International Journal of
INTELLIGENT SYSTEMS AND APPLICATIONS IN ENGINEERING
ISSN:2147-6799 www.ijisae.org Original Research Paper

Utilization of Block chain Technology and Smart Contracts in the Education Procedure of Universities

Abdulaziz Meri M. Alzahrani

Submitted: 27/11/2023 **Revised**: 26/12/2023 **Accepted**: 07/01/2024

Abstract: The development of new technologies and the accessibility of high-speed internet are essential to every facet of our daily lives. There are a lot of issues that come with this development, particularly those that are security-related. One of the most significant innovations of the past 10 years, blockchain technology is gaining popularity because to its ability to secure supply chains, transportation, and other industries. The use of technological innovations that disrupt is a basic prerequisite for increased accountability and openness. We investigated the main elements influencing educational universities' plans to employ the technology of blockchain for online education. A digital negotiation procedure that involves multiple anonymous participants without the involvement of any reliable middlemen is called a Smart Contract (SC). It is computer code that operates on its own accord. The blockchain powers smart contracts. As a result, the agreement and the code are locked into place and kept on an online public view database. Smart contracts have numerous potential applications in the world of digital commerce, such as in the fields of management, finance, medical care, or the Internet of Thing. Two of the most popular open-source, cutting-edge, cross-industry blockchain systems are Ethereum and Hyper Ledger. The findings demonstrated that blockchain adoption in intelligent learning environments was significantly impacted by compatibility. The widespread acceptance of the technology known as blockchain was also shown to be significantly impacted in other ways. This research provides a broader version of the Technology Acceptance Model (TAM) for blockchain implementation, which may help policymakers create intelligent learning environments for the education universalities of developing countries.

Keywords: *Blockchain Technology, Smart Contract, Educational Technology, Technology Acceptance Model (TAM).*

1. Introduction

Introduced in 2008, distributed secure ledger technology, or blockchain, originally was utilized for peer-to-peer electronic payment system transactions for the bitcoin cryptocurrency. A time-series information blocks linked together to create a chain structure with distributed ledgers and cryptography is known as blockchain technology [1].

Due to its broad security capabilities, blockchain technology has drawn attention from a variety of industries, including global banking, trade administrations, and healthcare. The blockchain's prospective uses extend beyond its present uses, and it appears that academia gets to benefit greatly from it. The academic sector may be just as important as the healthcare and financial sectors, and some subsectors within it might advance by using this innovation. The function of learning has long been under the supervision of educational institutions, whereas researchers, teachers, and individual's students have very little autonomy over the process and results of learning. Long-term learning, online learning, adaptable learning, and communicated learning based on real-world problems are becoming more and more common as a result of the rapidly advancing cloud computing technology and the internationalization of the setting for learning, [2], which is gradually changing the traditional school-centered classroom learning environment.

Blockchain technology has the potential to enhance educational institutions' ability to support teachers, give information to parents and community members so they may engage, empower modern educational frameworks, and expand and offer opportunities for learning to more students.

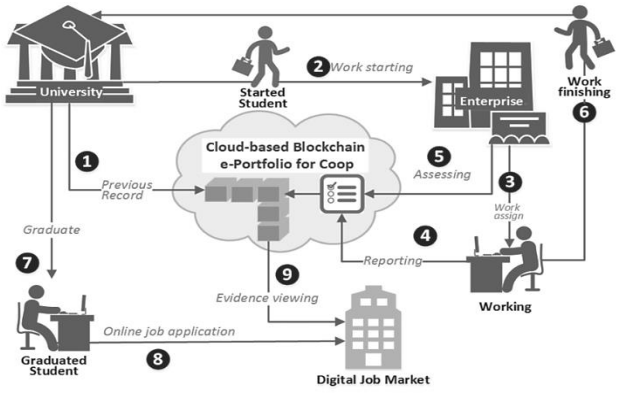

Fig. 1 Blockchain use in Education. [2]

DLT, or distributed ledger technology, for short, is seen as a crucial component of the fourth industrial revolution. Resolving trust-related problems in a commercial setting is the goal of establishing an environment that is decentralized. Blockchain technology's distributed database structure and

Research Scholar, Faculty of Computing & Information, Al-Baha University, Al-Baha, Kingdom of Saudi Arabia.

Corresponding Author: az.kz1991@gmail.com

potential audit trails make it useful in a variety of industries. DLT is essential to enhancing the established higher learning system.

While some universities employ blockchain technology to manage college degrees and evaluation outcomes efficiently, several institutions have already embraced it in their educational programs. Exam grades and an academic degree are involved. It then comprises research skills, group meetings, online courses, and presentations [3]. One university that uses DLT to verify credentials earned by students from Massively Open Online Classes (MOOCs) is Nicosia University. Blockchain technology has also been used by Sony Global Education to create an open assessment system for the supply of data management and storage services. Furthermore, MIT developed a digital recognition system for online learning that is based on ledgers that are distributed.

A. Smart Contract

A smart contract is a digital negotiating system that allows anonymous parties to exchange money, content, assets, ownership rights, and anything else of value programmatically (via computer coding) without the need for any reliable middlemen and with zero risk of fraud [4].

