy, industry and media (Zheng et al., 2017, p. 557). Blockchain, described as a "distributed, transparent and persistent" ledger, operates through various consensus structures (Sankar et al., 2017, p. 1). Regarded as a seminal invention marking the dawn of a new digital era, blockchain holds immense potential for shaping the next generation of internet interaction systems (Singhal et al., 2018). It operates as a shared, decentralized and open ledger of transactions, facilitating the transfer of value without the need for intermediaries or trusted third parties. This ledger database is replicated across numerous nodes and operates on an append-only system, ensuring the permanence of each entry without the possibility of alteration.

Blockchain technology rose to prominence as the underlying protocol of bitcoin, emerging amidst the financial crisis of 2009 (Zohar, 2015). Since then, it has been recognized as a revolutionary technology with wide-ranging implications. Its potential has been harnessed and applied across various sectors such as finance, supply chain management, healthcare (Ragnedda & Destefan, 2019), art, gaming and AI. The increasing adoption of blockchain in practical applications, coupled with its growing coverage in the media and academia, has underscored the need for research in this field.

As an emerging technology, blockchain possesses a complexity that affects adaptability (Iansiti & Lakhani, 2017). This complexity demands new skills and literacy from individual users. There is a burgeoning literature on blockchain technologies, but factors influencing adaptation to these technologies have largely been addressed in studies involving organizations (Lu et al., 2024; Marikyan et al., 2022; Orji et al., 2020; Prisco et al., 2024; Sciarelli et al., 2022). While these limited studies have aimed to shed light on organizational adaptation, there is a significant gap in research concerning individual adaptation, skills, literacy and usage.

To address this research gap, this study develops a scale for assessing individuals' blockchain literacy. Therefore, this research aims to identify the key themes of literacy skills related to blockchain technologies and develop a scale to measure these skills. In identifying literacy skills related to blockchain and Web 3.0—considered the next generation of the internet—related areas such as social media literacy, digital literacy, internet literacy and computer literacy are thoroughly reviewed. The lack of research into blockchain literacy, along with the novelty of this study in its field, guided the researchers towards this endeavour. It was evaluated that the literacy skills from the aforementioned areas could be applicable to blockchain as well. Furthermore, the selection of literacy skills was supported by the researchers' long-term engagement with blockchain platforms, experiential learning and consultations with field experts. By identifying literacy skills that may influence individual adaptation and usage, and by developing a corresponding scale, this research aims to contribute to future studies on blockchain by focusing on individual adaptation. It also seeks to aid decision makers in developing adaptation programmes.

1.1 Gaps in literature

In recent years, blockchain technologies have garnered significant attention across various sectors, including finance, supply chain management, healthcare and beyond. Despite the growing adoption and exploration of blockchain, a substantial gap remains in the literature concerning blockchain literacy. Existing research predominantly focuses on the technical, economic and regulatory dimensions of blockchain (Daluwathumullagamage & Sims, 2020; Golosova & Romanovs, 2018; Gorevoy et al., 2020; Malik et al., 2020; Marengo & Pagano, 2023; Perkusic et al., 2020; Rajasekaran et al., 2022; Saheb & Mamaghani, 2021), leaving the concept of literacy inadequately addressed. This oversight is particularly concerning given the potential of blockchain to transform industries. Without a comprehensive understanding of blockchain literacy, both individuals and organizations may struggle to navigate the complexities of this technology, potentially leading to issues such as misinformation, misuse, or underutilization of blockchain capabilities. Therefore, there is an urgent need for scholarly attention to develop frameworks and tools that can assess and enhance blockchain literacy among diverse user groups. Addressing this gap is crucial for effectively measuring and improving blockchain literacy.

1.2 Dimensions of blockchain literacy

Although there is no prior research specifically into individual blockchain literacy, existing studies focus on areas such as individual and organizational adoption, cryptocurrencies, banking and educational programmes. When these approaches are examined in terms of the necessary skills, they also provide insights into blockchain literacy. For example, Habitat Association has outlined key topics in its blockchain literacy education programme, including infrastructure elements such as information sources, legal frameworks, economy and finance and security. In a study on cryptocurrency literacy, Jones et al. (2024) defined a "literate individual" by incorporating dimensions such as economy, politics and regulations and security risks. Similarly, Uysal et al. (2024) explored Web 3.0 awareness, developing a scale that emphasizes risks and opportunities. In their scale development study, Suwanposri et al. (2021) underscored the importance of security risks and legal regulations, focusing on organizational compliance.

