Article

Blockchain Technology Adoption in Smart Learning Environments

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Abstract: The conventional education system in developing countries has been enhanced recently by implementing the latest technology of distributed ledger. Disruptive technology is a fundamental requirement for greater accountability and visibility. We explored the key factors affecting the intentions of educational institutions to use blockchain technology for e-learning. This study proposed an expanded model of Technology Acceptance Model by integrating the diffusion of innovation theory. Based on an online survey, the conceptual model was tested and validated using structural equation modeling. The results showed that compatibility had a significant impact on blockchain use in smart learning environments. Other significant effects were also found on adoption of blockchain technology. This study offers an expanded Technology Acceptance Model for implementing blockchain that could assist decision makers in building a smart learning environment for the educational institutes for the emerging economies.

Keywords: blockchain; diffusion of innovation theory; TAM; e-learning; distributed ledger technology

Citation: 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. <https://doi.org/10.3390/su13041801>

Received: 20 December 2020

Accepted: 1 February 2021

Published: 7 February 2021

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1. Introduction

The distributed ledger technology (DLT) is considered a key part of the 4th industrial revolution. The aim of creating a decentralized environment is to remove trust related issues in a business environment. Blockchain technology is used in many fields because of its distributed database nature and the prospect of audit trails [1]. DLT plays a central role in improving the traditional higher education system [2]. Many colleges have already adopted blockchain technology in education, while others use it to effectively manage academic degrees and summative results [3]. It involves an academic degree and grades of exams. Subsequently, it includes online courses, group meetings, presentations, and research skills [4]. Nicosia university is one institution that uses DLT to get student credentials obtained from massive open online courses (MOOCs) [5]. Sony Global schooling has also adopted blockchain to build a transparent evaluation framework for the provision of information storage and management services. In addition, the MIT built a distributed ledger based digital badge for online learning [3]. The Holberton school is the earliest that uses distributed ledger technology to store degrees and shared educational information. The distributed ledger can fit any type of information with unique student ID.

Because of the particularity of e-learning, the evaluation requires not just the measurement of learners' studying results using conventional techniques, but it also requires to be linked with the assessment of their learning mechanism by evaluating e-learning data of the learners such as online meetings, presentations, and conferences, especially during pandemic times. The variety of e-learning data, however, may trigger the complexity of an e-learning evaluation. An autonomous e-learning model is urgently needed to lessen the burden on online instructors and improve the sprite of the e-learning appraisal [6].

In addition, the lack of a consistent evaluation system makes it difficult to approve and pass e-learning accomplishments of a learner into accepted credits or credentials, which would significantly dampen learners' excitement and impede the improvement of online education. Furthermore, digital certificates are more convenient to query than paper based, but also seem to be manipulated and tampered with due to the dangers of the hackers. Currently, the security of electronic credentials still depends on the environment of the Certificate Authority centralized management. However, the current ecosystem's reputation is slowly diminishing and now reaching the end of its life [7].

Smart contract in particular offer the distributed ledgers progressive programmability, improving the tasks that the distributed ledgers can perform and massively increasing the blockchain applications range, like digital rights management, digital wallet control, health care data management, and supply chain [8]. Blockchain based smart contracts are extremely powerful, having public blockchain framework of Ethereum and private Hyperledger Fabric network based on consensus algorithm and hash cryptography [9]. Independence of measures can be ensured by using transparent smart contracts on several blockchain peers, which adds to the improved trustworthiness [10]. The comparison between existing and basic blockchain based smart contract is shown in Figure 1.

The aim of the blockchain based university platform is to expand efforts by using smart contract to automate and reveal assessment process to enable the negotiation of curricula, and to create certificates. The public blockchain blockcert project of MIT [11] main features are to store digital credentials by using a bitcoin transactions, store documents in OP RETURN transactions field on comprehensive bitcoins blockchain. In addition, Figure 2 presents an outline of instructor system's technical architecture, which offers client applications such as Learner application, Teacher application and Reader verification application. The client services include simple testing service, external content delivery and other automated marking services. The Hyperledger Fabric is an open source blockchain platform that run user defined smart contract, as well as offering better privacy and identity features. The Hyperledger composer support the Hyperledger Fabric architecture and permits for faster blockchain networks [12]. The application connect with the blockchain via REST web APIs by using HTTP and JSON data format.

