Blockchain Technology in Peer-to-Peer eLearning: Opportunities and Challenges

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Abstract

Since the introduction of the cryptocurrency "bitcoin" (peer-to-peer electronic cash transaction) in 2008, its foundation technology "Blockchain" has gained tremendous interests both in industry and academia. Peer-to-peer eLearning strategy is becoming very crucial now-a-days when in-person learning may be limited specially during the situations such as in case of a pandemic (e.g., COVID-19) well as for the learners from poor socio-economic background for whom the tutoring cost sometimes plays an important role. In peer-to-peer eLearning, learners can receive free or low-cost tutoring or instructions from the peers. Peer-to-peer eLearning also proven to be very useful. There has been a lot of research on using Blockchain technology on eLearning in general, but not enough research has been conducted specifically in peer-to-peer eLearning area. Most research cover the area of online instructional methods, certifications, payments, keeping records, etc. but there is almost no comprehensive work exists in the specific area of peer-to-peer eLearning to create value. So, there is a huge gap that requires a lot of attention and Blockchain technology can be a valuable tool to fill this gap. This research studies to identify and analyze the past and current research of using Blockchain technology in peer-to-peer eLearning, investigates and explores the opportunities the Blockchain technology has in this area, discusses the challenges the Blockchain technology may have to deal with, and proposes recommendations of using Blockchain technology in peer-to-peer eLearning to create value that will help the community and increase the usability and popularity of this technology as a whole.

Keywords: Blockchain, peer-to-peer, eLearning, online learning, decentralized, distributed.

1. INTRODUCTION

Since the introduction of the cryptocurrency "bitcoin" (peer-to-peer electronic cash transaction) in 2008 (Nakamoto, 2008), its foundation technology "Blockchain" has gained tremendous interests both in industry and academia. Different sectors such as business, banking, health care, security, government, and education (also online education) showing a higher interest in the underlying Blockchain technology and many of these sectors have already accommodated the technology in certain aspects. However, there are still a lot of opportunities and venues for this technology to accelerate.

Over the past two decades, online education (eLearning) has been growing tremendously. Peer-assisted, peer-created, peer-led or simply peer-to-peer learning strategy is also becoming very crucial now-a-days specially when face-to-face learning, tutoring, or teaching instructions are very limited such as during the situations like a pandemic (e.g., COVID-19) that brings the social distancing as recommended or mandatory. Peer-to-peer eLearning also could be very helpful for the first-generation college students in minority institutions (e.g., HBCUs) with poor socio-economic background where tutoring cost sometimes plays an important role. In peer-to-peer eLearning, learners can receive free or low-cost tutoring or instructions from the peers online. Peer-to-peer learning and teaching also proven to be very useful. Peer-to-peer eLearning is different than traditional eLearning platform. In Traditional eLearning platform, an instructor teaches the learners online, whereas, in peer-

peer eLearning a learners learns from anther peer learner (for example, one student can teach another student).

There has been a lot of research on using Blockchain technology in online learning and teaching in general, but not enough research has been conducted specifically in the area of peer-to-peer eLearning. Most research cover the area of online instructional methods, certifications, payments, keeping records, and so on but there is almost no comprehensive work has been done in the specific area of peer-to-peer eLearning to create value using Blockchain technology. So, there is a huge gap that requires a lot of attention and Blockchain technology can be a valuable tool to fill this gap. Because of its distributed, documented, digitized, decentralized, and peer-to-peer network properties, Blockchain technology can play a very important role to create value in the area of peer-to-peer eLearning.

This study explores this new decentralized and distributed technology with its possible use in a time-related issue of peer-to-peer eLearning by understanding the technology, studying the past and current use of this technology in peer-to-peer eLearning area to find the gaps, exploring the new opportunities it has in this specific area, identifying the challenges it may have to deal with, and finally recommending how it can be used and what need to be done to create value. The study addresses the following research questions:

RQ1: What is Blockchain technology and how (so far) it has been used or addressed in peer-to-peer eLearning?
The first research question of this study is to understand the Blockchain technology including the technical component and how it works in general. The question also explores how Blockchain technology is being used in peer-to-peer eLearning so far by collecting and studying the relevant articles that provides the information regarding the use of Blockchain technology in this area.