In their study on blockchain adaptation, Komulainen and Natti (2023) categorized the challenges affecting adaptation to psychological and functional difficulties, forming an adaptation model that highlights technological risks, regulatory and policy issues, economic uncertainties, lack of information and logistical challenges. In a qualitative study, Mohammad and Vargas (2022) identified variables influencing blockchain adaptation, including security and privacy risks, regulatory deficiencies and economic and financial barriers. Saheb and Mamaghani (2021), examining blockchain adoption in the banking sector, emphasized key issues such as legal regulations, economic challenges and security risks.

Social media has emerged as a critical source of information for blockchain users, with platforms such as Twitter playing a key role in how users learn about both the technology and cryptocurrencies (Merkley et al., 2024). Studies by Tandoc et al. (2021) and Celik et al. (2021) have emphasized the importance of information access and evaluation skills in social media literacy. Consequently, access to accurate information, evaluation of that information and information literacy are crucial factors for blockchain. Thus, in the following section, the five major dimensions of blockchain literacy are identified and defined based on a synthesis of the literature related to blockchain studies.

1.2.1 Legal framework for blockchain

Blockchain legal literacy, which encompasses an understanding of the legal aspects and regulatory requirements associated with this technology, is becoming increasingly crucial. Auer (2019) stressed the importance of legal frameworks to enhance the effective adoption of blockchain, especially in sectors such as finance. As blockchain continues to drive social and economic transformations, awareness of regulatory requirements will be essential to ensure its responsible use (Hutson et al., 2023). Legal literacy in the blockchain domain builds on historical precedents, as legal regulations have been evolving since the early days of the internet (Jha & Kumar, 2022; Swire, 2003). Various institutions have outlined regulatory areas, such as the European Commission in its "Legal and Regulatory Framework for Blockchain" report, highlighting the need for collaboration between regulators, companies and technology experts. This level of literacy is necessary for understanding the guidance provided by organizations such as The Law Society, which in its guide "Blockchain: Legal & Regulatory Guidance" addresses the environmental, social and governance implications of blockchain, including cryptocurrencies.

Regulatory awareness extends beyond just understanding the legal environment; it includes being informed about the enforceability of regulations, a critical aspect given the unique characteristics of blockchain (Mohsin, 2021; Shen et al., 2022). The gap between the rapid evolution of blockchain and the slower pace of legal regulation has led to challenges such as money laundering and fraud. An informed understanding of how regulations can improve accountability and auditability within the blockchain ecosystem is crucial for ensuring its sustainable growth. Comprehensive understanding of legal regulations not only motivates users (Otieno & Kiraka, 2023) but also influences compliance at both institutional and individual levels by providing guidance and oversight (Khan et al., 2023; Piazza, 2017).

1.2.2 Information literacy: access and evaluation

In the context of blockchain technology, the information access skill refers to an individual's ability to effectively search for and retrieve relevant blockchain-related data, a process that can be exploratory and iterative, much like the general search experience described by Bates (1989). This skill is essential given the complexity of blockchain systems, where users must navigate a variety of sources, including regulatory documents, financial data and technical reports, to find accurate and relevant information.

Blockchain evaluation literacy, on the other hand, goes beyond information retrieval to encompass the critical assessment of the information relevance, reliability and accuracy. As the American Library Association (1989) emphasized, information literacy involves not only finding information but also evaluating its trustworthiness and effectively using it to address specific issues. Goad (2002) further reinforced that users must assess the credibility of sources during their information-seeking process, particularly with regard to newer technologies such as blockchain.

Mastery of blockchain information literacy requires individuals to develop skills for both acquiring and critically evaluating information (Behrens, 1994). This includes an awareness of the source, accuracy and material value of the information they access (Johnston & Webber, 2010). With the rapid adoption of blockchain, individuals need to be adept at consuming and assessing information to make informed decisions, enhancing both their material and cognitive capacities (Park et al., 2021). Therefore, blockchain information access and evaluation literacies are vital for users to navigate the technology effectively and responsibly.

1.2.3 Economic literacy for blockchain

Economic literacy entails having the knowledge and skills necessary to comprehend the intricate structure of the economy and manage it effectively (Yıldırım & Öztürk, 2017). Related concepts include economic awareness and financial literacy. Economic awareness involves understanding of the economic impacts of various phenomena and activities (Kushnirovich, 2011). Financial literacy, as defined by the European Commission, is "the capability of consumers to understand retail financial products with a view to making informed financial decisions" (EU Commission, 2005). Economic awareness with regard to blockchain involves understanding of the economic impacts and benefits of blockchain, such as digital asset registries, global financial inclusion and efficient financial transactions (Omarova, 2020; Swan, 2017). Moreover, economic awareness and literacy can lead to more rational behaviour, as individuals become better equipped to assess the economic promises of blockchain and its potential to drive the digital economy (Chen et al., 2022; Rahmatullah et al., 2020). This literacy fosters a deeper understanding of how blockchain enhances speed, transparency and cost-efficiency in financial transactions, contributing to more informed decision making in economic matters (Dilek et al., 2018). As blockchain technology continues to expand into areas such as payments, loans, savings and asset financing and promotes circular economy principles (Kouhizadeh et al., 2020), individuals with strong economic literacy will be better positioned to recognize these opportunities and make informed financial decisions. Economic literacy concerning blockchain enables individuals to grasp the potential of the technology and make rational decisions.

