*sustainability*

MDPI

*Systematic Review*

# Blockchain in Online Learning: A Systematic Review and Bibliographic Visualization

**Mao Zhao [1], Wei Liu [2], Abu Naser Mohammad Saif [3,4], Bo Wang [5,*], Rasheda Akter Rupa [6], K. M. Anwarul Islam [7], S. M. Masudur Rahman [8], Nusrat Hafiz [9,10], Rehnuma Mostafa [11] and Mohammad Anisur Rahman [4]**

1 School of Economics and Management, Chengdu Normal University, Chengdu 611130, China
2 City Graduate School, City University, Petaling Jaya 46100, Malaysia
3 School of Business and Economics, Universiti Putra Malaysia, Serdang 43400, Malaysia
4 Department of Management Information Systems, Faculty of Business Studies, University of Dhaka, Dhaka 1000, Bangladesh
5 College of Food Science and Technology, Bohai University, Jinzhou 121013, China
6 School of Business, Ahsanullah University of Science and Technology, Dhaka 1208, Bangladesh
7 Department of Businesses Administration, The Millennium University, Dhaka 1217, Bangladesh
8 Faculty of Business and Law, Swinburne University of Technology, Kuching 93350, Malaysia
9 BRAC Business School, BRAC University, Dhaka 1212, Bangladesh
10 Putra Business School, UPM, Serdang 43400, Malaysia
11 Faculty of Applied and Human Sciences, Universiti Malaysia Perlis, Arau 02600, Malaysia
* Correspondence: daqingwb@163.com

**Abstract:** In the contemporary era of global and sustainable information management, blockchain has made a cutting-edge transformation in online learning. To apprehend this new trajectory, this current systematic review with bibliographic visualization aims to identify the thematic clusters of underlying aspects concerning the sustainable nexus of blockchain and online learning. Using the updated guidelines of the PRISMA flowchart, a total of 434 scholarly research papers from the mainstream research databases, i.e., Web of Science, Scopus, IEEE Xplore, and ScienceDirect, were inspected to be categorized into 15 relevant publications. Bibliographic data were assembled and analyzed accordingly to construct network visualization maps, such as co-authorship, citation, co-citation, bibliographic coupling, and term co-occurrence using VOSviewer 1.6.18. Significant terms were reported and later cross-mapped with those identified by critically reviewing the applicable 15 papers. Standardized scholarship, behavior pattern, and digital badging have been found and derived as themes from the connected clusters. Therefore, current research findings reveal these three broad clutches of themes concerning the sustainable nexus of blockchain and online learning.

**Keywords:** Blockchain; online learning; qualitative; systematic review; bibliographic; PRISMA; VOSviewer



**Citation:** Zhao, M.; Liu, W.; Saif, A.N.M.; Wang, B.; Rupa, R.A.; Islam, K.M.A.; Rahman, S.M.M.; Hafiz, N.; Mostafa, R.; Rahman, M.A. Blockchain in Online Learning: A Systematic Review and Bibliographic Visualization. *Sustainability* **2023**, *15*, 1470. https://doi.org/10.3390/su15021470

Academic Editors: Neil Gordon and Han Reichgelt

Received: 22 November 2022
Revised: 19 December 2022
Accepted: 5 January 2023
Published: 12 January 2023



## 1. Introduction

Blockchain is the newest buzzword in digital transformation technologies. This trailblazing technology is so versatile that it has the potential to disrupt practically every industry. Since the peer-to-peer electronic monetary transaction "bitcoin" [1] was first introduced, its underlying technology, "Blockchain," has attracted much attention from both business and academic domains. Blockchain technology is an irrevocable, decentralized database using a chain of "blocks" to record data, such as transaction dates, timings, amounts, and/or participants [2–4]. Different industries are exhibiting more significant interest in the underlying blockchain technology, including business, banking, healthcare, security, government, and education (including online education), and several of these industries have already adopted the technology in some ways. Nevertheless, this technology can advance in numerous ways and places [5].

Online learning has expanded dramatically during the past two decades [3,6]. According to the [7], E-learning/online learning continues to have the fastest growth in the industry, with an average annual growth rate of 20%. By 2027, it is predicted that the market for mobile learning will be worth $80.1 billion worldwide [7,8]. China is considered the second leading economy globally, and is expected to have a market of US$18.8 billion by 2027 [9]. Japan and Canada also have potential markets, which are expected to increase by 15.7% and 18.3%, respectively, between 2020 and 2027 [7]. Moreover, blockchain technology has great potential for use in online education and can yield excellent results [10,11].

This online education, commonly referred to as distance education or virtual learning [12,13], is a web-based teaching approach for quick learning and content distribution. With the advent of Web 3.0 and the internet as the platform, online instruction has surpassed restrictions of geographic location, setting, time, and academics and provides students with top-notch learning opportunities whenever and wherever they are [8]. Furthermore, blockchain and online learning are a potent combo because of Web 3.0 [14]. Blockchain technology enables decentralized learning environments. These platforms are handled by consensus rather than by a single body. This vibrant technology enables a peer-to-peer learning environment. Additionally, instructors may utilize the blockchain to check transcripts and report cards [15], create digital agreements, and assist students with debt repayment [16–18]. As a result, blockchain can help education by boosting transparency, strengthening accountability [19,20], and rewarding learning through smart contracts [21,22]. It also fosters consistency across educational institutions.

As a result, much emphasis has been paid to the rapid transition to online education and learning through blockchain. Moreover, COVID-19 has accelerated the transition from traditional classroom settings to online learning environments [5,23,24]. Online learning is becoming increasingly important in today's world, where in-person instruction may be limited, especially for students from low socioeconomic backgrounds, for whom the cost of tutoring can occasionally be a significant factor [25,26]. Online education can be broken down into early childhood education, occupational training, examination and certification training, personal skill development, and language education [27,28]. Massive open online courses (MOOCs) have received media interest recently. MOOCs were first created in the US by eminent content providers, including Coursera, Udacity, and edX. [29,30]. Popular American colleges have been creating online learning environments and providing open courses since 2012 [31,32].

In light of a more open and digital internet, the current models and frameworks for online education have numerous flaws, despite their enormous popularity [33,34]. For instance, the student's privacy is in jeopardy [35], since the courses and safety of information exclusively rest on the integrated online education platform [36], the students' intellectual property cannot be effectively maintained because of the open access to internet and data [10], and there is no established cross-platform course sharing mechanism to wholly share the teaching materials [37].

Blockchain technology can address and solve online education issues, such as inadequate accreditation, a lack of acceptance, and data security [38,39]. Additionally, the preliminary use of blockchain technology in the sphere of education has been initiated [40]. The MIT Media Lab created a digital learning certificate system combining blockchain technology and Mozilla's open badge [41]. Additionally, the industrial sector has utilized blockchain technology for designing equipment related to educational settings. In order to realize the fairness and digitization of education, Sony Global Education [42], a blockchain technology infrastructure platform run by Sony Corporation of Japan, allows users to share learning courses and data openly and safely without disclosing them to the education management authority [10].

According to [43], the nexus of online learning and blockchain technology is going to be a significant agenda. According to [44], the potential benefits of using blockchain in online education include empowering students (self-sovereignty), improving security, and increasing efficiency for corporations and educational institutions.

There has been a range of research on utilizing blockchain technology for online learning in general, but not enough has been done to identify the thematic clusters of underlying aspects concerning the nexus of blockchain and online learning [45,46]. Numerous previous studies [10,20,47] have focused on teaching strategies, credentials, payments, and record keeping; however, there is essentially no thorough or in-depth research on the underlying aspects concerning the nexus of blockchain technology and online learning. Therefore, to bridge the existing research gap and add new knowledge, [48–51] have called for further investigation into this specific domain. Thus, the present research will probe the following research question.

RQ: What are the thematic clusters of underlying aspects concerning the nexus of blockchain and online learning?

Hence, this current research systematically reviews existing literature with bibliographic visualization to identify the thematic clusters of underlying aspects concerning the nexus of blockchain and online learning.

## 2. Research Methods and Procedures

Four rudimentary and progressive steps, i.e., searching, assessing, synthesizing, and analyzing [52,53] have been followed by the authors, as accessibility to formerly published appropriate research must be clear and unambiguous as a prerequisite for a systematic review and bibliographic enquiry [54,55]. Several filters and conditions have been fixed and applied to search the relevant literature using multiple steps [56,57].

### *2.1. Literature Search*

To sort out appropriate documents for this study, a thorough search process consisting of multiple steps was utilized. The search process was limited to four well-known and acknowledged databases. They are Web of Science, Scopus, ScienceDirect, and IEEE Xplore, and they were chosen due to these databases' progressive search and analysis options. The Web of Science database has been selected because its journals' quality and indexing are beyond question and consistent enough [58,59], whereas Scopus provides access to a wide variety of peer-reviewed documents from almost all research fields [59–61]. ScienceDirect includes interdisciplinary documents such as Scopus, with a substantial emphasis on IT [62,63], which makes this database compatible with this study. IEEE Xplore was also picked since it offers a universe of information from numerous new and emerging technologies to enhance or uncover the next breakthroughs.

Literature published from 2015 to 2022 has been considered for searching databases, with 2015 as the starting point, given that all of the chosen databases exhibited outcomes from 2015 for review. Table 1 presents the database searching proprieties for this study.

**Table 1.** Proprieties and procedures for searching.

| Keywords for Search | Search within | Research Database | Period | Fundamental Query String | Sort by | Number of Documents |
|---|---|---|---|---|---|---|
| Blockchain in online learning | Title, Abstract, Keywords | Scopus, Web of Science, IEEE Xplore, ScienceDirect | 2015 to 2022 | TITLE-ABS-KEY (blockchain AND in AND online AND learning) AND PUBYEAR > 2014 AND PUBYEAR < 2023 | Relevance | 434 |

434 scholarly research publications were found in those databases, as is shown in Table 1.

### *2.2. Literature Assessment Process*

The pertinent literature for this study has been assessed by applying a data flow diagram simply known as PRISMA [64], which is elaborated as preferred reporting items for systematic reviews and meta-analysis. Relevant documents applicable for reporting were classified utilizing the new and updated guidelines of PRISMA 2020 (Supplementary Materials).

The strategies for tracking the appropriate number of publications are depicted in Figure 1. In the end, 15 papers were traced.