RQ2: What are the current gaps and what opportunities Blockchain technology has in peer-to-peer eLearning?
This research question is the next step of the previous research question and this question finds the gaps of using Blockchain technology in peer-to-peer eLearning. The question analyzes the current application of Blockchain technology in peer-to-peer eLearning and explores further opportunities of using it to create value in this area.

RQ3: What challenges Blockchain technology may have to deal with for successful use in peer-to-peer eLearning?
This research question identifies the challenges Blockchain technology may have if it is used for the opportunities found in the previous research question. The challenges from different aspects will be explored through this research question.

RQ4: What are the recommendations to use Blockchain technology in peer-to-peer eLearning to create value that will help the community and increase the usability and popularity of the Blockchain technology as a whole?
This research question provides recommendations and suggestions how Blockchain technology can be used in peer-to-peer eLearning. This also recommends any other issues need to considered for successful use of this technology and overcome the possible challenges in order to create value to help the community with the blessings of this new technology. The recommendations also address to increase the usability and popularity of Blockchain technology as a whole.

2. LITERATURE REVIEW

Blockchain technology has been already proposed by many and some already applied in traditional education. Sun, Wang, & Wang (2018) studied that blockchain technology can store learning records in a trusted, distributed manner, provide credible digital certificates, realize learning resource sharing with smart contract, and protect intellectual property through data encryption. Sharples & Domingue (2016) proposed blockchain technology for the distributed storage of education data and can form knowledge currency.

MIT media labs used blockchain technology to issue academic certificate (Coleman, 2016). Other institutions such as Holberton school in San Francisco and Ngee Ann Polytechnic in Singapore also use blockchain technology to have their students to record their academic credentials, manage them as their learning outcomes, and use them for job-searching (Campbell, 2016; Rohaidi, 2017). Sony Global Education used blockchain technology in education field where an individual's academic proficiency records and measures of progress can be shared securely between two specified parties leveraging blockchain's secure properties (Sony Global

Education (2016). Centre for Blockchain Technologies in University College London (UCL) implemented a pilot program that offers the MSc graduates in Financial Risk Management to instant verification of their academic qualifications using bitcoin (UCL, 2020).

Grech & Camilleri (2017) also studied some use cases in education on using blockchain technology. Alammary, Alhazmi, Almasri, & Gillani (2019) conducted a systematic review of research investigating blockchain-based educational applications and discovers the main use of blockchain technology in education that includes to issue and verify academic certificates, share students' competencies and learning achievements, securely share students' data, lowering cost, and enhancing trust and transparency.

Online learning or eLearning area has also adopted blockchain technology in certain areas. Zhong, Xie, Zou, & Chui (2018) proposed an application using blockchain technology to improve engagement by rewarding virtual currencies to the top ranked learners based on predefined policies deployed on the blockchain network. Swan (2015) stated that application of blockchain technology may significantly influence the online learning system. Hori et al. (2016, 2018) proposed a decentralized architecture for an e-learning platform named Creative Higher Education with Learning Objects (CHiLO) that can retrieve content resources from the Internet to create the educational materials and distribute on the web, and manage the Internet resources as assets and record them in the blockchain by adopting blockchain smart property.

Gopane (2019) studied the possibility of using blockchain technology in education specially in the context of Self-directed, Motivated, Adaptive, Resource enriched, and Technology embedded (smart) university environment (Hwang, 2014; Tikhomirov & Dneprovskaya, 2015; Uskov et al., 2019) and proposed several areas where blockchain technology can be of great use but the study does not cover anything specific to peer-to-peer eLearning area. Bdiwi et al. (2017) proposed a Blockchain based architecture for ubiquitous learning environment (ULE) that preserves the benefits of security and privacy. The architecture allows to design decentralized topology-based secure learning system. Duan & Zhong (2017) addressed the Blockchain technology for educational-purpose using this technology and an automatic assessment software as a learning tool based on the university's graduation condition index and professional certification. They used block to save grades, process and evidences, course names, name of learning output (graduation condition indicator), course credits, etc. Curriculum evaluation was also part of this.

There are many articles have been published regarding peer-to-peer learning in general and many shows that the peer-to-peer learning is a very effective learning environment (Sadykova, 2014; Ahn et al., 2013, Purser, Towndrow, & Aranguiz, 2013, Trena, Senom & Ching-Fen, 2003, Huijser, Kimmins, & Evans, 2008), Taylor & Zeng, 2008, Bostrom, Gupta, & Hill, 2007, Biström, 2005), however they did not use or propose Blockchain technology as the foundation of the system.