1.2.4 Risk and security literacy for blockchain

Blockchain risk literacy refers to an individual's understanding of the various risks associated with blockchain technology, such as sybil attacks, denial-of-service attacks and smart contract vulnerabilities (Nikolic et al., 2018; Zaghloul et al., 2020). Despite the benefits—such as increased efficiency, lower costs and immutability—blockchain still faces significant risks, including architecture and design flaws, endpoint/oracle risks and private key management issues (Prewett et al., 2020). Developing risk literacy allows individuals to identify and comprehend the potential threats in blockchain environments and respond appropriately.

Blockchain security literacy, on the other hand, encompasses the knowledge and skills needed to manage and mitigate security risks. While blockchain utilizes public-private key cryptography, encryption and consensus mechanisms to safeguard the system, security breaches such as those experienced by Bitfinex and Coindash highlight the importance of security literacy (Zamani et al., 2020). Users must understand the potential vulnerabilities in blockchain applications, such as smart contracts, social engineering attacks and other online security threats that also affect blockchain (White et al., 2020; Wu et al., 2021).

Despite the growing use of blockchain technologies, awareness of privacy and security risks remains low compared to other online technologies (Furnell & Moore, 2014). Blockchain security literacy helps users better understand these risks, ensuring they can take preventive measures and maintain trust in the system.

2 RESEARCH METHODS

2.1 Participants and procedure

The surveys were administered in person. After explaining the research topic to the participants, the survey was conducted with those who volunteered. The study included 561 university students, comprising 393 males (67.8%) and 168 females (29%). All the participants were enrolled in a faculty of engineering. Purposive sampling was used to select participants, focusing on engineering students with a foundational understanding of blockchain technologies and coursework in new technologies and artificial intelligence. The selection of engineering students as the study sample was grounded in the assumption that this group possesses a higher level of knowledge and experience with blockchain technologies. Given the technical nature of blockchain, engineering students are more likely to have been exposed to related concepts through their academic curriculum, research projects or extracurricular engagements. This prior exposure makes them a more suitable population for providing informed and accurate responses. By targeting this demographic, the study seeks to enhance the reliability and validity of the collected data, thereby yielding more precise insights into blockchain literacy and its associated factors. The necessary ethical permissions for the study were obtained from the Ethics Committee before commencing the data collection process.

In this exploratory research study, the survey method was employed to collect data on users' blockchain literacy levels. Participants were asked to complete questionnaires distributed face-to-face. The data collection took place in the fourth quarter of 2023. After cleaning the data, the responses of 561 participants were deemed usable. Missing data and participants whose responses were not normally distributed (Mahalanobis distance) were removed from the dataset. Following the approach of Hair et al. (2014), survey responses with a response rate below 15% and evidence of straight-lining were eliminated before analysis. Consequently, the responses of 43 participants, which were deemed insufficient, were not included in the dataset used for analysis. The data were analysed using SPSS and AMOS 24 software. Likert scale items presented to the participants were rated on a 5-point scale. The scale ranged as follows: 1 strongly disagree, 2 disagree, 3 no idea, 4 agree, 5 strongly agree.

2.2 Item generation and scale development

The development of the blockchain literacy scale (BLS) in this study followed established scale development guidelines (Carpenter, 2018; Churchill, 1979) and validation procedures (Carpenter, 2018; Crocetta et al., 2021; Hair et al., 2019). First, studies on blockchain technologies were reviewed (Albayati et al., 2020; Caliskan, 2020; De Filippi et al., 2020; Herian, 2018; Janssen et al., 2020; Jones et al., 2024; Kowalski et al., 2021; Marengo & Pagano, 2023; Marikyan et al., 2022; Morkunas et al., 2019; dePina Cesario, 2023; Staples et al., 2017; Ur-Rehman et al., 2019). When evaluating the studies, it was noted that there is limited extensive literature on blockchain. Furthermore, no studies on blockchain literacy were found. In the next step, previous studies in the literature addressing issues such as computer literacy, social media literacy and internet literacy, which are believed to be related to blockchain technologies, were thoroughly examined (Carretero et al., 2017; Celik et al., 2021; Chetty, 2018; Eshet, 2012; Gammon & White, 2011; Jones & Flannigan, 2006; Koc & Barut, 2016; Morgan et al., 2022; Oh et al., 2021; Reddy et al., 2023; Rodriguez-de-Dios et al., 2016; Tandoc et al., 2021; Van Deursen et al., 2016). Blockchain literacy shares key principles with internet, digital and social media literacies, such as critical thinking, technological competence and risk awareness, making established frameworks for these technologies relevant. As blockchain is part of the broader digital progression, methods for measuring these earlier literacies can inform the development of blockchain literacy. Since specific studies on blockchain literacy are limited, drawing from related fields helps bridge this gap and provides an evidence-based foundation for understanding blockchain. A total initial item pool of 24 items was adopted and adapted from the literature for use in the scale development process.