One method used in blockchain-based applications, where many security concerns have been taken into account, is the smart contract. The likely fixes for such security issues are then put out by other researchers. We have examined the security risks associated with both public and private blockchain in this article and have developed a prototype method to address those risks. The Linux Foundation hosts Hyper Ledger Fabric, a free, open-source blockchain system that protects user privacy [5].

Exams are a tool used in the educational system to rank pupils according to a common standard and evaluate them. Educational establishments are required to keep student evaluation records for a significant amount of time. These data are utilized not just to confirm the students' academic qualifications but also to do additional analysis in the hopes of bringing about more successful and beneficial improvements.

As a result, it is crucial to keep such data safe and ensure that it doesn't get modified or destroyed. Furthermore, the examination procedure itself must to be as transparent and reliable as feasible. These kinds of data are becoming more and more in bulk and are needed virtually constantly to provide various services. In addition to adhering to security protocols, these services must be provided at a reasonable cost [6].

A smart contract that is entered into between the institution of learning and the students, or between such education institutions and any permitted third party, may be used to carry out the services. Blockchain technology's smart contracts would provide trust, security, and a savings in both time and money.

In order to support, preserve, or improve the educational system, we examine in this research the role that blockchain plays in higher education when it comes to the usage of Information Technology (IT) and technology for monitoring the many systems inside a university [7].

There is a rumored annual increase in breaches of security and privacy in higher education, particularly in relation to academic degrees and certificates [8]. Blockchain technology plays a part of maintaining correct records and guaranteeing their legitimacy.

Concerns about safe storage have also become more apparent as higher education becomes more digitalized. Blockchain technology, on the other hand, provides decentralized open data, eliminates fraud, secures information storage, and lowers transaction costs related to educational information control. Some have proposed blockchain as a solution to major issues facing higher education, namely diploma archiving and student-centric design [9].

However, previous studies have only partially succeeded in synthesizing current information using Systemic Literature Reviews (SLRs). Some talk about how the newest technologies are being applied to create intelligent educational institutions and universities; others talk about the benefits of using distributed open data for safe information storage in particular case studies; still others talk about how these technologies are being used to help students develop their technical knowledge and engineering skills; and still others talk about how these technologies are being applied to create distributed applications that involve many different parties without having the oversight of a central authority.

B. Blockchain Technology

Blockchain is seen as an innovative technology that will have a significant influence on a wide range of industries. It allows for the development of decentralized apps that are designed to operate on networks and stores data sets that can be safely transferred without the need for intermediaries. Blockchain applications employ encrypted group signatures to store data in order to address the issue of anonymous misuse in conjunction with shared algorithms. The main obstacle to the successful application of blockchain in education, where massive amounts of data, including diplomas and degree certificates, are traded across institutions, is these characteristics for maintaining information and validity.

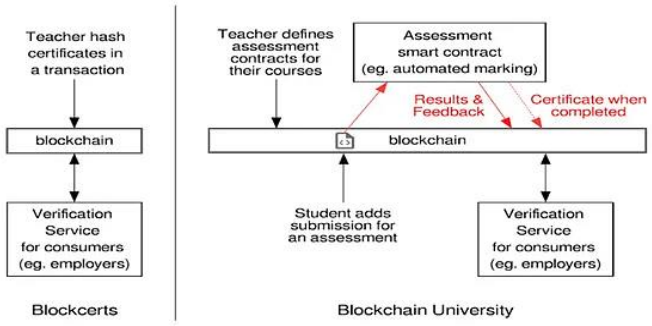

Fig. 2 Blockchain Certificates, or Blockers, for Academic Communities [10].

As previously stated, the development of blockchain technology began with crypto currencies and has progressed to the use of smart contracts in a variety of industries, including higher education, healthcare, supply chain, banking, voting systems, as well as in the Internet of Things (IoT). It's possible that the Blockchain's focus on application diversity stems from its ability to provide a reliable, decentralized contract ecosystem.

Because smart contracts in blockchain technology enable stakeholders to verify identity management and learning records, for example, educational institutions might benefit from using them. This might provide universities the freedom to choose among other HEIs to exchange data with, preventing the possibility of reliable credentials—like diplomas or certificates—being forged or counterfeited. One of the main benefits of blockchain for higher education is that it can enhance smart commitment-based protocols that automatically implement a contract in student across several levels of administration, thanks to its distributed database and lack of need on a third party. Not to mention, this technology may streamline procedures while reducing the likelihood of mistake.

C. Objectives

- Evaluate the current procedures, challenges and inadequacies in the university's traditional educational system.
- Examine the security advantages of integrating blockchain technology into teaching practices, focusing on data integrity, fraud protection, and preventing unwanted access.
- Compile information about how the use of smart contracts and blockchain affects the educational and professional experiences of teachers and students.

2. Literature Review

In the Brazilian educational system [11], academic credits are now validated and degree certificates are issued in a manner that is either entirely or partially manual. This system's true digitalization might reduce overhead in terms of documentation validation, increase security, and save labour and storage costs. For all parties involved, it is critical that this procedure become more open and dependable in light of the recent rise in record forgeries and deletions. The idea and execution for the digitalization of academic credits and degree certificates for institutions of higher learning in the Brazilian educational system are presented in this article. A transparent blockchain-based paradigm is suggested, whereby universities use the Brazilian private key infrastructure for managing identities to register student and their academic credentials in a chain of records.