The only study found by the literature review for this research that addresses the specific area of peer-to-peer eLearning is a graduate dissertation study that proposed a model for decentralized access control in a peer-to-peer eLearning platform using Blockchain structure. The study compared the mean response time to evaluate the proposed model in two network environments (LAN and Cloud Web Service); and argued that the LAN environment is ideal for the most appropriate condition and the cloud environment is better for the real situation in the real world as well as the average response time in LAN environment is 1.5 times faster than that of cloud environment (Ma, 2018). However, the study does not cover the area of finding gaps of using Blockchain in peer-to-peer eLearning as well as opportunities, challenges, and recommendation of using Blockchain technology for peer-to-peer eLearning which are the focus of this research paper.

3. RESEARCH METHODOLOGY

This study adopted the systematic mapping research methodology specially for the research questions RQ1 and RQ2. Systematic mapping provides the overview of a research topic or area to explore the existence and quantity of research evidence (Kitchenham & Charters, 2007). The systematic mapping methodology followed in this study was proposed by Petersen, Feldt, Mujtaba, & Mattsson (2008) and used the guidelines proposed by Kitchenham & Charters (2007) to search the related articles. The main goals for the RQ1 and RQ2 are to understand the Blockchain technology, how the technology works, find the past and current research of Blockchain technology in peer-to-peer eLearning as well as the use of Blockchain technology in this specific area to find the gaps. Finding the gaps will lead to the second part of RQ2 to identify the possible

opportunities of this decentralized and distributed technology to use in in peer-to-peer eLearning. The research questions RQ1 and RQ2 are the foundations of the research questions RQ3 and RQ4. The findings from research questions RQ1 and RQ2 will lead to answer the research questions RQ3 and RQ4 to identify the challenges the Blockchain technology may have if to be used successfully in peer-to-peer eLearning as well as to provide recommendations about at what aspects this technology should be used to create value in this specific area and increase the usability and popularity of this technology as a whole. The Figure 1 (see Appendix) presents the research methodology process.

As mentioned earlier, a lot of research has been found regarding the use of Blockchain technology in traditional education and online education (eLearning) in general, however, not enough found specific for the peer-to-peer eLearning.

To understand the Blockchain technology, how it works, and to find the research gaps, a systematic mapping research methodology was adopted. it is important to conduct review widely in capturing qualitative attributes for cumulative knowledge-creation and by going beyond systematic review notion to a certain extent in particular for an analysis (Okoli & Schabram, 2019). Considering the popularity of the Blockchain technology and time frames for reviews, the study focused on collecting sample articles through open-sourced Google Scholar database for published article or content in a complete form in journal, conference proceedings, technical report, white paper, and blogs. Articles published only in English were considered. The keyword-based search was conducted using the terms "Blockchain", and "Blockchain Technology" for the research question RQ1, and "Blockchain in education", "Blockchain in online education", "Blockchain in eLearning", "peer-to-peer learning", "Blockchain in peer-to-peer learning", and "Blockchain in peer-to-peer eLearning" for the research question RQ2. As the main focus of this study towards the use of Blockchain technology specific in the area of peer-to-peer eLearning, the study considered only some major articles found in the general areas of Blockchain in "education", "online education (eLearning)", and "peer-to-peer learning" as there are a huge number of articles found in those general areas. As mentioned earlier the search found only one article which is a graduate thesis dissertation specific for Blockchain in peer-to-peer eLearning.

The collected articles were then reviewed to remove the duplicate and unrelated articles form the collection. The final list of articles ranges from the introduction of this technology in 2008 to the most recent in 2020. The final list of articles were then categorized in term of "Blockchain technology and how it works", "Blockchain technology in traditional education", "Blockchain technology in online education or eLearning", "peer-to-peer learning/eLearning", and "Blockchain technology in peer-to-peer eLearning" based on the title, abstract, and main theme or idea of the articles. The snapshot of the categories of articles is presented in Table 1 (in Appendix). Each of the articles was then studied thoroughly to understand the Blockchain technology and how it works; and to find the gaps of using Blockchain technology in peer-to-peer Learning. Based on the findings of studying the articles and literature review, this study then focused on identifying the possible opportunities the Blockchain technology has for using in peer-to-peer eLearning. Then it focused on identifying the challenges the technology may have to deal with for successful use in peer-to-peer eLearning. Finally, the study provides recommendations for using Blockchain technology in peer-to-peer eLearning to create value and increase the usability and popularity of this technology as a whole.