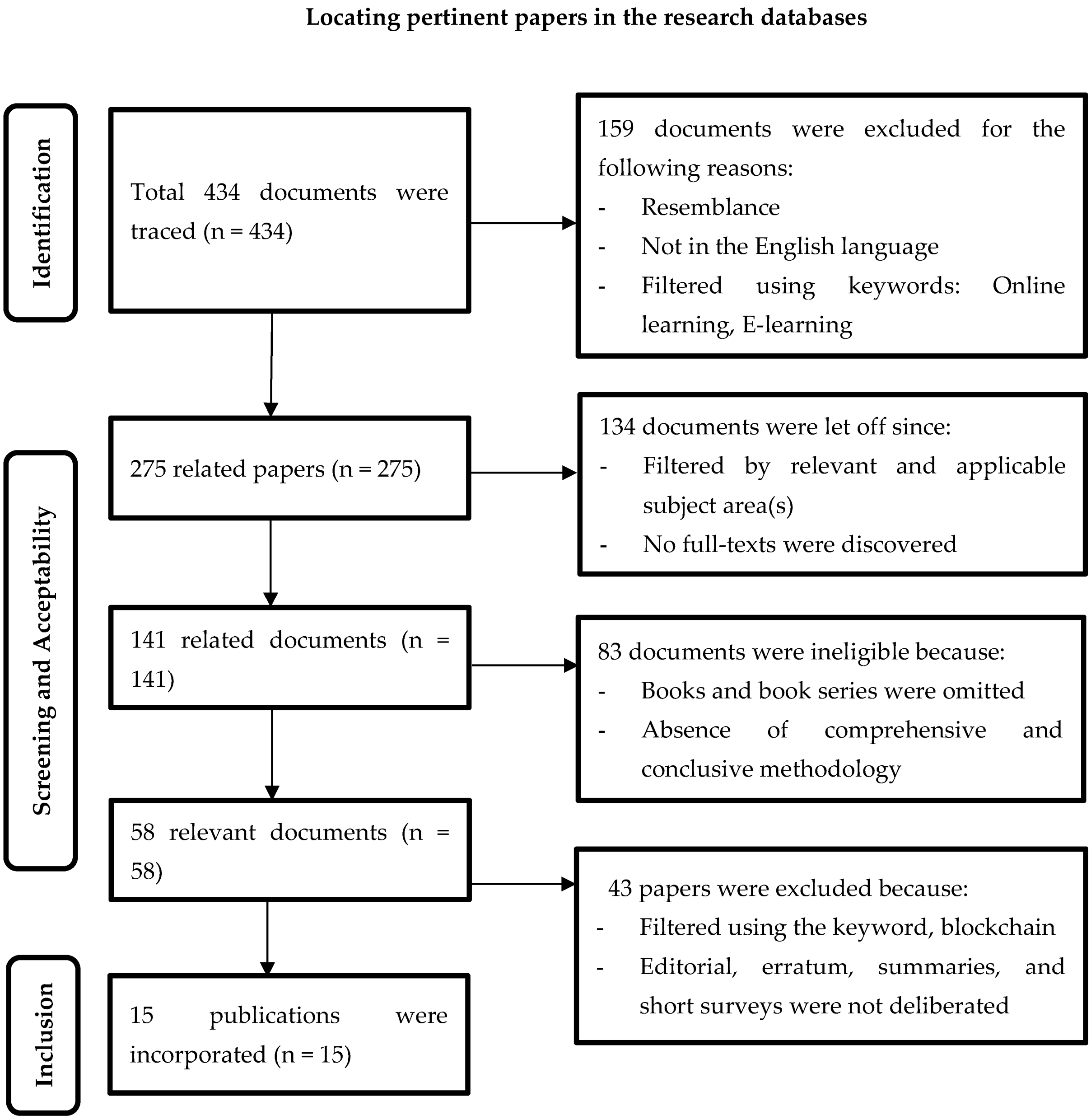


**Figure 1.** Updated PRISMA flow diagram.

## *2.3. Literature Synthesis*

Fifteen relevant publications were sorted out for reporting bibliographic information from them and presented systematically in a table. Since wide-ranging bibliographic information is essential for investigating research inclinations [53], the bibliographic evidence of the chosen documents was exported as CSV and RIS files for additional exploration to be conducted.

## *2.4. Analysis and Reporting Procedure*

Several figures were created using bibliographic information from the previous literature published from 2015 to 2022 for assessment and the summary of outcomes and inclinations of current studies. VOSviewer 1.6.18 was adopted to generate bibliographic maps and networks for data presentation [65].

Finally, broad categories of themes connecting blockchain and online learning were developed.

## 3. Results

Figure 2 denotes documents published by countries on blockchain and online learning from 2015 to 2022. China is the leader in published documents in this field, which reflects its ongoing concerns about implementing blockchain in online learning. India produced 50 documents, while the United States published 36 papers. Italy, Indonesia, and Australia had the same contribution in this area, each having nine published papers.

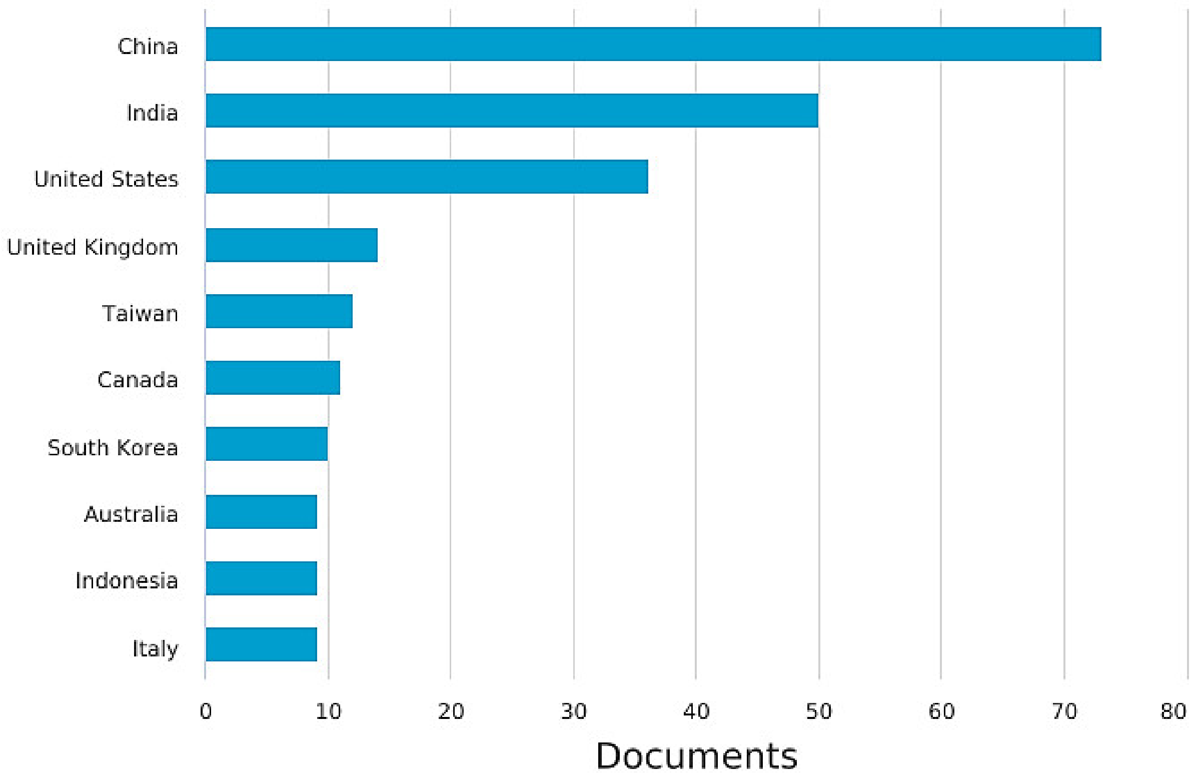


**Figure 2.** Publications by country (2015 to 2022).

Figure 3 compares the documents articulated by different authors from 2015 to 2022. During the period, Aini reported the highest number of documents, five, whereas Altinay produced the lowest number of documents, two. Byun and Shahbazi produced four documents each, while the rest of the six authors contributed equally with three documents each.

Figure 4 shows the countries' co-authorship network based on total link strength. In this map, every node stands for a country, and the thickness of the line connecting every two countries demonstrates the strength of collaboration between the counties. From the network graph, it is evident that the USA has the strongest co-authorship network, as it has the most central nodes, and the co-authorship networks of the USA consist of Taiwan, Japan, Italy, Bangladesh, Singapore, and Saudi Arabia. India and Taiwan have slightly smaller co-authorship networks than the USA. On the other hand, Portugal is the most minor in this network. Taiwan and the USA have the thickest link representing the most robust collaboration between these two countries.

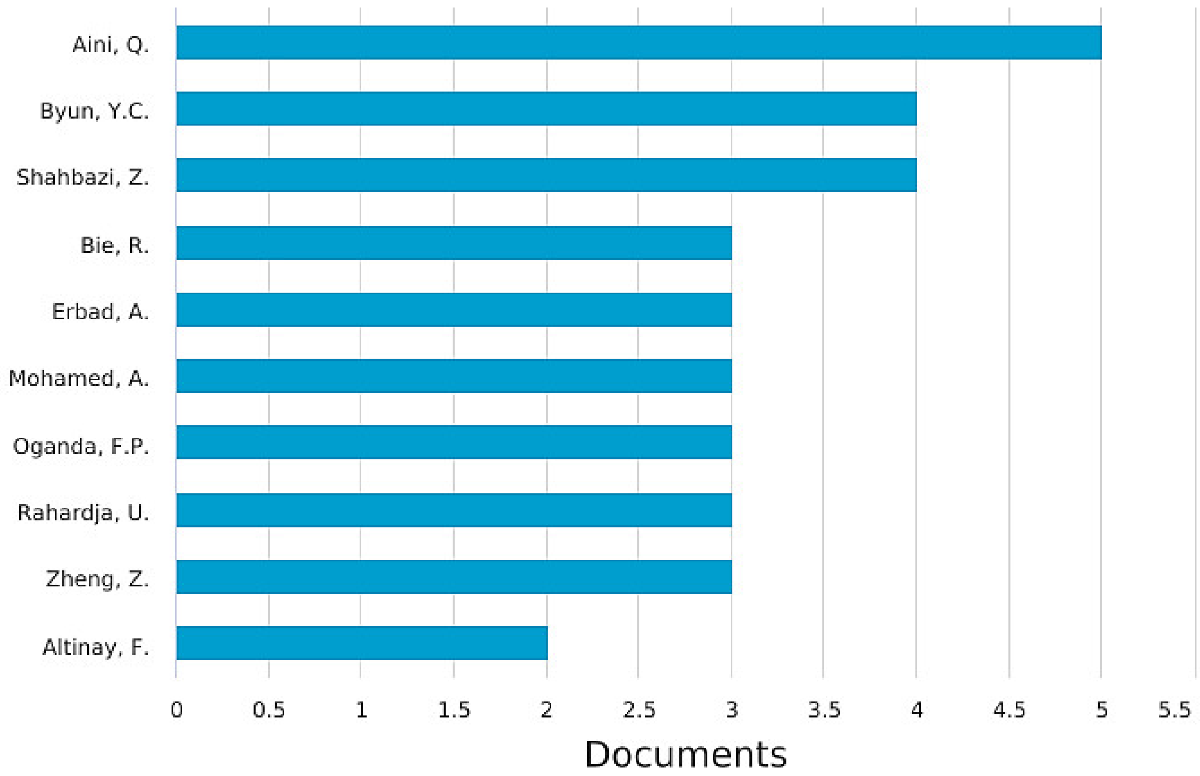


**Figure 3.** Documents by author (2015 to 2022).

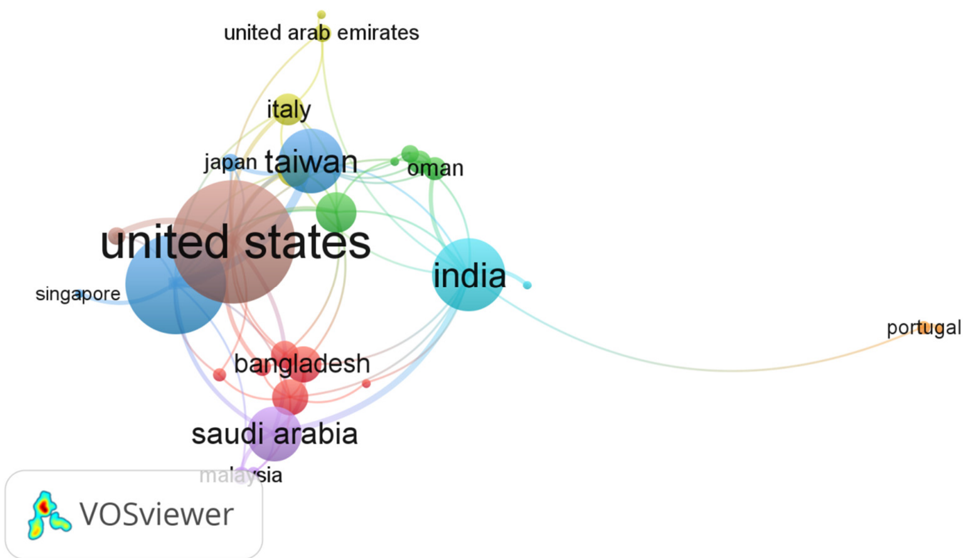


**Figure 4.** Countries' co-authorship networks based on total link strength.

Figure 5 demonstrates a co-authorship network of authors where each node represents different authors. Li had the highest collaboration and collaborated with all other authors, while Dai had the least. Guo had somewhat lower collaboration than Li, but it was higher than Sun, Zhang, Wang, Bie, An, Chen, and Dai. Regarding the intensity of collaboration, Li and Guo have the most significant association.