The idea of data portability [12] is gaining traction as a means of encouraging data diffusion and personal data use. One study record that a student in high school utilized for an entrance exam, etc., is a perfect instance of such personal data. The electronic distribution of educational documents is being done because they are now still printed on paper in Japan. However, even in the event of an error or incorrect transmission, the information included in a research document—which contains a great deal of sensitive information—must not be disclosed. Furthermore, information fabrication must be prevented. The Ministry of Education's Department of Schooling, Culture, Sports, Science, and Technology is currently planning to update the format of study documents. In these updated documents, students will be able to add their own research activities, extracurricular activities, qualifications, and certifications in addition to teachers' input of information.

A thorough use of Information Technology [13] (IT) can enable smart teaching at universities; different systems put in place to support this can take precedence over cloud computing and the Internet of Things (IoT). Resulting in the requirement for connectivity into Internet of Things gateways and nodes and the implementation of an architecture that relies less on wireless communication coverage and energy conservation to maximise the performance of IoT node batteries. Blockchain technology, which can offer security, transparency, and data availability that can be governed by institutions, must be given priority when using such an architecture. The secret of early technology adoption that can foster intelligent learning with intelligent learning is covered in this article. The specifics of the newest technology for communication that are most pertinent to the smart school applications may be examined once the attributes of the university or smart education have been established.

People are becoming increasingly interested in the use of blockchain technology in several disciplines [14], like education, as a result of advancements in biotechnology and artificial intelligence. The decentralisation, non-tampering, anonymity, traceability, and other benefits of blockchain technology have the potential to enhance the security of the administration of teaching information technology in higher

education. In order to enhance the usage of the system for teaching information management in higher education, we attempt to investigate the use of blockchain in education. There are three key ways in which this will be evident: 1) The asymmetric encryption algorithm: it protects user privacy in the education information management system; 2) distributed database technology: it could aid in the decentralisation of the teaching information technology administration system; 3) smart contract: it's enhances the legitimacy of the instructing information management system.

At the nexus between ICT and higher education [15], blockchain has become a key idea. This system keeps track of transactions between many computers connected to a peer-to-peer network. Therefore, it permits the establishment of a decentralised system in which no third-party organisation has authority over the data. A systematic bibliometric review of studies on blockchain-based applications in higher education is presented in this work. The evaluation included 37 papers that provided the most recent information on the consequences of using blockchain technology to enhance higher education procedures. Blockchain is being utilised to develop fresh approaches to enhance the current methods of exchanging, distributing, and safeguarding knowledge data and private student information, according to the LRSB results.

This is an initial investigation [16] of the current state of the blockchain usage in the field of education. The purpose of this research is to raise public knowledge of blockchain technology while highlighting the benefits, dangers, challenges, and obstacles related to its application in educational settings. This essay provides a blockchain-based approach to the problems related to online education while also delving further into the core technological ideas and application features of blockchain technology. The accomplishments of a pupil may be tracked more closely and anonymously with blockchain technology. Furthermore, this guarantees that businesses have reliable electronic certificates that protect their intellectual property and enable learning through the application of intelligent contracts.

Smart contracts [17] on the blockchain are computer programmes that represent an agreement between parties that are not trustworthy. If certain requirements are satisfied, smart contracts can be carried out on a system based on blockchain without the assistance of a reliable third party. In recent years, blockchain technology and smart contracts in general have attracted a lot of attention—even from academic circles. We do a comprehensive mapping analysis of all the peer-reviewed, technology-focused studies on smart contracts. We are interested in identifying academic study trends and adoption as well as providing a review of the scientific literature. In order to determine how academics have used smart contract technology and established scientific outputs, we only concentrate on peer-reviewed scientific papers. All research articles were sourced from the primary scientific databases, and 188 pertinent publications were identified through the use of the systematic mapping approach.

The Higher Educational Commission (HEC) and institutions [18] engage in intricate one-to-one processes for degree certification verification and traceability. Although the process has been digitalized, manual authentication is still necessary on specific points. The university initially checked the degree and stamped seal during the first procedure. Subsequently, a physical channel with degrees submissions is turned on at both ends. Subsequently, the degree is authenticated by appropriately reviewing and evaluating the records of tampering pertaining to degree qualifications via electronic correspondence with the institution to ensure validation and verification. The integrity and privacy of educational material are seriously threatened by this problem.

Numerous people's lives [19] have been made easier by the use of technology in numerous areas. However, there are drawbacks to technology use as well. One such drawback is data and transaction security. In light of these problems, we provide in this article a blockchain-based system for authentication that will safeguard data rights and objectives and be impervious while storing sensitive textual material, particularly in the context of educational technology. There are two advantages to this writing. Firstly, because blockchain technology is decentralised, all data kept in the educational system is guaranteed. Consequently, parents, teachers, and other stakeholders will have more faith in the system.