Additionally, we examined user behaviour in communities related to blockchain issues on social media platforms and actively engaged with blockchain technologies (Metaverse, X and Discord communities, CEX, DEX, AI, NFTs, trading, etc.) using accounts that we created. We sought to observe the required skills and potential negative and positive situations that users might experience.

***Table 1**. Scale development steps.*

Phase 1: Item generation
Construct definition (Literature review)
⬇
Phase 2: Measurement development
Expert evaluation and content validity
Scale refinement
⬇
Phase 3: Instrument testing
Exploratory factor analysis
Confirmatory factor analysis

Following a thorough and extensive literature review, structures and items encompassing blockchain literacy were identified by drawing on similar scale studies. Next, the study gathered feedback from selected experts through interviews and focus group discussions to ensure both face and content validity. Face validity was assessed to verify that each item in the initial pool appropriately aligned with the intended construct (Churchill, 1979; Hardesty & Bearden, 2004). A panel of five experts, each holding a PhD in communication studies and communication technologies, was engaged to evaluate the content validity of the developed measurement. Individual interviews were conducted with each expert to determine whether any critical aspects of blockchain literacy had been overlooked and to assess whether the initial item pool sufficiently covered the relevant dimensions of blockchain literacy. During the evaluation process, experts were asked to observe "the suitability of the instrument language for the target audience, the presence of technical terms and whether they are made understandable and whether the identified items and constructs are related". The experts confirmed that the proposed items effectively represented the conceptual domain of blockchain literacy. Based on the expert feedback, two items were removed and three items were revised. One of the constructs initially identified as security literacy was changed to risk literacy. Additionally, two items were rearranged and rephrased. After this purification process, 22 items were obtained.

3 RESULTS

This exploratory study aims to develop a scale or instrument for measuring blockchain literacy. A similar methodology has been employed in numerous other studies, wherein the literature was reviewed, constructs and items were identified, field experts were consulted and the structure of the scale along with its items was developed (Lin et al., 2022; Ulfert & Schmidt, 2022). The final refined instrument consists of five constructs and 18 items. The identified constructs and validity analyses were adapted from similar studies in the literature and scrutinized through expert evaluations.

3.1 Exploratory factor analysis

An exploratory factor analysis (EFA) was applied to assess the construct and validity of the scale (Tifferet, 2021; Khan et al., 2022; Ruggieri et al., 2023). The suitability of the constructs and items determined before the EFA was measured with Bartlett's sphericity, which indicated that the dataset was suitable for factor analysis. The Kaiser-Meyer-Olkin (KMO) measure achieved a value of 0.808 and Bartlett's test yielded a statistic of 17,104.981, with a significance level of $p < 0.001$. The EFA was performed using the varimax rotation method and the principal components factor analysis technique. The recommendations by Hair et al. (1998) were followed: an eigenvalue of 1 was used as a cut-off value for extraction and items with factor loadings below 0.5 and cross-loading items were deleted. After the EFA, four items were removed.

The analysis continued with the remaining 18 items and five constructs: economic literacy (three items), legal literacy (three items), risk literacy (four items), information access (four items) and information evaluation literacy (four

items). According to the EFA results, the five constructs together explained 92.15% of the variance. It is generally recommended that factors contain at least three items; this condition is met by the final scale. The items included in the scale were not used verbatim but were adopted during the process to align with and support the subject matter and are presented in Table 2. Deleted items are not included in the final scale.