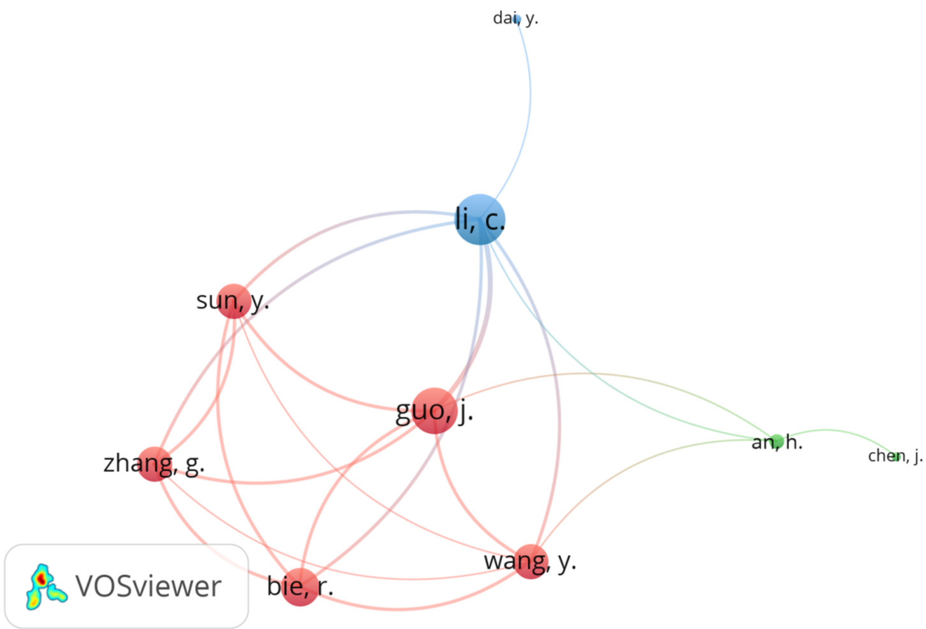


**Figure 5.** Co-authorship network of authors.

A total of 35.7 percent of all documents were published as conference reviews, as is shown in Figure 6. Conference papers and articles accounted for 31.1 percent and 26.3 percent, respectively. Only 4.4 percent of documents were produced as book chapters, whereas 2.3 percent and 0.2 percent were reported as reviews and editorials, respectively. Aggregately, conference reviews and conference papers constituted 66.8 percent of documents.

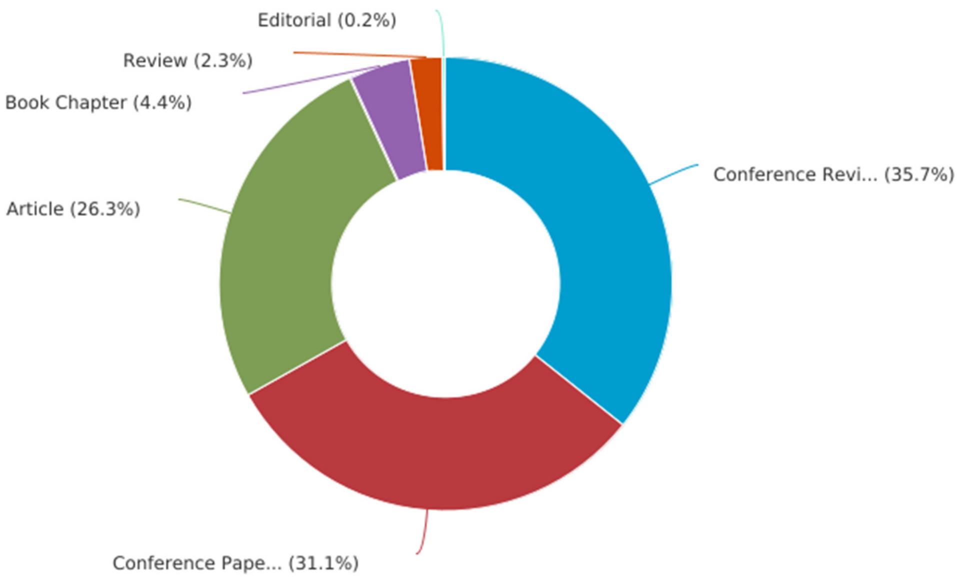


**Figure 6.** Publications by type (2015 to 2022).

Figure 7 exhibits documents published in various fields regarding blockchain and online learning. From the figure, it is notable that scholars from diversified fields produced documents regarding the stated topics. Computer science was the leading field for blockchain and online learning, and this field constituted 37.9% of documents, while material science had the lowest concern for these topics. Engineering, mathematics, decision science, and social science accounted for 16.6%, 13%, 9.6%, and 7%, respectively.

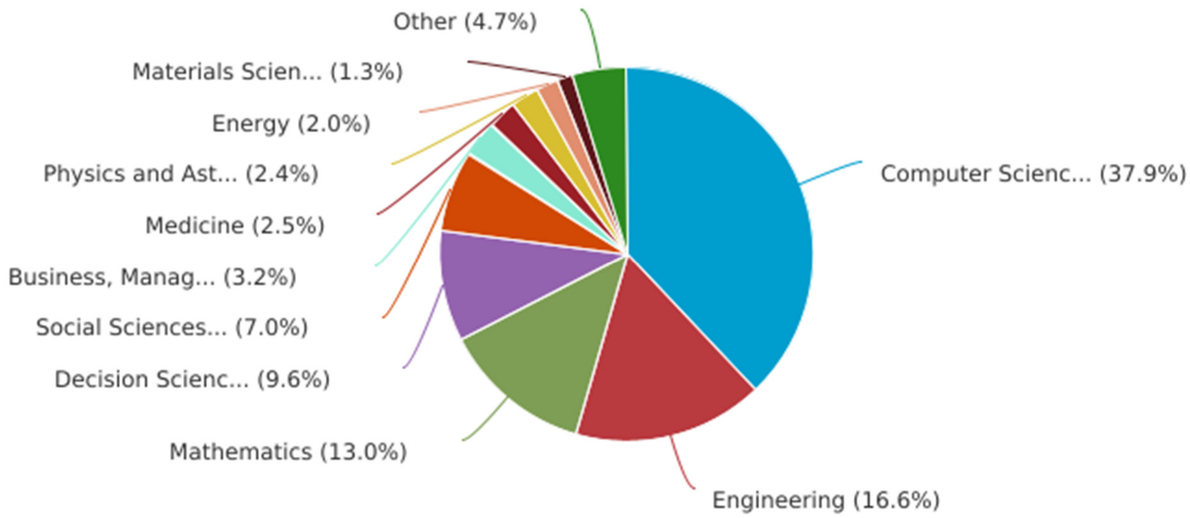


**Figure 7.** Publications by subject areas (2015 to 2022).

The number of documents produced from 2015 to 2022 is denoted in Figure 8. In 2015, there was only one published document. There was a slight increase in the next year, which remained the same in 2017. After 2017, there was a substantial surge in document production as this field received significant attention from many more researchers. In 2021, 141 publications were published. Despite the fact that, before the end of 2022, 114 publications were produced, by the end of the year, the number of documents may exceed the number reported in the previous year.

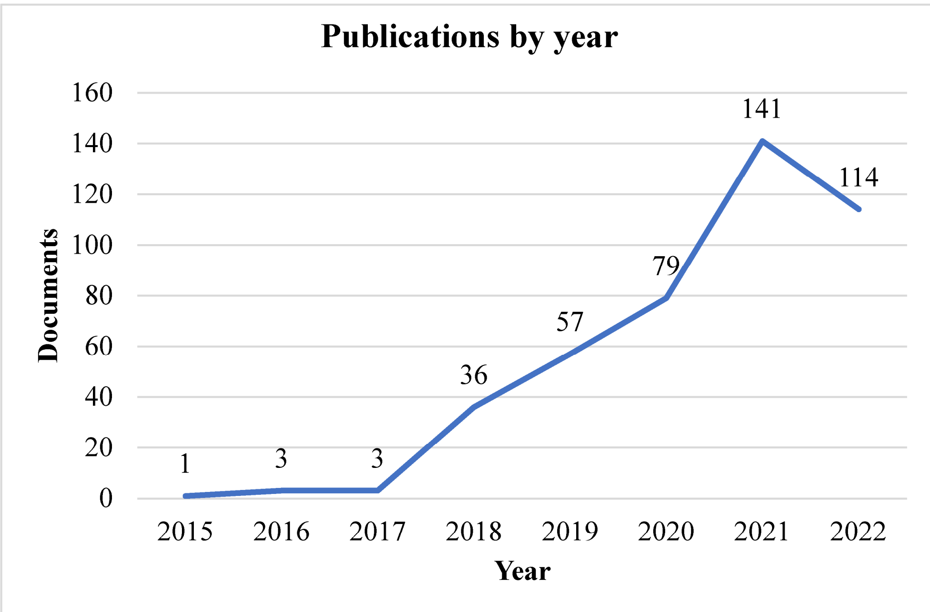


**Figure 8.** Publications by year (2015 to 2022).

The number of publications by the top ten affiliated organizations is depicted in Figure 9. Universitas Raharja produced the highest (six publications) number of documents. Beijing Normal University and Jeju National University reported the second highest number, each with five publications, while the other seven organizations had three publications each in blockchain and online learning domains.

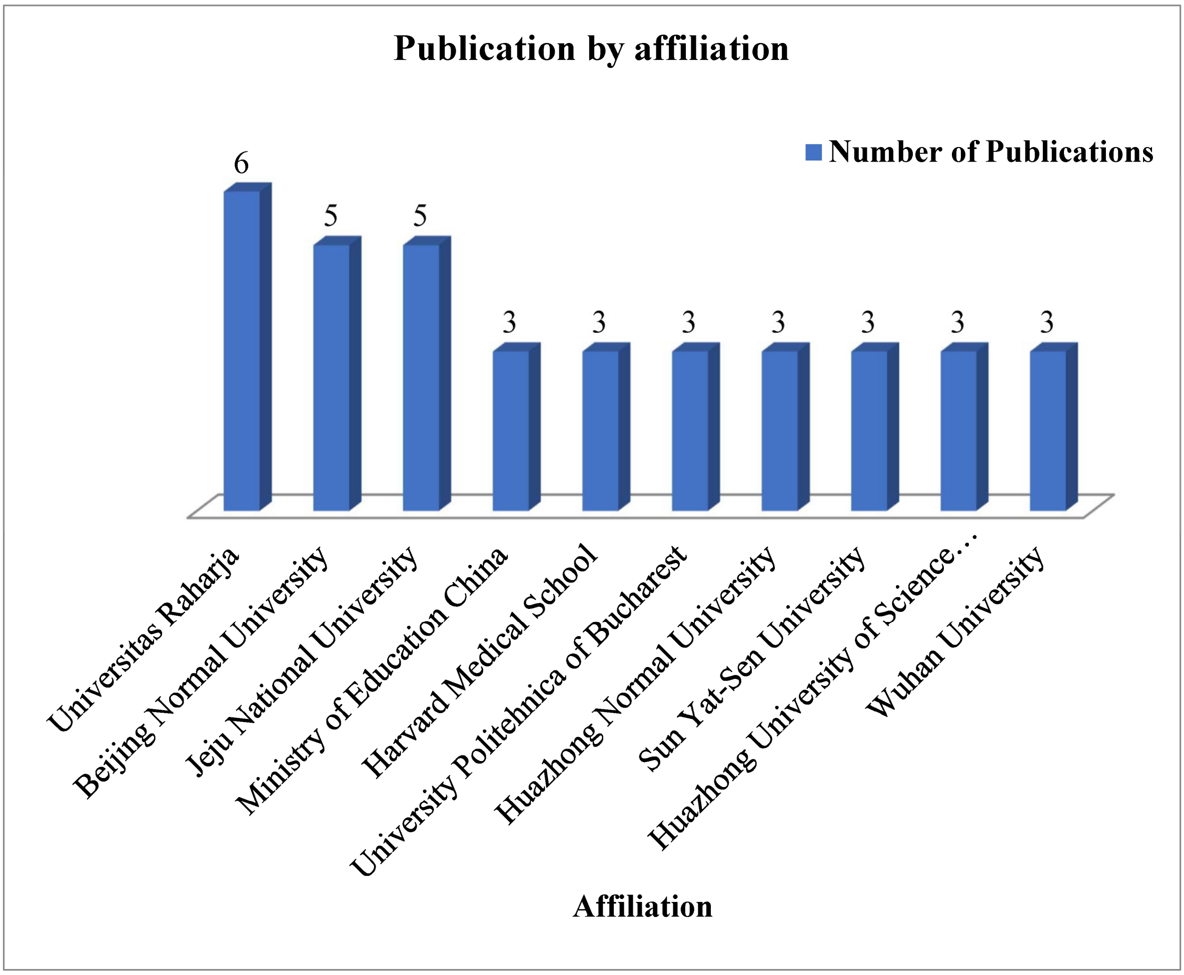


**Figure 9.** Publication by affiliation.

Figure 10 illustrates documents by the top five funding sponsors. Among the top five sponsors, the majority are from China. The National Natural Science Foundation of China reported the highest (22) documents, and the National Key Research and Development Program of China had the second highest (9) documents. The Horizon 2020 Framework Program funded only four documents, which was the lowest number among the top five sponsors.