The world is slowly but definitely changing thanks to blockchain [20]. Cryptocurrencies are changing the economic scene in a big way. With the introduction of COVID-19, the educational system, like other sectors, has to be completely redesigned or reinvented in order to continue generating graduates who can meaningfully contribute to a world that is always changing. The administrative duties involved in overseeing the granting of academic credentials is frequently disregarded. In the current globalised world, education is longer viewed as taking place inside all four walls of a classroom, especially in light of COVID-19. Collaborating across universities and combining resources from many sources will be key components of higher education in the future. This may also be thought of as the capacity to put together the many building pieces in order to enable the students to get the required abilities and information. The development and roll-out of a blockchain-based examination, transcript, and certification system is the main goal of this project.

A. Hypothesis

- ***Hypothesis 1 (H1).*** *Trial ability positively affects how valuable people think DLT is.*
- ***Hypothesis 2 (H2).*** *Perceived DLT utility is positively impacted by relative advantage.*
- ***Hypothesis 3 (H3).*** *Compatibility positively impacts how beneficial DLT is seen.*

3. Methodology

Perceived usefulness, intention of use, and ease of use are the TAM components that make up the model that is being suggested in this study. The conceptual model illustrates how trial ability, comparative advantage, and compatibility—three concepts from the diffusion innovation theory—can be combined with TAM. Every survey tool was created using prior research findings. To investigate the relationships between the conceptual model's components, we employed an online survey for data collection [21]. During the pilot's testing phase, the questions' phrasing was examined by top specialists. Twelve IT specialists and sixteen research researchers from various educational institutions have been pretested the study survey.

A. Data Collection

We got 212 online survey questionnaires from professionals in Malaysia's education sector overall, and we discovered that the average time taken to complete was around 5 minutes, which is comparable to the completion time projected from the pilot test. Fourteen replies that took less than 1.5 minutes were removed. Furthermore, after testing every response, we discovered that no response to any item had the exact same score. In the end, 198 legitimate responses were deemed to be available for further examination. The majority of the information was gathered from men, who made up (67.67%).The greatest amount of information was gathered from specialists in the IT department, accounting for 43.43%. 47.47 percent of the workforce has worked at the educational institution for more than five years. It was discovered that the sample of 198 people who responded satisfied the minimal requirements, with five observations for each parameter. For our structural equation modelling study, we took into account 28 parameters, with a minimum of 165 responders being required, as recommended [22]. Table 1 displays the profile data of those who responded.

Table 1 Users' Demographic Background [22].

Profile		Frequency	Percentage
Gender	**Male**	133	66.3%
	Female	65	32.3%
Age	**22-26**	62	2.32%
	27-30	64	25.6%
	31-34	72	63.9%
	35-40	44	4.95%
	40-44	18	3.6%
Education sector	**ITD**	15	36.1%
	Finance Department	89	5.45%
	Management Department	58	9.69%
	Administrative Department	49	5.99%
Experience with digitalization	**>2 years**	52	51.3%
	5> years	42	25.6%
	6> years	92	63.3%

B. Modelling using Structural Equations

We employed the Partial Least Squares Structural Equation Modelling (PLS-SEM) in this investigation. It is a multifunctional method that supports additive and linear models and is frequently used in IS and business management research.

It has been utilized more frequently in a variety of studies due to its suitability for investigating composite models in exploratory research [23]. The comparison analysis promoted PLS-SEM use for disruptive technology. In order to identify the highly correlated components in PLS-SEM, the Variate Inflation Factor (VIF) has been examined prior to testing the structure model due to frequent technique bias concerns. The results verified that the maximum value for the VIF was 3.3220, which was less than the 5.00 criterion. Table 4 displays the VIF values for both the outer and inner models. The structural model can create endogeneity iteratively. Consequently, we ran an error test using the Ramsey regression equation and discovered no variability issues.

Table 2 Test Results for the Variance Inflation Factor [24].

	VIF	1/VIF
Control Environment	1.69	0.791
Risk Assessment	2.491	1.497
Info.	2.491	0.797
Monitoring activities	1.698	1.794

C. A use case for a smart contract for the university examination system

We have examined a Use-Case in this section that involves a sizable, traditional universities that includes multiple post-graduate departments and hundreds of linked schools that provide undergraduate programs in the faculties of technology, science, commerce, law, and humanities [25]. We first examine the current system and identify its shortcomings, and then we offer our suggestion for utilizing blockchain-based smart contract technology to mitigate some of them.

D. The current data management system's shortcomings

We take into consideration a university that administers over 750 distinct exams across 600 exam sites. At the university under review, there are over 65 departments and over 1.2 million students enrolled annually.

The University handles a variety of administrative tasks, including processing scholarships, exams, student registration, financial aid, and admission [26]. Mark sheets, temporary certificates, duplicate certificates, recordings, and migration certificates are the things that the procedure aims to deliver. Both the system and its security are currently fully manual or semi-automated. Users (students, business agencies, mathematical, and government organizations) can submit a request to the relevant colleges under the current system (Fig. 3). The application is sent to the university by the college. The user is prompted to complete the payment after receiving approval from the university. The university receives the fees from the college. After analysing the document for a while, the university forwards it to the college. The document must be picked up by the user from the college. It is a procedure with a deadline.