Table 2. *Items and EFA loadings.*

Scale	Format and rating type	Items	Loadings
		Information access	
Adopted from New Digital Literacy Scale (Reddy et al., 2023)	5-point Likert, Self-reported	I can find information about blockchain technologies on the internet.	0.897
		I know ways to search for information about blockchain technologies.	0.781
		I can access information about blockchain technologies that suits my purpose.	0.823
		I can access information about blockchain technologies from different sources.	0.842
		Information evaluation	
Adopted from Perceived Social Media Literacy Scale (Tandoc et al., 2021); Digital Literacy Scale for Teenagers (Rodriguez-de-Dios et al., 2016)	5-point Likert, Self-reported	I know where to find accurate information about blockchain technologies.	0.764
		I can discern accurate information about blockchain technologies.	0.728
		I can evaluate the reliability of those who provide information about blockchain technologies.	0.745
		I do not believe every piece of information about blockchain technologies.	0.818
		Economic	
Developed from Yayar and Karaca (2017), economic literacy levels of public officers in Turkey	5-point Likert, Self-reported	I am aware of the economic impacts of blockchain technologies.	0.837
		I know the economic opportunities in the blockchain ecosystem.	0.810
		Blockchain technologies have economic potential.	0.802
		Legal	
Self-developed	5-point Likert, Self-reported	I am aware of the need for legal regulation regarding blockchain technologies.	0.805
		I am aware of the importance of legal regulations for blockchain technologies, like other technologies.	0.828
		With legal regulations, blockchain technologies will be able to reach more people.	0.763
		Risk	
Adopted from Digital Literacy Scale for Teenagers (Rodriguez-de-Dios et al., 2016)	5-point Likert, Self-reported	I know there will be different types of digital attacks on blockchain platforms.	0.849
		I know that I need to be careful about the risks when using blockchain platforms.	0.870
		I am aware that I need to take precautions against risks when using blockchain platforms.	0.899
		I think I should take security precautions when using blockchain platforms.	0.872

3.2 Confirmatory factor analysis

A confirmatory factor analysis (CFA) was conducted on the constructs and items obtained from the EFA. The maximum likelihood method was used for model estimation. Standardized loadings of the constructs ranged from 0.811 to 0.983, all of which were significant at p = 0.001. The fit indices were as follows: x2/df = 4.904, GFI = 0.932, AGFI = 0.859, NFI = 0.976, CFI = 0.981, IFI = 0.981, RMR = 0.008, RMSEA = 0.083, SRMR = 0.028. The Cmin/df value was below 5, meeting the criteria at the moderate level (Kline, 2005). Although the RMSEA value was above 0.08, it was considered acceptable (Chen et al., 2008). Overall, the fit indices met the expected criteria (Hu & Bentler, 1995).

Table 3. *Confirmatory factor analysis values.*

Constructs	CR & AVE	Constructs mean	Item	Mean	α
Information access	CR = 0.943	4.82	Infoaccess1	4.84	0.958
	AVE = 0.806		Infoaccess2	4.80	
			Infoaccess3	4.81	
			Infoaccess5	4.82	
Information evaluation	CR = 0.965	4.77	Infoeva1	4.76	0.958
	AVE = 0.874		Infoeva2	4.75	
			Infoeva3	4.75	
			Infoeva4	4.82	
Economic literacy	CR = 0.950	4.80	Eco1	4.79	0.947
	AVE = 0.863		Eco2	4.79	
			Eco3	4.82	
Legal literacy	CR = 0.966	4.89	Legal2	4.88	0.966
	AVE = 0.906		Legal3	4.89	
			Legal4	4.88	
Risk literacy	CR = 0.979	4.88	Risk2	4.87	0.975
	AVE = 0.920		Risk3	4.89	
			Risk4	4.88	
			Risk5	4.87	

Reliability and validity were assessed for all five constructs of the BLS. All the standardized factor loadings obtained were above 0.70 (Hair et al., 2014). Composite reliability was calculated for convergent and discriminant validity, and both composite reliability (CR) and average variance extracted (AVE) values were above the recommended thresholds (0.6-0.5) (Bagozzi & Yi, 1998), meeting all the necessary conditions for convergent validity. To control for common method bias, Harman's single-factor approach was used (Podsakoff et al., 2003) and discriminant validity was assessed using the plugin developed by Gaskin; it was observed that the values (HTMT) did not exceed the threshold values, indicating that the condition was met. The AVE values for all the constructs were greater than their squared inter-factor correlations. With these fit and validity data, the model was found to be acceptable.