The citation network of authors is symbolized in Figure 11. Oganda and Aini have mainly intensified citation networks and associations with three other authors, while Li, Bie, and Guo each have a small network.

The citation network of countries in Figure 12 exhibits that China has the most robust network, followed by the USA. Although the citation network of China is connected to the networks of the USA, India, Romania, Saudi Arabia, Indonesia, Turkey, and Italy, there is no link with the network of Australia. However, the intensification between the networks of China and the USA is very strong, which reveals that the authors of these two countries frequently cited the scholarly works of one another.

Co-citation happens when two particular documents are cited together in another document. The co-citation network of cited authors provides an overall idea of connection among the authors in a particular field. Figure 13 embodies the co-citation network of cited authors. From the diagram, it is marked that Zhang and Zheng received the most citations from Meybodi and Rahardja and a few from Kumar. Meybodi had a strong co-citation network with Zhang, Kumar, and Zheng, whereas Zhang and Zheng frequently cited Rahardja's works.

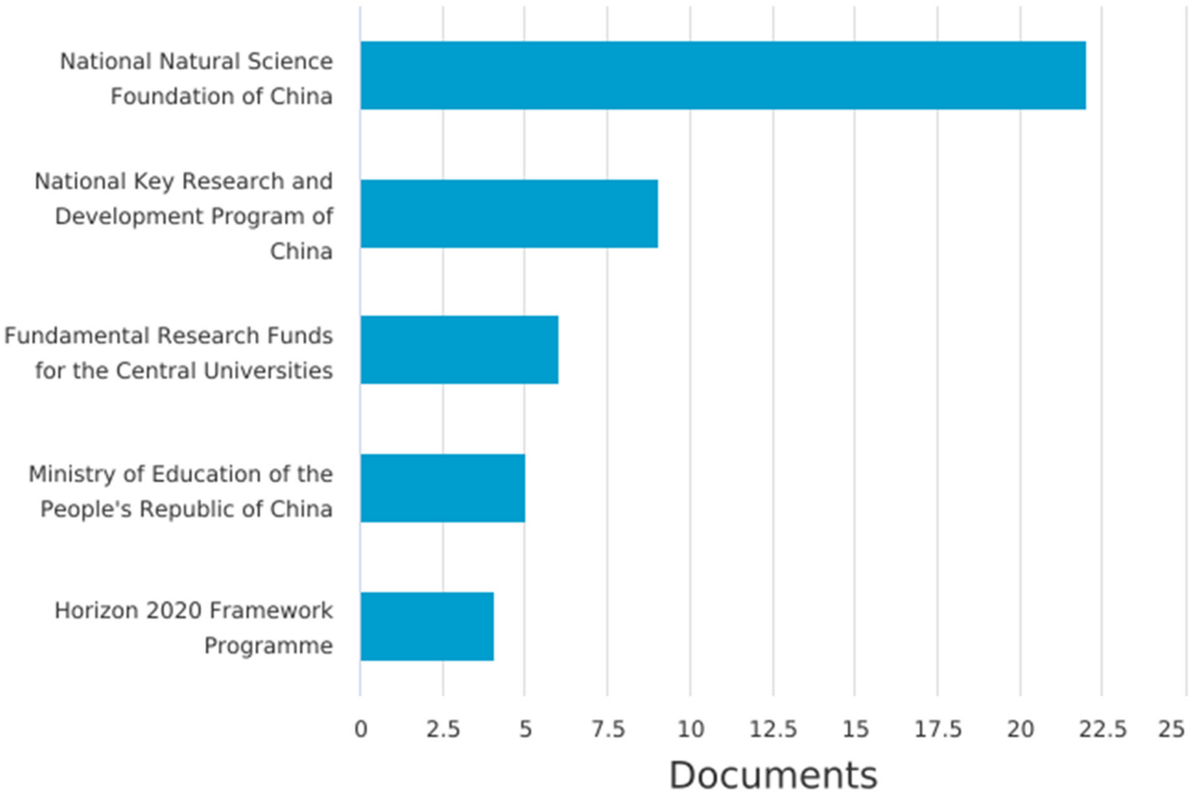


**Figure 10.** Documents by top five funding sponsors.

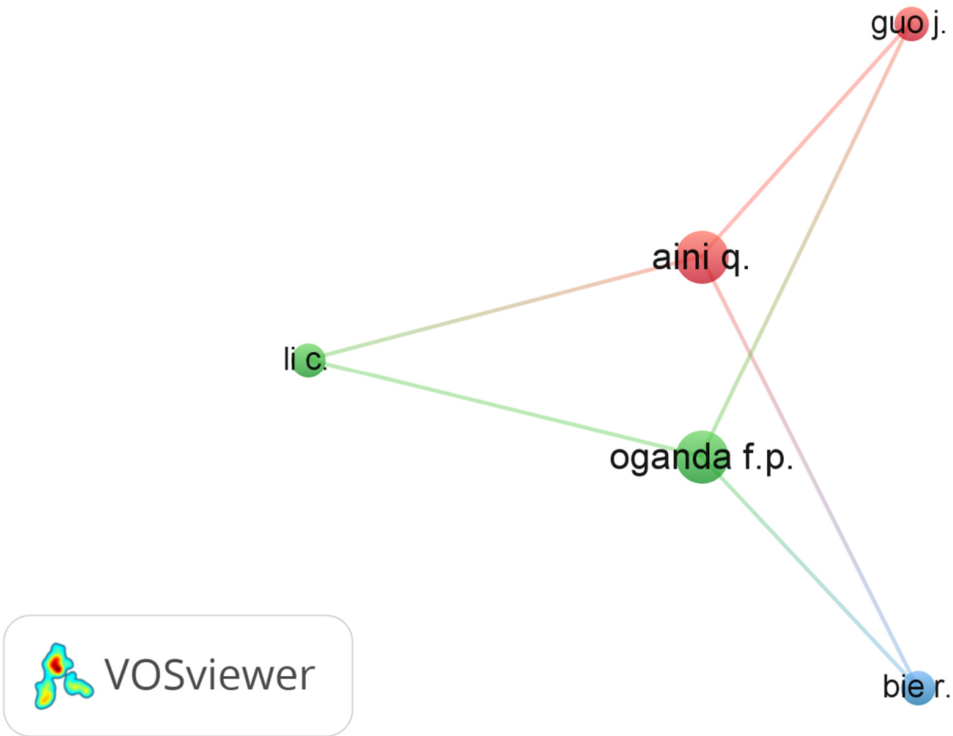


**Figure 11.** Citation network of authors.

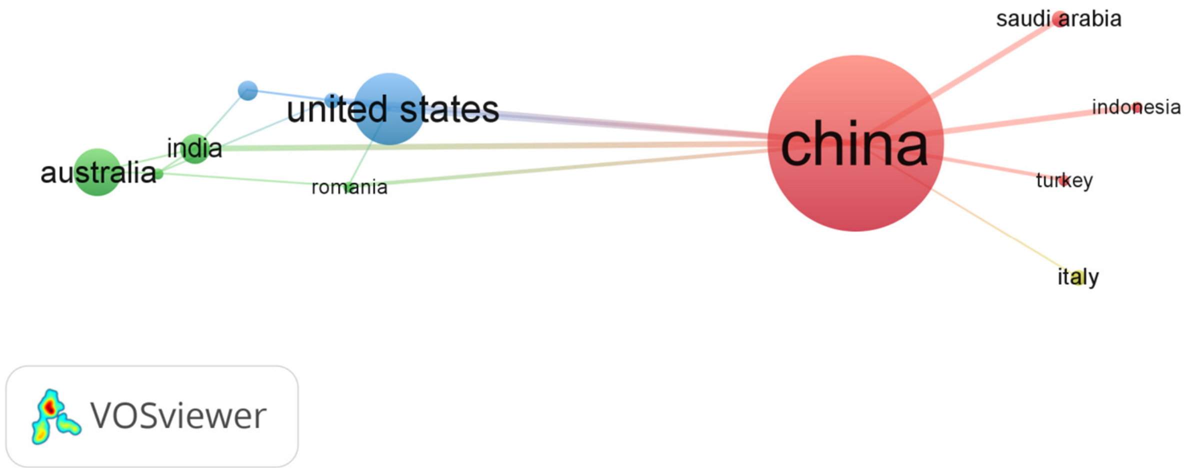


**Figure 12.** Citation network of countries.

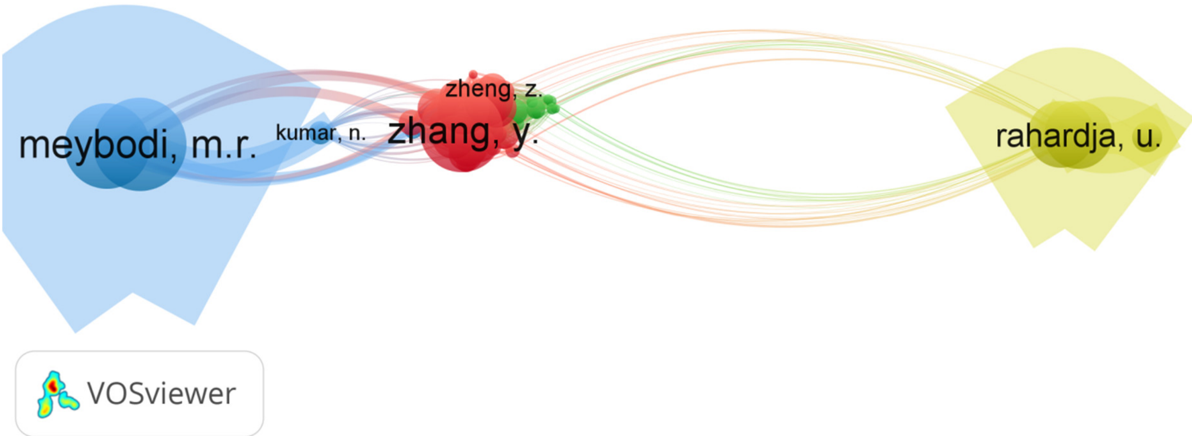


**Figure 13.** Co-citation network of cited authors.

Figure 14 exhibits a co-citation network, which represents a network of references that have been co-cited by a number of publications. The clusters are allocated to publications based on the dispersion of their references. Therefore, from the figure, we can infer that the potential of blockchain in education may go beyond bitcoin.

Bibliographic coupling of countries states that countries in the same bunch usually cite the documents of one another, which is demonstrated in Figure 15. There are six groups of countries represented by blue, green, red, sky, purple, and yellow, respectively. China is at the center of the network, followed by the USA and India. China's network includes the USA, Denmark, and Germany, while India, Taiwan, South Korea, Turkey, and Spain formed a separate group with citations of common documents. China has more bibliographically coupled documents with the USA than with Denmark.

Figure 16 accounts for the bibliographic coupling of documents used to assess the similarity between documents. The bibliographic coupling of documents arises when two individual documents commonly cite another document. There are eight bibliographically coupled document clusters, with [66] as the top most bibliographically coupled document, followed by [67].

A bibliographic data-driven network map was constructed based on the keywords from the respective publications, as is shown in Figure 17. The map signifies a web of repeated and remarkable terms, with blockchain as the center of the map, which is linked to other terms in the map. Although there are 30 related terms, blockchain, smart contract, security, privacy, artificial intelligence, human, students, online education, education, and authentication are the top ten central identified themes.