4. DISCUSSION

This section presents the findings and answers to the four research questions defined earlier.

RQ1: What is Blockchain technology and how (so far) it has been used or addressed in peer-to-peer eLearning?

Blockchain was introduced in 2008 by Nakamoto and the concept of cryptocurrency bitcoin became known to the world (Nakamoto, 2008; Grinberg, 2012; Barber et al., 2012). Bitcoin code was released in 2009 and described as a peer-to-peer electronic cash transaction for online payments from one party to another without the involvement of any financial institution.

Blockchain is the technological foundation of digital currency or cryptocurrencies such as "bitcoin". Blockchain is mainly a distributed database across a peer-to-peer network that records documented, digitized, and decentralized public ledger of all cryptocurrency transactions in chronological order. Blockchain technology is the combination of several areas including cryptography, algorithms, mathematics, and economics. This disruptive technology solves

synchronization issues from traditional distributed database by combining peer-to-peer networking and distributed consensus algorithms (Garay, Kiayias, & Leonardos, 2015).

Blockchain mainly enables a distributed database of transactions or records that works as a documented, digitized, and decentralized public ledger of all cryptocurrency transactions in chronological order, that are shared among all end parties (Al-Debei & Avison, 2017; Ai, Han, Wang, & Yan, 2016; Alexandre, 2019; Al-Saqafa & Seidlerb, 2017). Blockchain holds every transaction ever recorded in it, verified, and never can be removed once entered in the ledger.

Blockchain works as a distributed database across the decentralized peer-to-peer network without the existence of any centralized database or server (Han, Yan, Li, Ji, & Li, 2014). Each computer in this peer-to-peer network is considered as a node, and each node contains automatically downloaded duplicate copy of the Blockchain. Public key and private key cryptography systems are used by the transactions. Transactions are digitally signed with a public key. Each public key is mathematically related with the corresponding private key. The public key is used to encrypt the message, and the private key is used to decrypt the message. The two major features of the Blockchain technology are anonymity and distributed computing (Ji et al., 2015, Han et al., 2013).

The transactions happen in groups called blocks, and then links them to the chain (of the block). All the transactions in a block are considered to be happened at the same time, and are linked to each other like a chain in a chronological order where each block contains the hash of the previous block (Crosby, et al, 2015).

Blockchain technology uses consensus mechanism (consensus of majority nodes) to validate the transactions and blocks to update the shared ledger. For example, proof-of-work consensus algorithm used for the bitcoin. The process by which nodes devote their resources (e.g., CPU, electricity) to perform rigorous computations to find the nonce, is called mining, and the nodes are called the miners. Through mining, nodes compute the proof-of-work which is a form of achieving consensus among the distrusted nodes (Puthal et al., 2018). Hash is a numeric value of fixed length that uniquely identifies the data, and used with digital signatures, which is a popular method in cryptography (Microsoft Docs, 2013). An overview of Blockchain technology is presented in Figure 2 (see Appendix) which is adopted from Puthal et al. (2018).

As mentioned earlier, not much use of Blockchain technology found in the area of peer-to-peer eLearning. The dissertation study by Ma (2018) addresses the use of Blockchain technology in the specific area of peer-to-peer eLearning that proposed a model for decentralized access control in a peer-to-peer eLearning platform using blockchain structure (Ma, 2018).

RQ2: What are the current gaps and what opportunities Blockchain technology has in peer-to-peer eLearning?

Gaps: As discussed in "Literature Review" and the category of articles presented in Table 1 (see Appendix), it can be seen that there are many articles address the use of Blockchain technology in traditional education and eLearning (online educations) in general, however, the focus of this study is very specific to peer-to-peer eLearning and not for the traditional education and eLearning in general. The graduate dissertation study by Ma (2018) addresses the use of Blockchain technology specifically in peer-to-peer eLearning. The dissertation proposed a model for decentralized access control in a peer-to-peer eLearning platform using blockchain structure. It compared the mean response time to evaluate the proposed model in two network environments (LAN and Cloud Web Service); and argued that the LAN environment is ideal for the most appropriate condition and the cloud environment is better for the real situation in the real world as well as the average response time in LAN environment is 1.5 times faster than that of cloud environment. So, this is clear that not enough work has been done to address the Blockchain technology specific for peer-to-peer eLearning and there exists a huge gap. This was a motivation for this study to identify the opportunities of using Blockchain technology for peer-to-peer eLearning. This decentralized and distributed technology could be so useful in peer-to-peer eLearning where each learner/tutor would be able to learn, teach, and communicate with other learners/tutors without any centralized or controlled system and everyone will have the same power in the network.