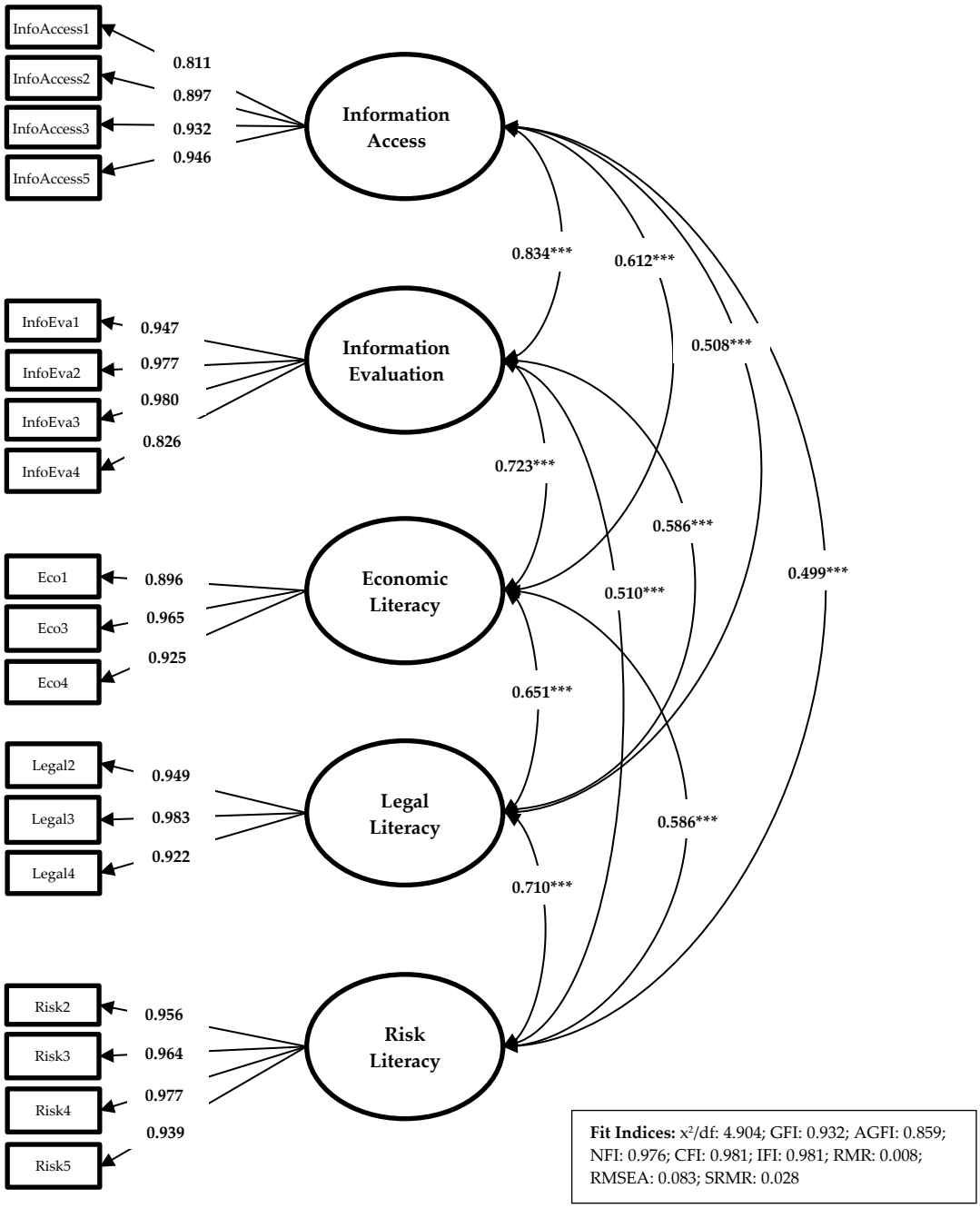
According to the research results, the highest scoring literacy skills were in the risk, access to information and legal literacy factors, respectively. Security is crucial on blockchain-based platforms, reflected in the low standard deviation, indicating a consistent understanding among the participants (Zetzsche et al., 2019). Especially in value-based actions such as cryptocurrencies, individuals must be able to evaluate all risks and have access to relevant information for making informed decisions (Wu et al., 2021). The fact that the participants are university-educated engineer candidates may contribute to these skills being relatively higher.

Factor 1 (access to information) consists of four items that assess users' ability to access information related to blockchain technologies. Given that blockchain is a rapidly evolving technology with items of financial value, the need for accurate information is high for both beginners and advanced users. Having access to accurate information in online environments can lead to more effective usage behaviour (Park et al., 2021).

Factor 2 (ability to evaluate information) comprises four items that assess the users' ability to effectively evaluate encountered information and distinguish correct information (Goad, 2002). With information overload being common in online environments, the ability to critically evaluate information, especially on platforms involving items of material value, is crucial (Johnston & Webber, 2010). Users must be able to identify false and manipulative information shared on platforms such as social media.

Factor 3 (economic literacy) consists of three items and measures individuals' ability to evaluate the economic transformations and impacts that blockchain technologies will create (Omarova, 2020). Blockchain technologies, particularly cryptocurrencies, have transformative potential in many aspects, including economic transformation (Swan, 2017). This factor aims to ensure that users are aware of the economic impacts and opportunities in this transformation process.