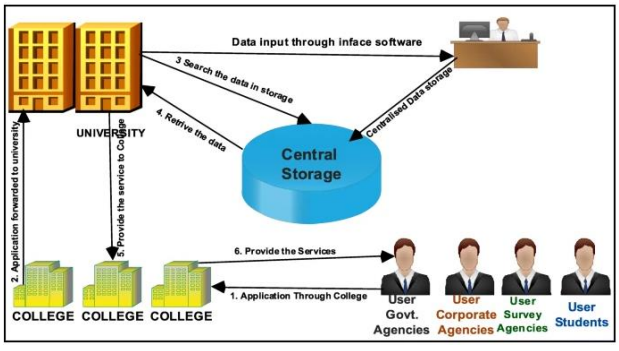

Fig. 3 Current college testing data management system [26].

One of the University's biggest problems is producing error-free findings on time with the current staff level, which is also being lowered on a regular basis, given the high and growing number of students and researchers. the security concerns related to digital signatures, security, confidentiality, authentication, integrity, and non-repudiation.

An insider who isn't allowed to do certain things poses a constant security risk to the current system. At the university level, the database administration and one or more trusted users are primarily in charge of data storage. But there's a good chance that grades (data) will be manipulated for a certain exam or retest[27]. The university receives the grades in an enclosed envelope.

E. The suggested smart contract methodology for university exams

To overcome the obstacles we are now facing, we suggested and created a smart contract. The contract and data flow between university and various stakeholders to deliver a safe, reliable, and high-quality service in the shortest amount of time are contained in this section.

Through the website, users (students, business agencies, statistical agencies, government departments, and even colleges) can directly contact the University with the valid number of registrations at their relevant category in order to obtain the appropriate paperwork (Fig. 4) [28]. There will be a generation of the required document validation, service fees, and a payment receipt. For the purpose of processing a smart contract associated with the regarded service, an automated trigger will be set. Together with the served transactions, the block of data will be produced. A private blockchain will be used to protect the applicants' privacy. Hyper ledger is used in the development of the private blockchain.

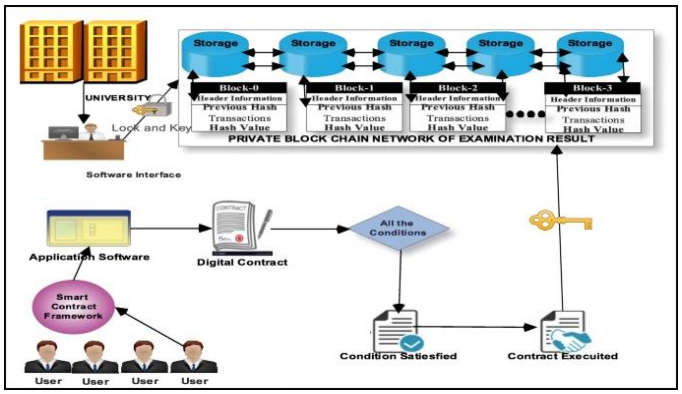

Fig. 4 University data management examination using smart contracts [28].

A process consisting of two stages was used in the current investigation to test the suggested model. Initially, we examined the notions' reliability and validity. In the second stage, bootstrap was used to assess the importance of the structural route.

4. Results

Table 3 displays the concept of reliability and AVE findings. Significant results were also obtained for the discriminant reliability (see Table 3) [29]. As a

consequence, AVE produced better findings, indicating that all of the components might be utilized for the SEM phase.

Table 3 Build Validity and Reliability[29].

Constructs	CA	CR	AVE
Com	0.5971	0.4971	0.7915
Bi	0.8971	0.5971	0.4972
PEU	0.4975	0.4926	0.4972
PU	0.2649	0.4971	0.4971
ADV	0.4975	0.4972	0.9861
TRI	0.2649	0.4975	0.5736

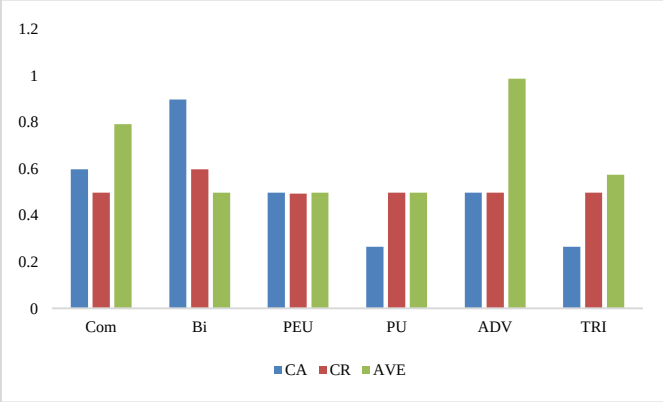

Fig. 5 Build Validity and Reliability.

Table 4 Differential Validity [29].