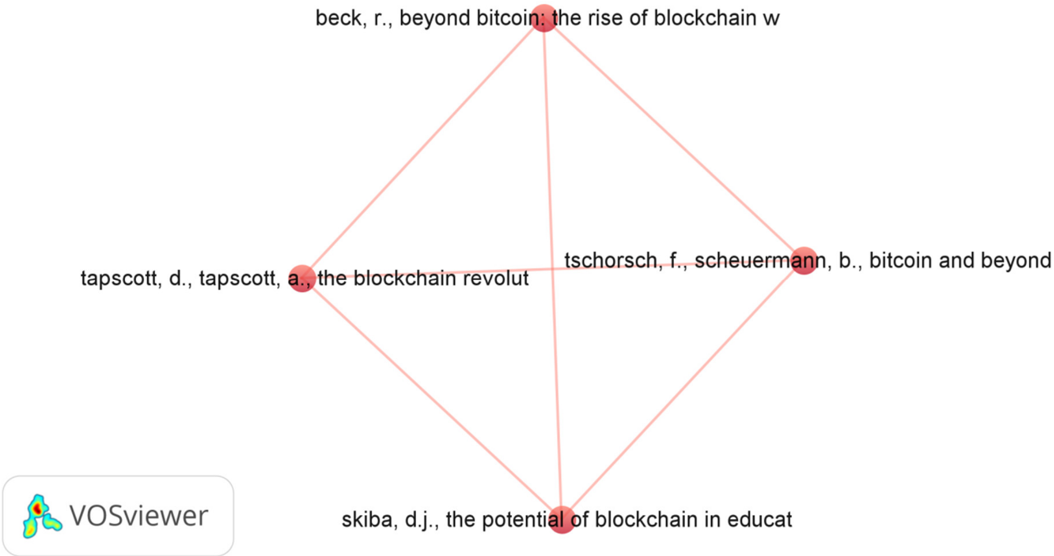


**Figure 14.** Co-citation network of cited references.

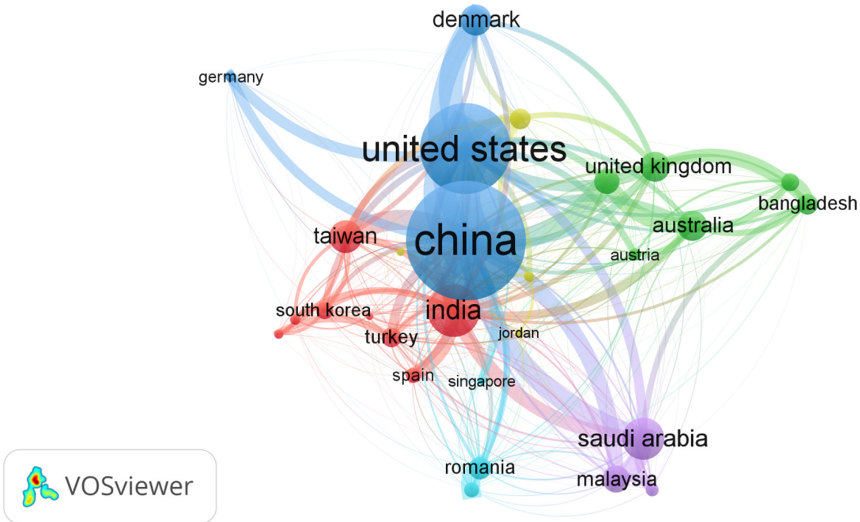


**Figure 15.** Bibliographic coupling of countries.

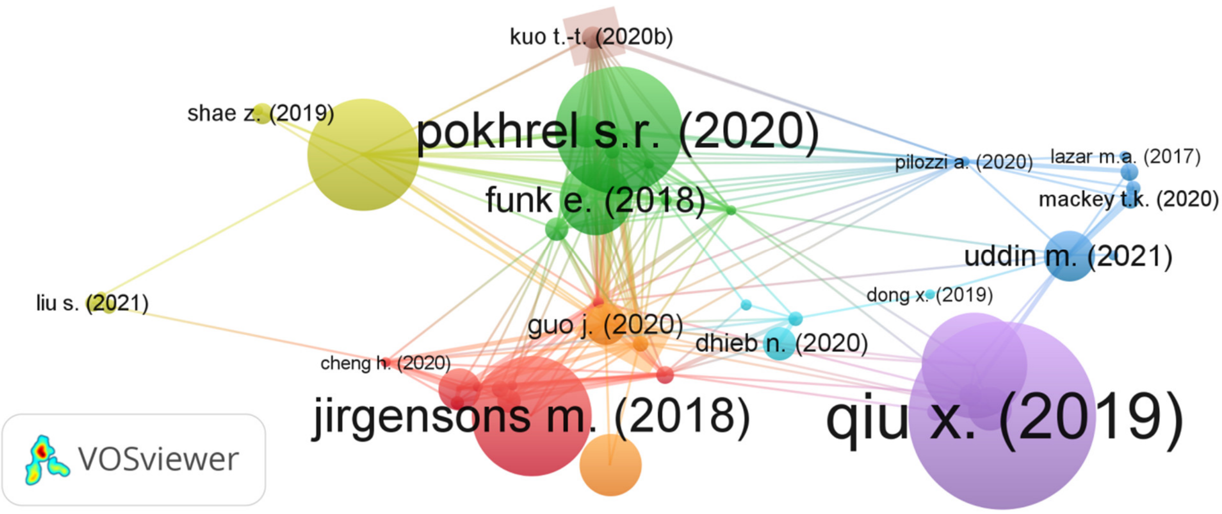


**Figure 16.** Bibliographic coupling of documents.

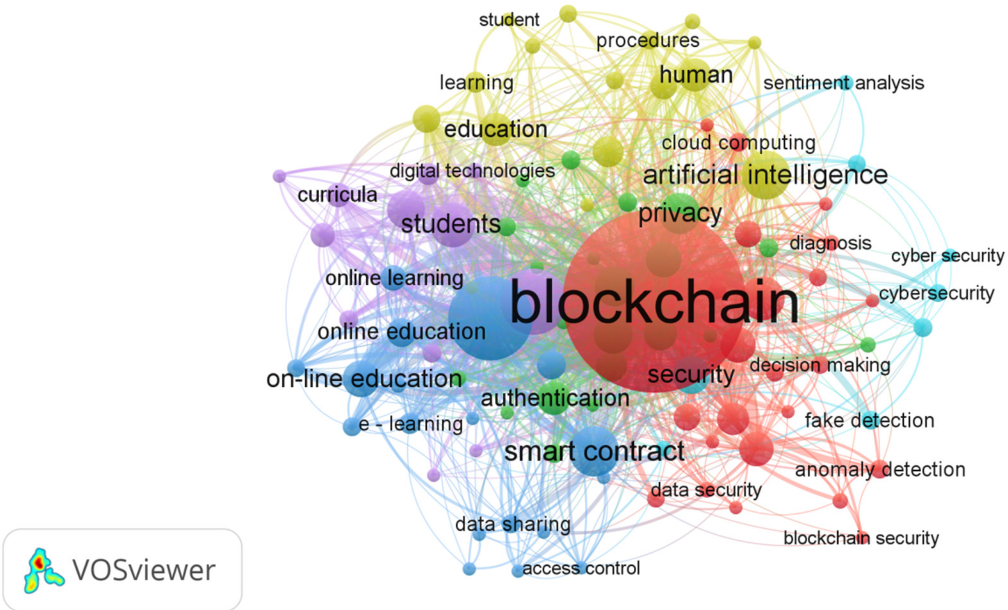


**Figure 17.** Bibliographic data-driven network map.

Figure 18 was developed using titles and abstracts of the chosen papers to determine the term co-occurrence. The bubble size for each term denotes the frequency of its usage, while terms of the same color typically confirm terms used together. The network map shows that, among a total of fourteen terms, knowledge, record, online education, online course, and anomaly detection were the most frequently used terms. On the contrary, sentiment analysis, shield chain, educational resource, and digital transformation were insignificantly used terms.

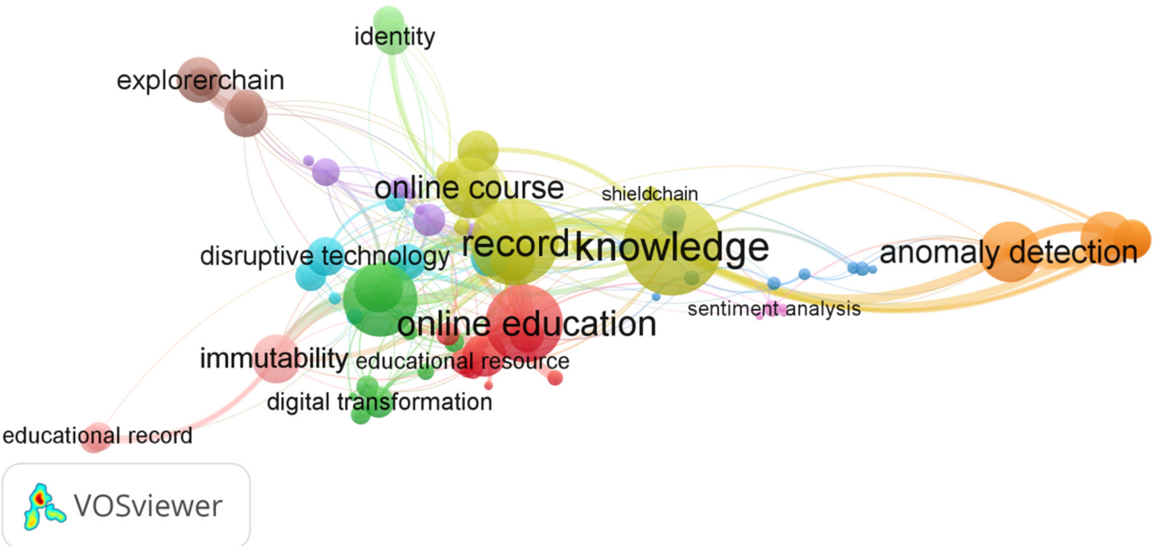


**Figure 18.** Text data-based term co-occurrence map.

## 4. Detailing the 15 Full-Text Documents

In Table 2, the authors have reported previously acknowledged publications relevant to the underlying aspects of the blockchain online learning nexus. In this sense, we adhered to the reporting standards, requirements, and suggestions recognized by [68].

**Table 2.** Reporting the identified documents.

| Study Code | Study Details | Objective(s) of Study | Research Methods | Underlying Aspects/Traits/Contexts |
|---|---|---|---|---|
| 1 | [69] | This study proposes a cross-university course learning system based on Hyperledger Fabric. This system stores student credits as well as the hash values of homework assignments and final exams on the blockchain, and all participating universities work together to manage the information on the blockchain. | The authors proposed a blockchain technology system for online learning in this study. So, researchers didn't use any particular method for conducting this study. They propose a complete system architecture describing the application process and chaincode. | The result indicated that, by using the chaincode provided by blockchain technology, educational institutions can validate student credits, analyze the substance of homework assignments and final exams, and assess whether students' skills satisfy their standards before recognizing the credits. Universities can provide information traceability, data integrity, privacy, and mutual authentication. |
| 2 | [70] | This study aimed to create a blockchain-enabled learning management system (LMS) as a metacognitive tool for online higher education to enhance development, monitoring, collaboration, zone of proximal development (ZPD), scaffolding, and reflection toward the growth of self-regulation and learning achievement. | Data were gathered both quantitatively and qualitatively. The quantitative data were obtained using the pre-and post-test questionnaires, which were analyzed using the *t*-test, and the qualitative data were obtained using reflective essays, which were analyzed using the content analysis method. | The research's conclusions showed that the blockchain-based systematic literature review (SLR) intervention online program had given MA candidates the chance to hone their abilities in genuine goal setting, self-monitoring, self-reflection, and self-awareness through coaching and collaboration. |
| 3 | [71] | This study analyzes a case study of how blockchain technology was used to decentralize lifelong learning. The authors specifically look into the many conditions and demands for increasing the accessibility and decentralization of online education and lifetime learning. | The three steps of this pilot case study were requirements elicitation, implementation and deployment, and evaluation. | Immutable formal and informal qualifications, sentimental analysis, lifelong e-learning routes, micro certificates, career counseling, data proprietorship, and confidentiality were the preliminary conclusions of this study. |
| 4 | [22] | The rudimentary focus of this study is on a blockchain-based online review and ranking system, which is a dispersed, trustworthy method focusing on the reliability of rating and freedom of content reviews by subject matter experts. | The authors of this study suggested using blockchain technology to score reviews for online courses. Researchers, therefore, did not employ any specific methodology for carrying out this investigation. | The study's findings showed that blockchain-based review systems improved the accuracy, reliability, and fairness of ratings for online courses offered by various universities. |
| 5 | [72] | The authors looked at the critical variables influencing educational institutions' intentions to embrace blockchain technology in online learning. | This research expanded the technology acceptance model by incorporating the principle of innovation diffusion. The validation of the conceptual framework used in this study was ensured through structural equation modeling. | The findings demonstrated that traceability, compatibility, convenience of use, and awareness of disruptive technology significantly impacted the adoption of disruptive technology in online education. |
| 6 | [73] | This paper discusses the creation of a blockchain education program using gamification to pique primary students' interests in the technology. By examining keyword data and subject-modeling language networks, it determines implications for how to teach the fundamentals of blockchain technology. | The ASSURE model, which emphasizes the use of digital media, was chosen as the development model for the education program, as opposed to the more well-known ADDIE model, after teaching design models were first analyzed in order to create the educational program. The educational program was then created using the ASSURE model's six phases. | The findings indicated that blockchain technology needs to be understood and given attention for the educational design model to work. This would guarantee the e-learning's quality, cyber security, accurate worksheet, and false data detection. |