Figure 1. *SEM diagram.*



Factor 4 (legal literacy) comprises three items that measure users' awareness of legal regulations regarding blockchain technologies and their importance. Similar to the early years of the internet and social media, new

technologies sometimes outpace legal regulations. While blockchain technologies offer transformative potential, they need to be harmonized with real-life legal rules (Bu et al., 2021; Zwitter & Hazenberg, 2020). This factor aims to measure users' awareness of these legal regulations and their impact.

Factor 5 (risk literacy) consists of four items that address users' literacy regarding risks on blockchain platforms. Online environments present various risks, such as hacking, password theft, phishing and fraud; blockchain platforms are no exception (Saghir, 2021). Since users' passwords can sometimes involve significant financial values, this aspect of literacy is particularly serious. It is important to measure these skills and have a tool to assess them effectively.

This study is one of the first to explore literacy in the context of blockchain technologies. It aims to develop a reliable tool by identifying the constructs that encompass literacy skills and the corresponding items related to these constructs. This tool can serve as a valuable resource for individual educational programmes and evaluations, helping address existing gaps in blockchain literacy.

4 DISCUSSION

The primary objective of this study was to develop and validate a scale for measuring blockchain literacy. To achieve this, a systematic process was followed to explore the dimensions of blockchain literacy and produce a reliable and valid scale. Previous research has demonstrated that blockchain is a transformative technology, progressively adopted by individuals and influential across various sectors (Al-Shamsi et al., 2022; Clohessy & Acton, 2019; Loukil et al., 2021; Wang et al., 2016; Wong et al., 2020). While numerous studies address the organizational and sectoral adaptation to blockchain, there is a lack of research focusing on individual blockchain literacy. Furthermore, during the development of the BLS, it became apparent that previous studies have attempted to measure cryptocurrency literacy and the factors influencing blockchain adoption and usage. In contrast, the BLS results from a rigorous multistage process, following the steps suggested in the literature on scale development and testing.

In developing the scale, a substantial number of resources were reviewed, resulting in an initial pool of items. An iterative process was then followed, during which field experts provided feedback, leading to modifications and item removal. The EFA identified a five-factor structure for the BLS, which was subsequently confirmed by the CFA on a sample of 561 university students. The reliability statistics indicated that the scale has a strong level of internal consistency. Descriptive statistics of the BLS factors revealed that participants exhibit high levels of economic awareness, legal regulation awareness, risk literacy, information access and evaluation literacy, which is expected given that the sample comprises experienced university students who have taken courses related to this technology.

Consistent with prior studies that conceptualize internet literacy, social media literacy and blockchain adoption as multidimensional constructs (Celik et al., 2021; Koc & Barut, 2016; Oh et al., 2021; Reddy et al., 2023; Rodriguez-de-Dios et al., 2016; Tandoc et al., 2021), the empirical evidence from this study supports the notion that blockchain literacy is also a multidimensional construct. The results indicate that the BLS possesses adequate reliability, internal and external convergent validity, as well as discriminant validity. This further confirms that the developed scale is a valid and reliable tool for measuring blockchain literacy in individuals.

The findings suggest that Turkish participants primarily perceive blockchain literacy across five dimensions: risk literacy, legal literacy, economic awareness, information access and legal regulation awareness. These dimensions align with previous studies that conceptualize blockchain literacy as a multidimensional construct (Komulainen & Natti, 2023; Jones et al., 2024; Merkley et al., 2024; Mohammad & Vargas, 2022; Suwanposri et al., 2021; Uysal et al., 2024). Additionally, three of these dimensions (risk literacy, legal literacy and economic awareness) correspond to the blockchain-related scales developed by Jones and Flannigan (2006) and Subaveerapandiyan et al. (2024). The other two dimensions (information access and evaluation literacy) represent new, emerging dimensions of blockchain literacy that were not addressed in previous blockchain studies.

This study also confirms the technical and socio-cultural characteristics of blockchain, as the scale includes relevant items. One of the most significant practical outcomes of this research is that it advances discussions on blockchain literacy and individual adaptation to an empirical level. It encourages further investigation into the competencies, skills and literacies required for interaction with blockchain technologies. Despite increasing interest in conceptual discussions on blockchain, there has been a notable lack of an operational tool to measure individuals' blockchain competencies, particularly for those actively using these platforms. The BLS developed in this study addresses this

gap and can be employed in both descriptive and experimental research settings, enabling researchers to explore various variables associated with blockchain literacy.

In conclusion, this study has produced a reliable and valid scale for assessing blockchain literacy. As digital technologies continue to evolve, individuals are expected to actively engage with blockchain platforms through activities such as trading, gaming, content creation and information exchange. To be blockchain-literate, individuals must also possess knowledge of the economic, legal and risk aspects of blockchain, in addition to its technical features.

The BLS incorporates the most recent and complex blockchain literacy competencies that have emerged in the past decade. Its availability is likely to stimulate future research and contribute to the growing body of literature on blockchain literacy.