Opportunities: Traditional eLearning systems utilize centralized control mechanisms and depends on maintaining a centralized database and under common administrative control (Miltchev et a., 2008). The centralized systems are good in terms of security and administrative

control; however, they are not very efficient when number of concurrent users grow rapidly and become very large. Also, the system is controlled by the central party. Building a decentralized and distributed peer-to-peer eLearning system using Blockchain can provide several advantages and can overcome some of the limitation of traditional eLearning systems.

- In a centralized system or network, if the centralized server or database fails, the whole system fails. Whereas, in Blockchain network each node or computer (user) communicate with other nodes and has the same power; and there is no centralized or controlling node, so failing of any node in the network does not affect the performance of other nodes. Blockchain technology can provide this benefit of decentralized system for peer-to-peer eLearning.
- Unlike the centralized system, in Blockchain network the total number of users does not depend on the capacity of a single centralized server, so it can accommodate a growing number of users easily. So, peer-to-peer eLearning using Blockchain should be able to accommodate a greater number of users.
- In centralized system, the performance is limited and depends on the capacity of the centralized server. In Blockchain network, the performance does not depend on any single node or server. So, the overall performance in peer-to-peer eLearning using Blockchain will not depend in any single centralized server.
- The traditional eLearning system has a high cost. Sometimes the cost is beyond the capability of independent learners and sometimes may be available only through an institution or organization. Also, it may be available for one-way teaching/learning when students learn from a teacher/tutor, and may not be available for peer-to-peer eLearning. Peer-to-peer eLearning can provide anyone the benefit to learn or teach. This can be free of cost or sometimes with a very minimal cost that can be beneficial for students who cannot afford high tuition cost specially for the students of HBCUs where many of students are first-generation college students and come from a poor socio-economic background. So, a peer-to-peer eLearning system using Blockchain technology can provide these benefits.
- Unlike traditional system, Blockchain network can expand the peer-to-peer eLearning worldwide and anyone would be able to learn from anyone on the other part of the world.
- The blockchain network is also transparent. Every node can see everything published in the network. So, the users on peer-to-peer eLearning using Blockchain technology will have more accessibility and transparency.
- As mentioned earlier, the blockchain technology uses public key and private key cryptography systems for security purpose. Transactions are digitally signed with a public key. Each public key is mathematically related with the corresponding private key. The public key is used to encrypt the message, and the private key is used to decrypt the message. This way security and privacy is maintained.
- One of the characteristics of Blockchain technology is that once the data or information entered on a block it cannot be changed or altered, this is called immutability. In this way the data provider can verify the security, efficiency, and originality of the data as well as the date, and the recipient can be confident about the authenticity and unchanged nature of the data. The immutability element is very beneficial for financial transactional specially when there is cost and payment involved in peer-to-peer eLearning (Joshi, Han, & Wang, 2018). This will be very useful when users of peer-to-peer eLearning system will pay or receive tutoring cost.
- As the Blockchain network is decentralized, the users do not need to rely on any third party for any financial transaction for paying and receiving tutoring cost or sharing documents that may be involved in peer-to-peer eLearning. This also makes the transaction faster (Sharma, 2019).
- The participants of Blockchain network do not have user identity. Each participant has a generated address which keeps the user's anonymity, especially in a public Blockchain network (Lastovetska, 2019). The Blockchain address results in the anonymity resolving trust issues (Möser, 2013). So, in peer-to-peer eLearning, the users would be able to maintain their anonymity while taking the advantage of learning and tutoring.

RQ3: What challenges Blockchain technology may have to deal with for successful use in peer-to-peer eLearning?

Even having a lot of possibilities and bright future, Blockchain technology faces some challenges in addition to the debate and doubt on the cryptocurrencies. However, one need to understand that the cryptocurrency is only one of the applications of Blockchain technology and this technology can be applied in almost every sector. Government and private sectors have already accommodated this new technology in some aspects but can accel a lot more. Some articles addressed major challenges faced by Blockchain in general (such as Yli-Huumo et al., (2016). Some challenges Blockchain technology may face specifically for using in peer-to-peer eLearning are discussed below.