**Table 2.** *Cont.*

| Study Code | Study Details | Objective(s) of Study | Research Methods | Underlying Aspects/Traits/Contexts |
|---|---|---|---|---|
| 7 | [74] | The authors of this paper presumed ElearnChain, which ensures privacy for educational records, as a solution to the problems with digital diploma insecurity, unacceptable digital diplomas between different institutions, and difficulty in locating superior audio-visual learning. | As part of a study on new models for online multimedia learning resources (MLR), the authors proposed a blockchain for evaluating MLR and applied consortium blockchain to e-learning educational records. | Blockchain technology offered fresh approaches to problems with digital diploma uncertainty, unacceptable digital diplomas between institutions, and difficulty in locating superior audio-visual learning resources. These issues were addressed by blockchain technology's traceability, immutability, and decentralization. |
| 8 | [75] | This article introduces NOTA, a cutting-edge online teaching and assessment system that makes use of blockchain technology to uphold the required teaching quality and assessment fairness while adhering to the course and exam schedules. | The authors considered the merits of the blockchain technology and algorithm model when creating the proposed approach. In order to perform this study, the authors read papers on the subject. | By putting forth this system, the authors achieved a number of goals, including data immutability, data authentication, teacher evaluation improvement, student sentimental performance improvement, online course performance improvement, assessment error ratio reduction, and student satisfaction ratio enhancement. |
| 9 | [76] | In addition to examining the importance of teachers' opinions about and experiences with blockchain in course development, this study also examines how blockchain is used in course development and assessment in Chinese institutions. | Five teachers were interviewed for performing this research using the TPACK framework, and course materials were gathered. | The research's findings highlighted how redesigning online courses based on the blockchain can enhance the alignment of the two technologies, the caliber of instruction, and the trust of different parties in online learning, as well as synchronize data sharing, online record data, and enhance data transformation into digital form. |
| 10 | [50] | This research proposed a blockchain-based system for online language learning that automatically assesses students' conduct and tracks their daily study habits in order to free teachers from the time-consuming and challenging task of verifying students' homework. | The authors of this research suggested a framework for online language learning using blockchain technology. The writers of this study just followed a few papers' instructions and created the framework on their own. | This study's findings suggested that the framework would automatically record and assess students' learning progress to attain the highest levels of openness, transparency, and trustworthiness. Additionally, this framework would significantly minimize the workload for teachers and prevent plagiarism by an incredible amount, while smart contracts would improve performance. Data protection and system security would be guaranteed. |
| 11 | [77] | The authors suggested a novel biometric authentication and blockchain-based online inspection mechanism to provide security for biometric features and granular access control. | This study focuses on using a blockchain-based online examination framework. | This blockchain-based online examination system would pinpoint the true source of malicious behavior, protect each user's data from leakage, do away with the need for a centralized authority, prevent user collusion from obtaining more data, and strengthen the authority's decision-making abilities. |

**Table 2.** *Cont.*

| Study Code | Study Details | Objective(s) of Study | Research Methods | Underlying Aspects/Traits/Contexts |
|---|---|---|---|---|
| 12 | [18] | Blockchain technology was utilized as a motivational element for enhancing learning capacities by creating a system.This technology might also improve students' enthusiasm for learning and development. | To pinpoint the factors (benefits of blockchain technology in the learning process) that contributed to greater satisfaction with educational services, a PLS-SEM analysis of students' perceptions was conducted. | The drivers of this blockchain-based e-learning system that the authors identified were trust, privacy and security, cost, data scarcity, scalability, and immaturity. Additionally, various advantages were discovered, including improved interactivity, career decision support, mental stability support, data authentication, etc. |
| 13 | [78] | In order to provide a unified and trusted data-sharing infrastructure for open learning and to address the issues of authentication, non-repudiation, and quickly accessible information distribution among open learning information systems and stakeholders, this paper suggested an extended consortium blockchain architecture with integrated and cross-chain functions. | The study's architecture comprised a pragmatic blockchain integration framework, an open learning scenario schema with blockchain integration, and an open learning application model. The Hyperledger Fabric 1.4 platform was assumed as the groundwork for the proposed blockchain integration framework. | The openness, scalability, security, and trustworthiness of this blockchain architecture were some of the author's findings as to its influencing factors. The outcome demonstrated that the blockchain system's implementation performed better than similar works examined while being implemented in a production context. |
| 14 | [79] | This study examined blockchain technology and emphasized how incentive affects teamwork and enhances learning outcomes in higher education institutions (HEI). | This study approach, literature review, content analysis (of blockchain platforms), content analysis of documents, and survey methodology were all used in this study. One hundred fifty students from three universities in Serbia, Romania, and Portugal provided data for this exploratory study. | Research showed that blockchain-based tools, as well as motivation, teamwork, collaborative effort, engagement, and student involvement, were significant contributors to enhancing student learning results. |
| 15 | [80] | This study aimed to create transparent and equitable interactions between students and professors by designing and developing a secure scoring system based on blockchain technology. | The three independent, smart contracts on the Ethereum blockchain were used to build the suggested scoring system. Experiments were then used to confirm the system's robustness and viability. | As a result, it was demonstrated that fraud on assessment tasks was prevented, fairness was improved, collaborative scoring policies were improved, educational assessment and peer review were improved, and trust in the online learning process was increased. |

As the application of blockchain in online learning is still in its inception phase in many countries across the globe, most previous studies have been conducted using qualitative methods. In contrast, a scanty number of empirical research has been conducted, as the framework(s) is (are) yet to be fully introduced. Therefore, the current body of knowledge concerning this domain still attempts to develop hypotheses instead of testing them.

Most researchers analyzed roughly 12–15 studies found by PRISMA methods for systematic reviews [81]. However, for a systematic literature review search, it is recommended that more than two databases be explored [82]. This research reported on 15 studies discovered using PRISMA 2020 methods. Furthermore, the researchers made use of four databases. As a result, in both cases, the authors have followed and maintained the thresholds.

## 5. The Development of Concomitant Clusters and Themes

Table 3 contains connected clusters that have been used to develop different themes.

**Table 3.** Development of themes.

| Terms from Bibliographic Visualization | Key Terms Derived from the 15 Papers | 1st Level Filtration and Association | 2nd Level Filtration and Association | Themes |
|---|---|---|---|---|
| Online learning, online education, students, privacy, artificial intelligence, security, smart contract, data security, data sharing, cloud computing, authentication, blockchain security, access control, sentiment analysis, fake detection, anomaly detection, privacy, security, e-learning, digital technology, diagnosis, online course, online education, record, knowledge, disruptive technology, immutability, identity, educational record, digital transformation, shield chain, sentiment analysis, educational resources. | Information validation, traceability, data integrity, privacy, mutual authentication, self-monitoring, self-awareness, sentiment analysis, lifelong e-learning routes, data ownership and privacy, accuracy, reliability, fairness, compatibility, cyber security, immutability, evaluation improvement, students' sentiment, data transformation, transparency, trustworthiness, scalability, interactivity, teamwork, collaborative effort, engagement. | Online learning, online education, data sharing, cloud computing, e-learning, digital technology, online course, record, knowledge, disruptive technology, shield chain, educational resources, fairness, educational record, digital transformation, scalability, evaluation improvement, compatibility, data transformation, transparency, trustworthiness. | Standardization across online learning settings | Standardized scholarship |
| | | Students, artificial intelligence, sentiment analysis, self-monitoring, self-awareness, lifelong e-learning routes, students' sentiment, interactivity, teamwork, collaborative effort, engagement. | Blockchain-based behavioral analysis | Behavior pattern |
| | | Information validation, security, smart contract, data security, traceability, data integrity, privacy, mutual authentication, authentication, blockchain security, access control, fake detection, anomaly detection, immutability, diagnosis, identity, data ownership and privacy, accuracy, reliability, cyber security. | Credentialing and immutability of nature | Digital badging |

## 6. Discussion on Themes and Conclusions

This study identified three themes concerning the nexus of blockchain and online learning, which were developed by filtering the key terms of bibliographic visualization and text of 15 systematically identified papers. The broad themes were standardized scholarship, behavior pattern, and digital badging.

The application of blockchain in online education has the potential to guarantee improved standards in online learning and education through the decentralization of educational resources and relevant information across the cloud, which is managed by a decentralized body, rather than a central authority. Decentralization frees the learning platform from the ownership of a single instructor, causing calibration in blockchain-based online learning systems, which boosts peer-to-peer learning [48,83]. In peer-to-peer learning, one student can directly learn from another [5,48].

Thus, blockchain can shift learning ownership from instructors to students [84]. Learning ownership by instructors refers to a learning environment in which instructors take an active role, whereas student ownership of learning represents students' active participation in learning, in which instructors serve as guides [85]. Besides, blockchain in online education empowers students to manage their data with a promise of easy and flexible access to data stored in blocks that ensures fairness and transparency in every aspect of learning. Furthermore, blockchain decentralizes the learning process, which allows students to learn from home and save time, costs, and energy for movement. This technology also contributes to introducing calibration in online learning systems by ensuring the authenticity of online education providers and maintaining the privacy and security of students' credentials [48,86]. Consequently, blockchain reduces adverse impacts on the environment, as it focuses on achieving the goal of decarbonization, digitalization, and decentralization [87,88]. It also improves the quality of education by supplementing traditional educational resources with disruptive technologies [21,89]. Therefore, blockchain and online learning are strongly associated, as blockchain results in standardization in online education.

The second theme of this research is a behavioral pattern, which designates the persistent methods of doing a task or interacting with an object or circumstance. Blockchain addresses several problems of the traditional online learning system, particularly emphasizing self-monitoring and self-regulation in learning [70]. Embracing blockchain in online education permits students to monitor their progress and evaluate themselves on their own, which is a rudimental key to the advancement of learning outcomes [80]. In addition, analysis of the attitudes and sentiments of students facilitates instructors and scholars to determine the effectiveness of particular learning methods and resources to, therefore, find ways to improve methods and resources, which consequently contribute to students' satisfaction and to the effectiveness of methods and materials. Furthermore, blockchain promises to provide real-time interaction between students and mentors, while facilitating collaboration between teams and students' interactivity and engagement in digital resource sharing. Once gained, sharing digital resources reduces the need for paper-based resources, i.e., books and papers, which reduces costs and adverse environmental impacts [90]. Above all, artificial intelligence and machine learning assesses the behaviors and detects anomalies in the behaviors of students by learning from students' past data; therefore, concerned authorities can gauge the future outcomes in the present and adopt a proactive approach to situational improvement.

Digital badging and immutable credentials are the vivacious advantages of blockchain in education, for which practitioners, educators, and scholars are highly enthusiastic about implementing blockchain in the online education system. The blockchain serves both students and teachers in maintaining and validating the digital identities of entities with a secure way of data sharing. In blockchain-based online learning systems, students can own their data, i.e., certificates and transcripts, and employers can quickly validate the candidates' authenticity. In contrast, institutions can easily and instantaneously share students' credentials, such as marks and evaluation scores, in soft forms, instead of using vast amounts of paper-based documentation, which drops the pressure on using paper. Moreover, blockchain supports respective entities to track and trace students' records effectively and efficiently, as it eliminates the obligation to keep bulks of paper for students' records, which is environment friendly as well [82,90]. Therefore, the stakeholders of blockchain reap substantial benefits from its application.