Constructs	Com	Bi	PEU	PU	ADV	TRI
Com	0.4610	0.7981	0.4971	0.4095	0.4972	0.5975
Bi	0.7916	0.9765	0.7945	0.7956	0.4976	0.4975
PEU	0.4971	0.8913	0.5976	0.4956	0.4972	0.592
PU	0.4971	0.6413	0.416	0.4972	0.8956	0.2679
ADV	0.4926	0.7946	0.4970	0.5971	0.7952	0.4976
TRI	0.4980	0.7986	0.4976	0.4979	0.7965	0.5973

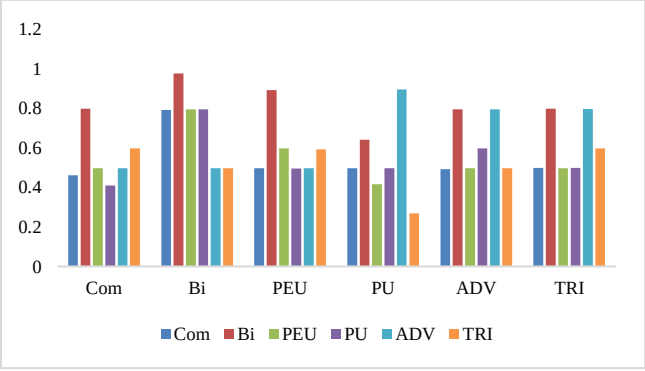

Fig. 6 Differential Validity.

A. Model of Structure

Bootstrapping was used for the structural path's significance assessment in the second phase of evaluating the structure equation modeling. Subsamples (5000) were evaluated using replacements in the bootstrapping approach to check for errors, which in turn guided the predicted T-values for the model's suggested significance testing [30]. The bootstrapping procedure approximates data normality for structural models, as shown in Figure 7.

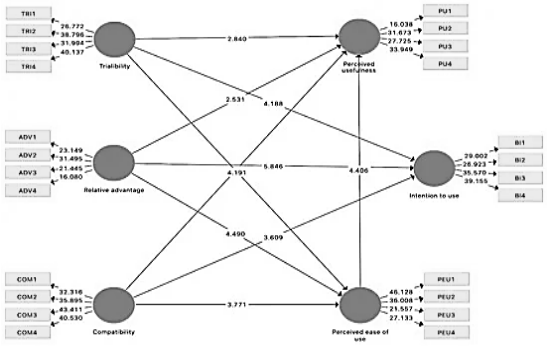

Fig. 7 Model of Structure. [30].

Table 5 Model Quality Standards.

Constructs	COM	Bi	PEU	PU	ADV	TRI	R square	R^2 ADj
COM			0.6422	0.4903				
BI		0.5962					0.1649	0.4697
PEU				0.5613			0.2462	0.1645
PU							0.4692	0.5972
ADV		0.1691	0.4972	0.5692				
TRI		0.4691	0.3978	0.4691				

Table 6 Results of Hypothesis Testing.

	Relationship	(O)	(M)	STD	T value	P value	Decision
H1	**TRI->PU**	0.6498	0.4975	0.4975	0.8569	0.04690	SUpp
H2	**TRI>PEU**	0.1649	0.5692	0.4975	0.4856	0.4600	SUpp
H3	**TRI>BI**	0.2649	0.4869	0.6975	0.1695	0.06591	SUpp
H4	**ADV>PU**	0.4679	0.2659	0.8975	0.7956	0.1660	SUpp

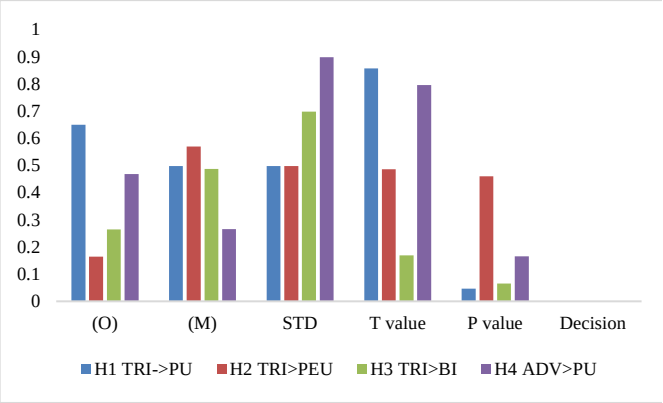

Fig. 8 Results of Hypothesis Testing.

B. Evaluation of Structural Models

Based on the results, each assumption from each of the 10 connection that were evaluated and utilized in the final model was deemed statistically significant. T = 2.7278, p = 0.0066), perceived usefulness (β = 0.2140, T = 4.4893, p = 0.000), and desire to apply (β = 0.3118, T = 4.1345, p = 0.0000) were shown to be significantly correlated with trial ability. The subsequent correlation between perceived usefulness and relative advantage (β = 0.1606, T = 2.5682, p = 0.0105) [30].

C. The Difficulty of Using Blockchain in Education

While the blockchain application has many benefits, it also has drawbacks. These include the need for extensive process changes within the organization, such as creating policies for the application of blockchain in grading, instruction, e-certificates, and other possible areas where the institution hopes to use the technology.

Each organization must adopt and approve the use of blockchain technology to hold the data because each has a unique method for managing and storing such information. Modern standards are being described every day as blockchain selection increases, maybe requiring expense. Because of their extreme repetition, blockchains are sluggish and bloated, which may lead to ineffective forms of information capabilities in terms of transmission. Since blockchain technology will make current records accessible, the issue that needs to be answered is what will take place to the information that is already in existence at all?