- Even though Blockchain network can handle more concurrent users because of its decentralized characteristic, but when the number of transactions becomes huge in volume and size then it requires a lot of storage which may lead to the scalability issue (Joshi, Han, & Wang, 2018; Puthal et al., 2018). This may happen in peer-to-peer eLearning system when too many users create a huge number of documents and share with each other.
- Blockchain relies on the trust of the nodes on each other. It is possible that some nodes or users may create fake blocks. When more than 51% of the nodes conspire to generate fake blocks or reverse confirmed transactions that is called "51% attack" problem (Puthal et al., 2018). This is not very likely to happen in peer-to-peer eLearning, but it may happen sometimes.
- Security and privacy could be another issue. In Blockchain network, the data can be vulnerable to potential security and privacy risks as the entire community can verify the records or transactions without using a trustable third party. Each node can view the data transmitted by any other node that's why data privacy may not be maintained (Elmaghraby, & Losavio, 2014).
- As discussed earlier that Blockchain technology uses public key and private key cryptography system. Each node or user can view the details and balances of all public keys in the network which may lead to the vulnerability for leakage of Blockchain transactional privacy (Crosby et al., 2015). It may not be a big deal for learning and teaching aspect in peer-to-peer eLearning but may be an issue when payment is made as part of peer tutoring cost.
- Selfish mining could be another issue in peer-to-peer eLearning using Blockchain. This happens when the users or miners create a private branch by keeping the mined blocks without broadcasting to the network and only broadcast under certain conditions, and honest miners waste a lot of time and resources while selfish miners mine (the process by which nodes perform rigorous computations devoting their resources called mining) the private chain (Joshi, Han, & Wang, 2018). This can happen in peer-to-peer eLearning when a group of learner and/or tutors create a private chain and do not broadcast over the network.
- Regulating and monitoring also could be challenging. Some kind of regulations and monitoring of the system also could be very important to have in place as bad people may misuse the technology, and conduct fraudulent activities like drug or money trafficking using the system developed for peer-to-peer eLearning using Blockchain (Crosby et al., 2015).
- Lack of users could be an issue if the system is not popular. So, it may be a challenge to attract users in the beginning.

Challenges faced by Blockchain technology can be eliminated or minimized in future with the maturity and enhancement of the technology.

RQ4: What are the recommendations to use Blockchain technology in peer-to-peer eLearning to create value that will help the community and increase the usability and popularity of the Blockchain technology as a whole?

Some major recommendations are discussed below.

- The first recommendation would be to build a peer-to-peer eLearning system using Blockchain technology in a small scale such as within a University campus only and make it available to all the students and faculty within the campus. The system should be mainly for the students for peer learning and tutoring but faculty also should be able to help each other in terms of learning from the peers. A big system like within a region, country, or even bigger will require a lot

of resources. Keeping within the campus will be easier to maintain and monitor.
- Have the system free of cost at the beginning. Later once the system is used by many users or learners, some good student tutors may be able to charge some cost from other student learners.
- Have a concrete plan to make the system working and have resources available in terms of hardware, software, people, etc.
- Have a good marketing plan within the campus to reach out to the campus community and bring a positive image for the system and Blockchain technology.
- Disseminate the benefits of using the system specially how the students are helping each other to learn and teach; and create a culture in the campus for peer-to-peer eLearning.
- Have a good monitoring in place to avoid any fraudulent activities such as sharing assignments, exam questions, and other illegal activities using the system.
- Offer some courses, seminars, or workshops on Blockchain technology to inform the community about this new technology and the benefits of it.
- Encourage people to use the Blockchain technology in other areas as much as possible and discuss the applications of it in different areas. This will lead to increase the usability and popularity of the Blockchain technology as a whole.
- Once the system is successful within the campus, then it can be expanded to a bigger community.

5. CONCLUSIONS

Recently "Blockchain", the foundation technology of the digital currency or cryptocurrency "bitcoin" has grown a tremendous interest both in industry and academia because of its distributed, documented, digitized, decentralized, and peer-to-peer network properties. Many private sectors and governments have already accommodated this new technology in certain aspects but there are still many areas this technology can accelerate. This research focused on the use of Blockchain technology in a very specific area of peer-to-peer eLearning. This research discussed the understandings of this technology and how it works, identified and analyzed the past and current research of using Blockchain technology in peer-to-peer eLearning to find the gaps, explored the opportunities the Blockchain technology has in this specific area, discovered the challenges the Blockchain technology may have to deal with, and proposed recommendations of using this technology in peer-to-peer eLearning to create value to help the community and increase the usability and popularity of this technology as a whole. As a future research direction, implementation of a peer-to-peer eLearning system using Blockchain technology and evaluation of the system after being used by the users would be a great achievement.