Thematically, blockchain and online learning are extensively associated, which is reflected by their popularity in online education or e-learning environments. Along with solving the significant challenges of conventional education arrangements, blockchain will bring immense success to online learning. Besides, it achieves environmental sustainability by saving fuels used for transportation by students and papers used for documents (educational resources and certificates). Therefore, theme, such as digital badging, can be predicted to become one of the vibrant agendas for future research opportunities. Hence, system developers, regulatory bodies, governments, and professionals in the education sector are encouraging the implementation and use of blockchain in online learning. However, in order for this to happen, a set of tailored strategies needs to be undertaken to make the bridge between blockchain and online learning. The set of strategies should be universal.

This study adds momentous findings to the blockchain and online learning field, but the findings are based on four databases. As a result, other databases, i.e., EBSCO, ProQuest, and JSTOR, can be considered for further study in this field to supplement the findings of this study. Another notable limitation of this study is that it is only based on published documents. Therefore, future studies can combine insights from primary data to contribute to current study outcomes.

**Supplementary Materials:** The following are available online at https://www.mdpi.com/article/10.3390/su15021470/s1, Checklist for PRISMA 2020.

**Author Contributions:** Conceptualization, M.Z., W.L., A.N.M.S. and B.W.; Methodology, M.Z., A.N.M.S. and R.A.R.; Software, A.N.M.S., B.W. and S.M.M.R.; Validation, W.L., K.M.A.I., N.H., R.M. and M.A.R.; Formal Analysis, W.L. and A.N.M.S.; Investigation, R.A.R., K.M.A.I., S.M.M.R. and M.A.R.; Resources, B.W., K.M.A.I., N.H. and R.M.; Writing—Original Draft Preparation, M.Z., W.L., A.N.M.S. and B.W.; Writing—Review & Editing, R.A.R., K.M.A.I., S.M.M.R., N.H., R.M. and M.A.R.; Visualization, M.Z., W.L., A.N.M.S., K.M.A.I. and S.M.M.R.; Supervision, M.Z., B.W. and M.A.R.; Project Administration, M.Z., W.L. and A.N.M.S. All authors have read and agreed to the published version of the manuscript.

**Funding:** This research received no external funding.

**Institutional Review Board Statement:** Not applicable.

**Informed Consent Statement:** Not applicable.

**Data Availability Statement:** This research examined publicly available datasets from Scopus, Web of Science, IEEE Xplore, and ScienceDirect. Data may be accessed using the identical search query that was used in this study.

**Acknowledgments:** The authors appreciate the managing editor's remarks and those of the anonymous reviewers, who have provided valuable suggestions.

**Conflicts of Interest:** The authors declare no conflict of interest.

## References

1. Nakamoto, S. Bitcoin: A peer-to-peer electronic cash system. *Decentralized Bus. Rev.* **2008**, *6*, 21260.
2. Niranjanamurthy, M.; Nithya, B.N.; Jagannatha, S.J.C.C. Analysis of Blockchain technology: Pros, cons and SWOT. *Clust. Comput.* **2019**, *22*, 14743–14757. [CrossRef]
3. Zheng, B.; Lin, C.H.; Kwon, J.B. The impact of learner-, instructor-, and course-level factors on online learning. *Comput. Educ.* **2020**, *150*, 103851. [CrossRef]
4. Saif, A.N.M.; Islam, K.A.; Haque, A.; Akhter, H.; Rahman, S.M.; Jafrin, N.; Rupa, R.A.; Mostafa, R. Blockchain Implementation Challenges in Developing Countries: An evidence-based systematic review and bibliometric analysis. *Technol. Innov. Manag. Rev.* **2022**, *12*, 22010202.
5. Miah, M. Blockchain technology in peer-to-peer elearning: Opportunities and challenges. In Proceedings of the EDSIG Conference ISSN, Virtual, 2020; Volume 2473, p. 4901.
6. Al-Balas, M.; Al-Balas, H.I.; Jaber, H.M.; Obeidat, K.; Al-Balas, H.; Aborajooh, E.A.; Al-Taher, R.; Al-Balas, B. Distance learning in clinical medical education amid COVID-19 pandemic in Jordan: Current situation, challenges, and perspectives. *BMC Med. Educ.* **2020**, *20*, 341.
7. GlobeNewswire. Global Mobile Learning Industry. 2020. Available online: https://www.globenewswire.com/news-release/2020/08/18/2080347/0/en/Global-Mobile-Learning-Industry.html (accessed on 11 September 2022).
8. eLearning Industry. The Impact of Blockchain Technology on the eLearning Industry. 2021. Available online: https://elearningindustry.com/impact-of-blockchain-technology-on-the-elearning-industry (accessed on 21 September 2022).
9. ReportLinker. Global Mobile Learning Industry. 2022. Available online: https://www.reportlinker.com/p05864358/Global-Mobile-Learning-Industry.html (accessed on 14 August 2022).
10. Alam, A. Platform Utilising Blockchain Technology for eLearning and Online Education for Open Sharing of Academic Proficiency and Progress Records. In *Smart Data Intelligence*; Springer: Singapore, 2022; pp. 307–320.
11. Dave, D.; Parikh, S.; Patel, R.; Doshi, N. A survey on blockchain technology and its proposed solutions. *Procedia Comput. Sci.* **2019**, *160*, 740–745. [CrossRef]
12. Gourlay, L. There is no'virtual learning': The materiality of digital education. *J. New Approaches Educ. Res.* **2021**, *10*, 57–66. [CrossRef]
13. Clark, J.T. Distance education. In *Clinical Engineering Handbook*; Academic Press: Cambridge, MA, USA, 2020; pp. 410–415.
14. Forbes. Blockchain And Online Learning Are a Powerful Combination. 2020. Available online: https://www.forbes.com/sites/seansteinsmith/2020/08/31/blockchain-and-online-learning-are-a-powerful-combination/?sh=21fcf246718d (accessed on 10 September 2022).
15. Bjelobaba, G.; Paunovic, M.; Savic, A.; Stefanovic, H.; Doganjic, J.; Miladinovic Bogavac, Z. Blockchain Technologies and Digitalization in Function of Student Work Evaluation. *Sustainability* **2022**, *14*, 5333. [CrossRef]
16. Alam, S. A blockchain-based framework for secure educational credentials. *Turk. J. Comput. Math. Educ. (TURCOMAT)* **2021**, *12*, 5157–5167.

17. Deenmahomed, H.A.; Didier, M.M.; Sungkur, R.K. The future of university education: Examination, transcript, and certificate system using blockchain. *Comput. Appl. Eng. Educ.* **2021**, *29*, 1234–1256. [CrossRef]
18. Chivu, R.G.; Popa, I.C.; Orzan, M.C.; Marinescu, C.; Florescu, M.S.; Orzan, A.O. The role of blockchain technologies in the sustainable development of students' learning process. *Sustainability* **2022**, *14*, 1406. [CrossRef]
19. Aisyah, E.S.N.; Haryani, H.; Budiarto, M.; Prihastiwi, W.Y.; Santoso, N.P.L.; Hayadi, B.H. Blockchain iLearning Platform in Education. In Proceedings of the 2022 International Conference on Science and Technology (ICOSTECH), Batam City, Indonesia, 3–4 February 2022; pp. 1–8.
20. Loukil, F.; Abed, M.; Boukadi, K. Blockchain adoption in education: A systematic literature review. *Educ. Inf. Technol.* **2021**, *26*, 5779–5797. [CrossRef]
21. Kuleto, V.; Bucea-Manea-Țoniş, R.; Bucea-Manea-Țoniş, R.; Ilić, M.P.; Martins, O.M.; Ranković, M.; Coelho, A.S. The potential of blockchain technology in higher education as perceived by students in Serbia, Romania, and Portugal. *Sustainability* **2022**, *14*, 749. [CrossRef]
22. Garg, A.; Kumar, P.; Madhukar, M.; Loyola-González, O.; Kumar, M. Blockchain-based online education content ranking. *Educ. Inf. Technol.* **2022**, *27*, 4793–4815. [CrossRef] [PubMed]
23. Akhter, H.; Abdul Rahman, A.A.; Jafrin, N.; Mohammad Saif, A.N.; Esha, B.H.; Mostafa, R. Investigating the barriers that intensify undergraduates' unwillingness to online learning during COVID-19: A study on public universities in a developing country. *Cogent Educ.* **2022**, *9*, 2028342. [CrossRef]
24. Maini, R.; Sehgal, S.; Agrawal, G. Todays' digital natives: An exploratory study on students' engagement and satisfaction towards virtual classes amid COVID-19 pandemic. *Int. J. Inf. Learn. Technol.* **2021**, *38*, 454–472. [CrossRef]
25. Akhter, M. Perceptions of Secondary Level Students and Teachers Taking Private Tutoring in English Online in Bangladesh. Ph.D. Thesis, Brac University, Dhaka, Bangladesh, 2022.
26. Bakar, A.; Shah, K.; Xu, Q. The effect of communication barriers on distance learners achievements. *Rev. Argent. De Clínica Psicológica* **2020**, *29*, 248.
27. Simamora, R.M. The Challenges of online learning during the COVID-19 pandemic: An essay analysis of performing arts education students. *Stud. Learn. Teach.* **2020**, *1*, 86–103. [CrossRef]
28. Belaya, V. The Use of e-Learning in Vocational Education and Training (VET): Systematization of Existing Theoretical Approaches. *J. Educ. Learn.* **2018**, *7*, 92–101. [CrossRef]
29. Duggal, S.; Dahiya, A. An Investigation into Research Trends of Massive Open Online Courses (MOOCs). *Int. J. Hosp. Tour. Syst.* **2020**, *13*, 17–28.
30. Li, Y. The Impact of Massive Open Online Courses Globalization on the Educational Equity. In Proceedings of the 2021 2nd International Conference on Education, Knowledge and Information Management (ICEKIM), Xiamen, China, 29–31 January 2021; pp. 248–251.
31. Adarkwah, M.A. "I'm not against online teaching, but what about us?": ICT in Ghana post COVID-19. *Educ. Inf. Technol.* **2021**, *26*, 1665–1685. [CrossRef] [PubMed]
32. Adedoyin, O.B.; Soykan, E. COVID-19 pandemic and online learning: The challenges and opportunities. *Interact. Learn. Environ.* **2020**, 1–13. [CrossRef]
33. Selvaraj, A.; Radhin, V.; Nithin, K.A.; Benson, N.; Mathew, A.J. Effect of pandemic based online education on teaching and learning system. *Int. J. Educ. Dev.* **2021**, *85*, 102444. [CrossRef] [PubMed]
34. Park, K.; So, H.J.; Cha, H. Digital equity and accessible MOOCs: Accessibility evaluations of mobile MOOCs for learners with visual impairments. *Australas. J. Educ. Technol.* **2019**, *35*, 48–63. [CrossRef]
35. Zhai, X.; Wang, M.; Ghani, U. The SOR (stimulus-organism-response) paradigm in online learning: An empirical study of students' knowledge hiding perceptions. *Interact. Learn. Environ.* **2020**, *28*, 586–601. [CrossRef]
36. Yin, B.; Yin, H.; Wu, Y.; Jiang, Z. FDC: A secure federated deep learning mechanism for data collaborations in the Internet of Things. *IEEE Internet Things J.* **2020**, *7*, 6348–6359. [CrossRef]
37. Krause, T.; Gösling, H.; Digel, S.; Biel, C.; Kolvenbach, S.; Thomas, O. Adaptive Cross-Platform Learning for Teachers in Adult and Continuing Education. In *International Conference on Artificial Intelligence in Education*; Springer: Cham, Switzerland, 2022; pp. 138–143.
38. Guo, J.; Li, C.; Zhang, G.; Sun, Y.; Bie, R. Blockchain-enabled digital rights management for multimedia resources of online education. *Multimed. Tools Appl.* **2020**, *79*, 9735–9755. [CrossRef]
39. Singh, A.; Sisodia, A. The Implementation of Blockchain Technology to Enhance Online Education: A Modern Strategy. In *Convergence of Blockchain Technology and E-Business*; CRC Press: Boca Raton, FL, USA, 2021; pp. 253–276.
40. She, J. Research on File Management Based on Block Chain Technology. In Proceedings of the 2021 4th International Conference on Information Systems and Computer Aided Education, Dalian, China, 24–26 September 2021; pp. 2099–2105.
41. Redman, J. MIT Media Lab Uses the Bitcoin Blockchain for Digital Certificates. 2020. Available online: https://gadgetsmalta.com/news/what-is-blockchain-and-why-do-we-need-it/attachment/mit-media-lab-uses-the-bitcoin-blockchain-for-digital-certificates/ (accessed on 18 December 2022).
42. Fedorova, E.P.; Skobleva, E.I. Application of blockchain technology in higher education. *Eur. J. Contemp. Educ.* **2020**, *9*, 552–571.
43. Son-Turan, S. The blockchain–sustainability nexus: Can this new technology enhance social, environmental and economic sustainability? In *Blockchain Economics and Financial Market Innovation*; Springer: Cham, Switzerland, 2019; pp. 83–99.