5. Discussions

Consistent with other research, trial ability was found to have a substantial impact on perceived usefulness. Additionally, we discovered that trial ability improved perceptions of assistance and convenience of use. Intention to use was significantly influenced by trial ability. In order to encourage workers to adopt blockchain, developers should focus more on creating innovative characteristics and materials for DLT that will appeal to users in the future.

The review's findings indicate that the majority of research on blockchain technology in higher education is geared toward generating ideas on how to use it to organize HEIs. These organizations' use of smart contracts for knowledge organization, bibliographic reviews, and informative systems has led to the evolution of this technology. In fact, the topic is the digitization of academic credits and degree certificates for postsecondary education in developing nations like Brazil, with the goal of simplifying the administration of their educational systems. This, when combined with smart contracts, allows for the dependable and distributed the award of degree certificates.

The problem of preventing fake or forged certificates has been addressed by emphasizing the use of blockchain technology and intelligent contracts as a means of putting in place a decentralized verification process for reliable credentials. As hiring organizations verify the validity and security of these certificates, it enables HEIs to register the documents that they issue on the blockchain. Consequently, existing research has integrated blockchain technology into higher education, emphasizing the division of data into safe blocks, guaranteeing confidentiality in safe data transfers, and enhancing HEIs' e-governance as a result.

Relative advantage has a considerable impact on how valuable and simple something was thought to be. The current study integrates transmission of innovative ideas with TAM, contributing to the small body of literature on blockchain technology.

The PLS-SEM approach is utilized to integrate established theories and generate statistically verified model constructs. These model constructs are demonstrated to have significant effect. Thus far, not many studies of empirical nature have been done on the use of DLT. For decision makers, having the capacity to cover the entire range of higher education disciplines would be extremely beneficial. The conventional education industry might benefit from a degree of traceability and transparency if distributed database systems were implemented for online instruction. DLT, for instance, can assist users in receiving remote education more swiftly, which would benefit emerging nations' higher education sectors.

But it's crucial to remember that blockchain technology is still very new, which has an influence on both the amount and quality of study being done on the subject. Even if there has been an increase in research recently, it continues to be fragmented and no thorough study has been done on the topic of blockchain's potential applications in education. It's possible that current blockchain technology isn't developed sufficiently to operate at scale for every application.

6. Conclusion

To sum up, the present study combines the technological acceptance model and the diffusion of innovations theory to

examine how well a DLT is accepted in the field of education management. The empirical analysis of the technology diffusion models for nations that are developing is the most important component of this research.

A secure technology for distributed ledgers is offered by blockchain applications. According to the study, blockchain has applications in a wide range of educational settings, including online learning, student data privacy and consent, learning outcomes, operational skill competitions, university grades, education-industry collaborative platforms, educational records, reputation and rewards, educational certificates, student capability evaluation systems, and online quizzes. built upon a double layer. Several further applications using blockchain technologies in education might enhance the study even more. The improved model's relevance is validated by its significant overall impact. The current research offers insightful perspectives for creating innovative technology solutions for blockchain technology execution expertise.

This condition requires secure and effective ways to share knowledge in a big, dispersed context. The work described in this article has the potential to be very important in the COVID-19 epidemic by utilizing the blockchain architecture to create safe, inexpensive digital apps that will benefit a huge group of kids who are not reliant on geography.

We have examined security concerns and smart contract domains in this study. We have examined and determined the benefits and requirements of smart contracts for data management using a real-life example of the higher education institution outcome. Future decision-making is also aided by the cost analysis.

Future work

Further study endeavors might explore the functionality of smart contracts for more evaluation, including self- and group-based smart contracts. In order to improve the reputation of online learning, it would be fantastic for researchers to investigate the function of micropayment in these systems.

References

[1] Reynolds, P.; Irwin, A.S. Tracking digital footprints: Anonymity within the bitcoin system. J. Money Laund. Control. 2017, 20, 172–189.

[2] Oh, J.; Shong, I. A case study on business model innovations using Blockchain: Focusing on financial institutions. Asia Pac. J. Innov. Entrep. 2017, 11, 335–344.

[3] Meunier, S. Blockchain 101: What is Blockchain and how does this revolutionary technology work? In Transforming Climate Finance and Green Investment with Blockchains; Mark, A., Ed.; Academic Press: Cambridge, MA, USA, 2018; pp. 23–34.

[4] Zet, C.; Dumitriu, G.C. Using blockchain technology for ensuring students results traceability for instrumentation classes. Meas. Sens. 2021, 18, 100315.

[5] Lohmer, J.; Lasch, R. Blockchain in operations management and manufacturing: Potential and barriers. Comput. Ind. Eng. 2020, 149, 106789.

[6] Deenmahomed, H.A.; Didier, M.M.; Sungkur, R.K. The future of university education: Examination, transcript, and certificate system using Blockchain. Comput. Appl. Eng. Education. 2021, 29, 1234–1256.

[7] Fedorova, E.P.; Skobleva, E.I. Application of blockchain technology in higher education. Eur. J. Contemp. Educ. 2020, 9, 552–571.

[8] Kamišalić, A.; Turkanović, M.; Mrdović, S.; Heričko, M. A preliminary review of blockchain-based solutions in higher education. In Proceedings of the LTEC 2019: Learning Technology for Education Challenges, Zamora, Spain, 15–18 July 2019.