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Appendix

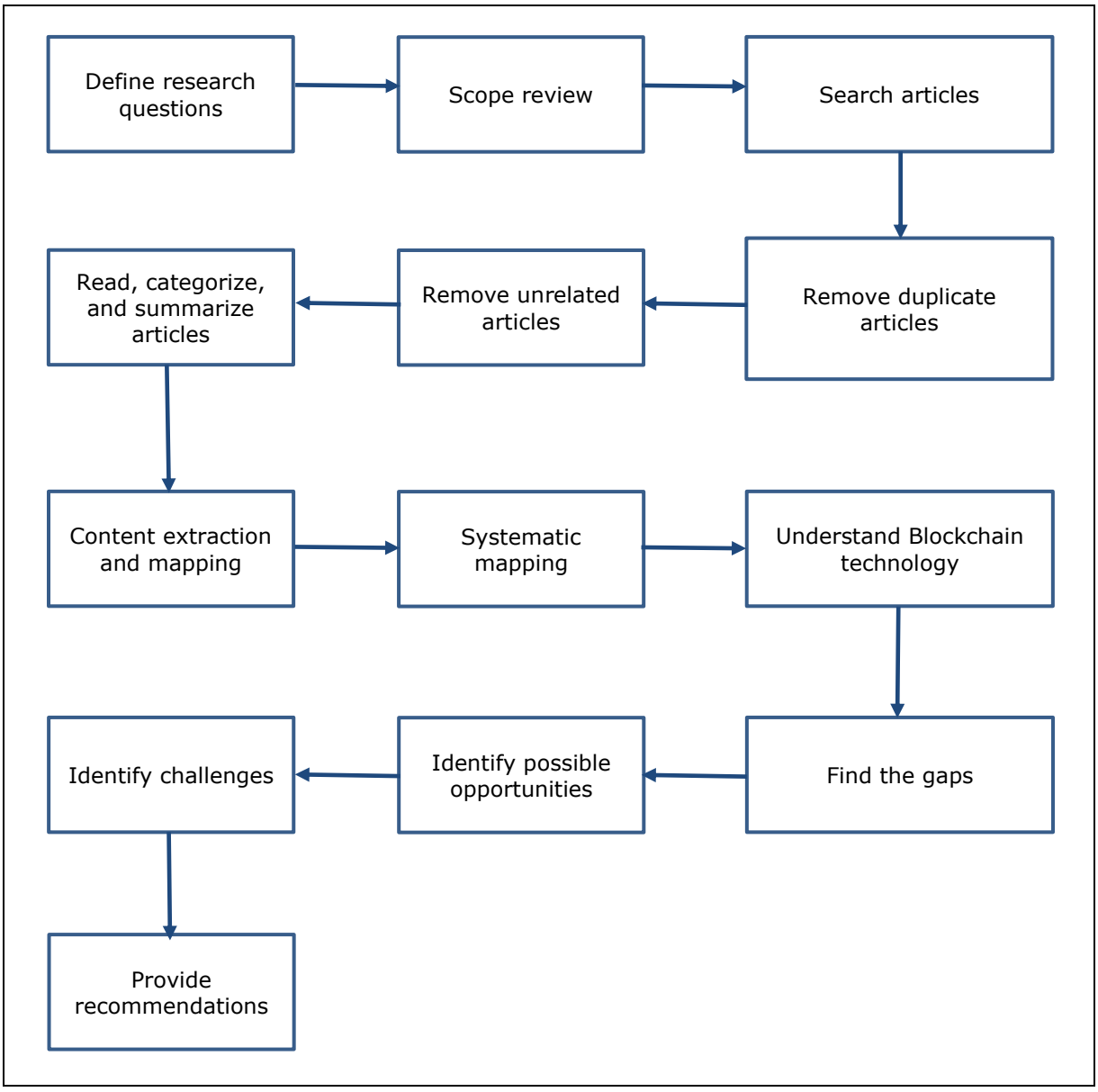

Figure 1. Research methodology process

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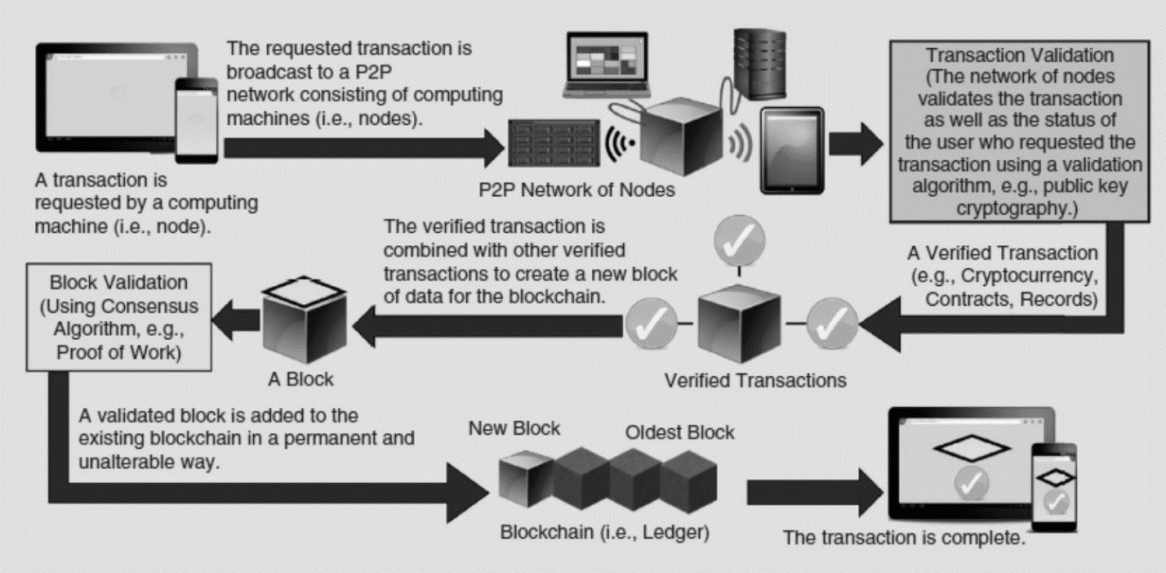

Figure 2. Overview of Blockchain technology and how it works (Puthal et al. 2018)

Category	Articles
Blockchain technology and how it works	Nakamoto, 2008; Grinberg, 2012; Barber et al., 2012; Garay, Kiayias, & Leonardos, 2015; Al-Debei & Avison, 2017; Ai, Han, Wang, & Yan, 2016; Alexandre, 2019; Al-Saqafa & Seidlerb, 2017; Han, Yan, Li, Ji, & Li, 2014; Ji et al., 2015, Han et al., 2013; Crosby, et al, 2015; Puthal et al., 2018; Microsoft Docs, 2013; Joshi, Han, & Wang, 2018; Sharma, 2019; Lastovetska, 2019; Möser, 2013; Yli-Huumo et al., 2016; Yli-Huumo et al., 2016; Elmaghraby, & Losavio, 2014
Blockchain technology in traditional education	Sun, Wang, & Wang, 2018; Sharples & Domingue, 2016; Coleman, 2016; Campbell, 2016; Rohaidi, 2017; Sony Global Education 2016; UCL 2020; Grech & Camilleri 2017; Alammary, Alhazmi, Almasri, & Gillani, 2019; Gopane, 2019; Bdiwi et al., 2017; Duan & Zhong, 2017
Blockchain technology in eLearning (online education)	Sharples & Domingue, 2016; Coleman, 2016; Campbell, 2016; Rohaidi, 2017; Zhong, Xie, Zou, & Chui, 2018; Swan, 2015; Hori et al. 2016, 2018; Hwang, 2014; Tikhomirov & Dneprovskaya, 2015; Uskov et al., 2019; Duan & Zhong, 2017
Peer-to-peer learning/eLearning	Sadykova, 2014; Ahn et al., 2013, Purser, Towndrow & Aranguiz, 2013, Trena, Senom & Ching-Fen, 2003, Huijser, Kimmins, & Evans, 2008), Taylor & Zeng, 2008, Bostrom, Gupta, & Hill, 2007; Biström, 2005
Blockchain technology in peer-to-peer eLearning	Ma, 2018

Table 1. Category of articles