5 THEORETICAL AND MANAGERIAL IMPLICATIONS

This study makes a significant contribution to both theory and practice. The measurement scale can be employed to measure individuals' blockchain literacy competencies in today's digital environment. Theoretically, the blockchain literacy construct was conceptualized and measured from the perspective of young and experienced blockchain users. In the rapidly evolving digital landscape, individuals are increasingly engaging with blockchain technologies. The growing interaction between individuals and blockchain platforms, such as exchanges, the metaverse, NFT platforms and games, necessitates enhanced skills and awareness. The results of this study offer a comprehensive framework for measuring blockchain literacy within the blockchain ecosystem. To the best of the authors' knowledge, this is the first study to develop and validate a tool specifically designed to measure blockchain literacy. Specifically, this research advances the existing literature by proposing a new taxonomy that categorizes blockchain literacy into five distinct dimensions, develops corresponding items and empirically tests the construct validity and reliability. The proposed blockchain literacy construct consists of 18 items, measured on a five-point Likert scale, reflecting five key dimensions: risk literacy, legal literacy, economic awareness, information access and legal regulation awareness. The findings indicate that blockchain literacy is a multidimensional reflective construct, offering a nuanced understanding of its complex components. The study also identifies the relationships between these factors and their indicators, representing a substantial contribution to theory, methodology and practice.

This conceptualization of blockchain literacy offers valuable assistance to blockchain developers, policymakers, educators and researchers by facilitating empirical studies and promoting innovative approaches to measuring and understanding blockchain literacy in future research. The study provides a practical tool for assessing users' skills, risk mitigation strategies and awareness, helping policymakers and educators focus on deficiencies and make informed decisions. Evaluations can be conducted by surveying current and potential users within the blockchain context. All stakeholders can leverage this scale to better understand individuals' blockchain literacy, thereby enabling more informed decision making and the development of targeted educational or policy interventions. Researchers and educators can use the scale to create effective teaching strategies and educational programmes, while policymakers can utilize it to assess blockchain literacy and implement appropriate policies and regulations. Overall, the study results offer strong evidence of the scale dimensionality, reliability and validity, making it an essential tool for enhancing the understanding of blockchain literacy.

6 LIMITATIONS AND FUTURE RESEARCH

The primary limitation of the BLS is the ever-changing nature of blockchain technology. Unforeseeable transformations, such as technical developments (for both users and attackers), economic shifts, legal changes and media hype cycles, may render this measurement tool outdated or necessitate updates. Similar effects have been observed for scales such as internet and social media literacy.

Secondly, thus far, the scale is validated in the Turkish language, which limits the application field to a Turkish-speaking population. The validation of the English-language adaptation of the scale is currently pending. Additionally, the instrument may be culturally specific. Therefore, applying the scale in different cultures is necessary for cross-cultural validation.

Thirdly, our sample was restricted to participants in a survey. Thus, generalizing our results to the overall population, mainly including individuals who lack a certain degree of computer literacy or do not use blockchain platforms, should be investigated in further studies. However, it can be assumed that with regard to the sample for which this scale was developed, the majority of the population is experienced in blockchain.

Due to the nature of the purposive sample used in the research, data were collected from participants who had at least basic knowledge of blockchain technologies. The purposive sampling technique was used to collect data from students who were approached on the basis of their experience and education. Therefore, results obtained from different samples can be expected to differ. As we mainly relied on blockchain-experienced college students as a sampling tool to reach a broad range of potential participants, our sampling procedure implied self-selection bias. In other words, participation was restricted to individuals that were willing to participate.

While this study provides a foundation for understanding blockchain literacy, several avenues for future research remain unexplored. Firstly, the conceptual relationships between blockchain literacy and other forms of digital literacy warrant further investigation. Future studies could examine the antecedents and consequences of blockchain literacy, particularly how it influences individuals' ability to engage with blockchain platforms and their capacity to manage associated risks. Moreover, exploring the role of blockchain literacy in promoting financial inclusion (Hooks, 2019), enhancing educational opportunities (Raimundo & Rosario, 2021) and facilitating secure online interactions (Zhang et al., 2019) offers promising areas for further exploration. Additionally, researchers could investigate how blockchain literacy affects adoption rates across different demographic groups, industries and regions (Batubara et al., 2018; Mbaidin et al., 2023). Comparative studies between countries with varying levels of blockchain infrastructure may reveal valuable insights into the role of literacy in fostering adoption (Queiroz & Wamba, 2019). Moreover, studies focusing on the specific challenges and barriers to achieving blockchain literacy, such as legal and technical complexities (Akram et al., 2020), can provide useful insights for policymakers and educators.

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