44. Steiu, M.F. Blockchain in education: Opportunities, applications, and challenges. *First Monday* **2020**, *25*. [CrossRef]
45. Dalal, N.; Pauleen, D.J. The wisdom nexus: Guiding information systems research, practice, and education. *Inf. Syst. J.* **2019**, *29*, 224–244. [CrossRef]
46. Kosmarski, A. Blockchain adoption in academia: Promises and challenges. *J. Open Innov. Technol. Mark. Complex.* **2020**, *6*, 117. [CrossRef]
47. Mackey, T.K.; Cuomo, R.E. An interdisciplinary review of digital technologies to facilitate anti-corruption, transparency and accountability in medicines procurement. *Glob. Health Action* **2020**, *13* (Suppl. 1), 1695241. [CrossRef] [PubMed]
48. Lam, T.Y.; Dongol, B. A blockchain-enabled e-learning platform. *Interact. Learn. Environ.* **2020**, *30*, 1229–1251. [CrossRef]
49. Rahardja, U.; Aini, Q.; Khairunisa, A.; Millah, S. Implementation of Blockchain Technology in Learning Management System (LMS). *APTISI Trans. Manag. (ATM)* **2022**, *6*, 112–120. [CrossRef]
50. Sun, X.; Zou, J.; Li, L.; Luo, M. A blockchain-based online language learning system. *Telecommun. Syst.* **2021**, *76*, 155–166. [CrossRef]
51. Ocheja, P.; Flanagan, B.; Ueda, H.; Ogata, H. Managing lifelong learning records through blockchain. *Res. Pract. Technol. Enhanc. Learn.* **2019**, *14*, 4. [CrossRef]
52. Vicente-Saez, R.; Martinez-Fuentes, C. Open Science now: A systematic literature review for an integrated definition. *J. Bus. Res.* **2018**, *88*, 428–436. [CrossRef]
53. Mishra, D.; Gunasekaran, A.; Papadopoulos, T.; Childe, S.J. Big Data and supply chain management: A review and bibliometric analysis. *Ann. Oper. Res.* **2018**, *270*, 313–336. [CrossRef]
54. Hernández-Torrano, D.; Ibrayeva, L. Creativity and education: A bibliometric mapping of the research literature (1975–2019). *Think. Ski. Creat.* **2020**, *35*, 100625. [CrossRef]
55. Linnenluecke, M.K.; Marrone, M.; Singh, A.K. Conducting systematic literature reviews and bibliometric analyses. *Aust. J. Manag.* **2020**, *45*, 175–194. [CrossRef]
56. McCoy, A.; Melendez-Torres, G.J.; Gardner, F. Parenting interventions to prevent violence against children in low-and middle-income countries in East and Southeast Asia: A systematic review and multi-level meta-analysis. *Child Abus. Negl.* **2020**, *103*, 104444. [CrossRef] [PubMed]
57. Nguyen, N.H.; Singh, S. A primer on systematic reviews and meta-analyses. *Semin. Liver Dis.* **2018**, *38*, 103–111. [CrossRef]
58. Gonzalez-Correa, C.A.; Tapasco-Tapasco, L.O.; Gomez-Buitrago, P.A. A Method for a Literature Search on Microbiota and Obesity for PhD Biomedical Research Using the Web of Science (WoS) and the Tree of Science (ToS). *Issues Sci. Technol. Librariansh.* **2021**, *99*. [CrossRef]
59. Harzing, A.W.; Alakangas, S. Google Scholar, Scopus and the Web of Science: A longitudinal and cross-disciplinary comparison. *Scientometrics* **2016**, *106*, 787–804. [CrossRef]
60. Al Ryalat, S.A.; Malkawi, L.W.; Momani, S.M. Comparing bibliometric analysis using PubMed, Scopus, and Web of Science databases. *JoVE (J. Vis. Exp.)* **2019**, *152*, e58494.
61. Pranckutė, R. Web of Science (WoS) and Scopus: The titans of bibliographic information in today's academic world. *Publications* **2021**, *9*, 12. [CrossRef]
62. Rochman, Y.A.; Herliansyah, M.K.; Sudiarso, A. Lean Implementation Framework for Small and Medium Enterprises Based on Sciencedirect Database: A Systematic Literature Review. In *Conference on Broad Exposure to Science and Technology 2021 (BEST 2021)*; Atlantis Press: Amsterdam, The Netherlands, 2022; pp. 302–306.
63. Li, X.T.; Abdullah, A.R.; Liu, W.; Saif, A.N.M. Blockchain adoption barriers in food supply chain: A systematic review and bibliometric synthesis. *Int. J. Bus. Innov. Res.* **2021**, in press. [CrossRef]
64. Page, M.J.; McKenzie, J.E.; Bossuyt, P.M.; Boutron, I.; Hoffmann, T.C.; Mulrow, C.D.; Shamseer, L.; Tetzlaff, J.M.; Akl, E.A.; Brennan, S.E.; et al. The PRISMA 2020 statement: An updated guideline for reporting systematic reviews. *Syst. Rev.* **2021**, *10*, 1. [CrossRef] [PubMed]
65. Van Eck, N.J.; Waltman, L. Citation-based clustering of publications using CitNetExplorer and VOSviewer. *Scientometrics* **2017**, *111*, 1053–1070. [CrossRef] [PubMed]
66. Qiu, X.; Liu, L.; Chen, W.; Hong, Z.; Zheng, Z. Online deep reinforcement learning for computation offloading in blockchain-empowered mobile edge computing. *IEEE Trans. Veh. Technol.* **2019**, *68*, 8050–8062. [CrossRef]
67. Pokhrel, S.R. WITHDRAWN: Towards efficient and reliable federated learning using blockchain for autonomous vehicles. *Comput. Netw.* **2020**, 107431. [CrossRef]
68. Saif, A.N.M.; Islam, M.A. Blockchain in human resource management: A systematic review and bibliometric analysis. *Technol. Anal. Strateg. Manag.* **2022**, 1–16. [CrossRef]
69. Chen, C.L.; Wang, T.; Tsaur, W.J.; Weng, W.; Deng, Y.Y.; Cui, J. Based on Consortium Blockchain to Design a Credit Verifiable Cross University Course Learning System. *Secur. Commun. Netw.* **2021**, *2021*, 8241801. [CrossRef]
70. Saadati, Z.; Zeki, C.P.; Vatankhah Barenji, R. On the development of blockchain-based learning management system as a metacognitive tool to support self-regulation learning in online higher education. *Interact. Learn. Environ.* **2021**, 1–24. [CrossRef]
71. Mikroyannidis, A.; Third, A.; Domingue, J. A case study on the decentralisation of lifelong learning using blockchain technology. *J. Interact. Media Educ.* **2020**, *2020*, 23. [CrossRef]
72. Ullah, N.; Mugahed Al-Rahmi, W.; Alzahrani, A.I.; Alfarraj, O.; Alblehai, F.M. Blockchain technology adoption in smart learning environments. *Sustainability* **2021**, *13*, 1801. [CrossRef]

73. Choi, E.; Choi, Y.; Park, N. Development of Blockchain Learning Game-Themed Education Program Targeting Elementary Students Based on ASSURE Model. *Sustainability* **2022**, *14*, 3771. [CrossRef]
74. An, H.; Chen, J. ElearnChain: A privacy-preserving consortium blockchain system for e-learning educational records. *J. Inf. Secur. Appl.* **2021**, *63*, 103013. [CrossRef]
75. Cheriguene, A.; Kabache, T.; Kerrache, C.A.; Calafate, C.T.; Cano, J.C. NOTA: A novel online teaching and assessment scheme using Blockchain for emergency cases. *Educ. Inf. Technol.* **2022**, *27*, 115–132. [CrossRef]
76. Min, L.; Bin, G. Online teaching research in universities based on blockchain. *Educ. Inf. Technol.* **2022**, *27*, 6459–6482. [CrossRef]
77. Zhu, X.; Cao, C. Secure Online Examination with Biometric Authentication and Blockchain-Based Framework. *Math. Probl. Eng.* **2021**, *2021*, 5058780. [CrossRef]
78. Xiao, J.; Jiao, Y.; Li, Y.; Jiang, Z. Towards a Trusted and Unified Consortium-Blockchain-Based Data Sharing Infrastructure for Open Learning—TolFob Architecture and Implementation. *Sustainability* **2021**, *13*, 14069. [CrossRef]
79. Bucea-Manea-Țoniş, R.; Martins, O.M.; Bucea-Manea-Țoniş, R.; Gheorghiță, C.; Kuleto, V.; Ilić, M.P.; Simion, V.E. Blockchain Technology Enhances Sustainable Higher Education. *Sustainability* **2021**, *13*, 12347. [CrossRef]
80. Tsai, C.T.; Wu, J.L.; Lin, Y.T.; Yeh, M.K.C. Design and development of a Blockchain-based secure scoring mechanism for online learning. *Educ. Technol. Soc.* **2022**, *25*, 105–121.
81. Gray, R. Why do all systematic reviews have fifteen studies? *Nurse Author Ed.* **2020**, *30*, 27–29. [CrossRef]
82. Charrois, T.L. Systematic reviews: What do you need to know to get started? *Can. J. Hosp. Pharm.* **2015**, *68*, 144. [CrossRef]
83. Liu, L.T.; Ma, R.; Gao, F. Design of Online Education Resource Sharing Model Based on Blockchain Technology. In *International Conference on E-Learning, E-Education, and Online Training*; Springer: Cham, Switzerland, 2021; pp. 205–217.
84. Gupta, T.; Burke, K.A.; Greenbowe, T.J. Shifting the ownership of learning from instructor to students through student-led instructor-facilitated guided-inquiry learning. In *Teaching Innovation in University Education: Case Studies and Main Practices*; IGI Global: Hershey, PA, USA, 2022; pp. 69–98.
85. Wiley, J. *Student Ownership of Learning: An Analysis*; University of Hawai'i at Manoa: Honolulu, HI, USA, 2009.
86. Lo, S.K.; Liu, Y.; Lu, Q.; Wang, C.; Xu, X.; Paik, H.Y.; Zhu, L. Towards trustworthy ai: Blockchain-based architecture design for accountability and fairness of federated learning systems. *IEEE Internet Things J.* **2022**. [CrossRef]
87. Borkovcová, A.; Černá, M.; Sokolová, M. Blockchain in the Energy Sector—Systematic Review. *Sustainability* **2022**, *14*, 14793. [CrossRef]
88. Bai, C.A.; Cordeiro, J.; Sarkis, J. Blockchain technology: Business, strategy, the environment, and sustainability. *Bus. Strategy Environ.* **2020**, *29*, 321–322. [CrossRef]
89. Maulani, G.; Gunawan, G.; Leli, L.; Nabila, E.A.; Sari, W.Y. Digital Certificate Authority with Blockchain Cybersecurity in Education. *Int. J. Cyber IT Serv. Manag.* **2021**, *1*, 136–150. [CrossRef]
90. Parmentola, A.; Petrillo, A.; Tutore, I.; De Felice, F. Is blockchain able to enhance environmental sustainability? A systematic review and research agenda from the perspective of Sustainable Development Goals (SDGs). *Bus. Strategy Environ.* **2022**, *31*, 194–217. [CrossRef]