[9] Hernandez-de-Menendez, M.; Escobar Díaz, C.; Morales-Menendez, R. Technologies for the future of learning: State of the art. Int. J. Interact. Des. Manuf. 2020, 14, 683–695.

[10] Awaji, B.; Solaiman, E.; Albshri, A. Blockchain-based applications in higher education: A systematic mapping study. In Proceedings of the ICIEI 2020: 5th International Conference on Information and Education Innovations, London, UK, 26–28 July 2020; Association for Computing Machinery: New York, NY, USA, 2020; pp. 96–104.

[11] Palma, L. M., Vigil, M. A., Pereira, F. L., & Martina, J. E. (2019). Blockchain and smart contracts for higher education registry in Brazil. International Journal of Network Management, 29(3), e2061.

[12] Mori, K., & Miwa, H. (2020). Digital university admission application system with study documents using smart contracts on blockchain. In Advances in Intelligent Networking and Collaborative Systems: The 11th International Conference on Intelligent Networking and Collaborative Systems (INCoS-2019) (pp. 172-180). Springer International Publishing.

[13] Nusantoro, H., Sunarya, P. A., Santoso, N. P. L., &Maulana, S. (2021). Generation smart education learning process of blockchain-based in universities. Blockchain Frontier Technology, 1(01), 21-34.

[14] Zhang, L., Ma, Z., Ji, X., & Wang, C. (2020, October). Blockchain: Application in the system of teaching informatization management of higher education. In 2020 3rd International Conference on Smart BlockChain (SmartBlock) (pp. 185-190). IEEE.

[15] Raimundo, R., &Rosário, A. (2021). Blockchain system in the higher education. European Journal of Investigation in Health, Psychology and Education, 11(1), 276-293.

[16] Alam, A. (2022). Platform utilising blockchain technology for eLearning and online education for open sharing of academic proficiency and progress records. In Smart Data Intelligence: Proceedings of ICSMDI 2022 (pp. 307-320). Singapore: Springer Nature Singapore.

[17] Alharby, M., Aldweesh, A., & Van Moorsel, A. (2018, November). Blockchain-based smart contracts: A systematic mapping study of academic research (2018). In 2018 International Conference on Cloud Big Data, Blockchain, and Computing (ICCBB) (pp. 1-6). IEEE.

[18] Ayub Khan, A., Laghari, A. A., Shaikh, A. A., Bourouis, S., Mamlouk, A. M., &Alshazly, H. (2021). Educational blockchain: A secure degree attestation and verification traceability architecture for higher education commission. Applied Sciences, 11(22), 10917.

[19] Sanni, M. I., &Apriliasari, D. (2021). Blockchain Technology Application: Authentication System in Digital Education. Aptisi Transactions on Technopreneurship (ATT), 3(2), 151-163.

[20] Deenmahomed, H. A., Didier, M. M., &Sungkur, R. K. (2021). The future of university education: Examination, transcript, and certificate system using blockchain. Computer Applications in Engineering Education, 29(5), 1234-1256.

[21] Mori K, Miwa H (2020) Digital University admission application system with study documents using smart contracts on Blockchain. The 11th International Conference on Intelligent Networking and Collaborative Systems 1035:172–180.

[22] Bigi G, Bracciali A et al (2015) Validation of decentralized smart contracts through game theory and formal methods. In Programming Languages with Applications to Biology and Security 9465:142–161.

[23] Cheng R, Zhang F et al (2019) Ekiden: a platform for confidentiality-preserving, trustworthy, and performant smart contracts. European symposium on security and privacy (EuroS&P), Stockholm, Sweden, pp. 185-200.

[24] Zheng P, Zheng Z et al (2019) EtherShare: Share Information in Joint Cloud Environment Using Blockchain-Based Smart Contracts. International Conference on Service-Oriented System Engineering (SOSE), San Francisco, pp. 233–2335.

[25] Jirgensons, M.; Kapenieks, J. Blockchain and the future of digital learning credential assessment and management. J. Teach. Educ. Sustain. 2018, 20, 145–156.

[26] Dhillon, V.; Metcalf, D.; Hooper, M. The hyperledger project. In Blockchain Enabled Applications; Springer: Berlin/Heidelberg, Germany, 2017; pp. 139–149.

[27] Lam, T.Y.; Dongol, B. A blockchain-enabled e-learning platform. Interact. Learn. Environ. 2020, 1–23.

[28] Brody, P.; Pureswaran, V. The next digital gold rush: How the internet of things will create liquid, transparent markets. Strat. Lead. 2015, 43.

[29] Mettler, M. Blockchain technology in healthcare: The revolution starts here. In Proceedings of the 2016 IEEE 18th international conference on e-health networking, applications and services (Healthcom), Munich, Germany, 14–17 September 2016; pp. 1–3.

[30] Filvà, D.A.; García-Peñalvo, F.J.; Forment, M.A.; Escudero, D.F.; Casañ, M.J. Privacy and identity management in Learning Analytics processes with Blockchain. In Proceedings of the Sixth International Conference on Technological Ecosystems for Enhancing Multiculturalist, Salamanca, Spain, 24–26 October 2018; pp. 997–1003.