Figure 1. Blockcerts (Blockchain Certificates) for University Communities [13].

Figure 2. An illustration of the Blockcerts framework [13].

A review of the literature on blockchain uncovers that most of the studies are focused on presenting the opportunities and challenges of implementing disruptive technology. There has been little focus on studying the adoption of distributed ledger technology applications. The present study will be one of the preliminary studies to examine the adoption of blockchain in the education sector. The aim of this study is to provide a comprehensive understanding of the various decision making factors that influence the user intention of adopting blockchain in education. The proposed model is to judge the suitability of TAM constructs within the context of diffusion of innovation theory. We developed a hypothetical model by incorporating main constructs of trialability, relative advantage and compatibility, perceived ease of use, and perceived usefulness. This study was conducted to respond to the following research questions:

1. What are the factors affecting DLT adoption in the Malaysian educational sector?
2. Which fact has a direct effect on blockchain implementation?

This study is organized as follows; Section 2 describes the theoretical background of the study. Section 3 explains the proposed model. Section 4 discusses research methodology. Section 5 clarifies the results obtained. Section 6 covers the discussion, and Section 7 provides a summary.

2. Literature Review

2.1. Disruptive Technology

Many different types of strategies have been put into place with the goal of building trust and reducing knowledge asymmetries between producers and customers. The expansion of a common label is one of the influential among producers who commit themselves to complying with specific predetermined provisions. Requirements about for example, the position of specifications for output and processes. Common label have been used widely, to guarantee consumers of specific values of the acquired products. The common label have shown a number of drawbacks and some serious limits. First of all, opportunistic approaches are reported. Some producers in fact, declare that they follow the rules of the common label, but in reality, are not compliant with those. In addition, fake strategies are frequently followed by competitors, either through the use of simply false labels or through more sophisticated options, including the use of names, symbols, and images of third nations that try of confound or to create a false impression on the consumers. The evolution of digital technologies made it possible to overcome many such limits, a premise for a disruptive new wave of innovations addressed not only to reinforce trust but, more generally, to build new relationships between producers and customers [14]. The IoT and blockchain technologies seem to be the basic ingredients of this new wave. The backbone

of this new digital revolution is the capability to give digital identity to each one and all of the single products and their components. As a result, more liquid and transparent markets will be created. By identifying and matching supply and demand for physical assets and services in real time, the IoT will create new marketplaces. These complex, real-time digital marketplaces will build upon the foundation established by mobile devices and social networks to expand the reach of this transformation very quickly. They will enable new peer to peer economic models and foster sharing economies [15]. Blockchain technology is actually a brain child of Satoshi Nakamoto. The distributed ledger technology (DLT) is commonly used to create a decentralized system where the businesses are regulated without a need of a third party. Due to its advantages in distributed ledgers data storage and prospect of audit trials, DLT is used in many domains. Since 2014, it has been implemented by several industries like construction engineering management, social media, supply chain management, decentralized governance, and health care management [16]. The DLT delivers peer to peer data transmission, transparency, immutability, and computational logic [17]. Still, the exact process depends on the consensus mechanism. There are three stages of DLT applications: Blockchain 1.0 which deals with the virtualization of digital currencies like bitcoin; Blockchain 2.0 which includes smart contracts for the transaction process; and Blockchain 3.0 which offers a high degree of autonomy with a decentralized autonomous organization based on smart contract with pre-defined complex rules [9]. In public/permission less blockchain like Bitcoin and Ethereum, anyone can participate and access the ledgers. It is mainly based on proof of work (PoW) consensus algorithm, in which each person can validate new blocks. However, in the private blockchain network (e.g., Hyper ledger Fabric), only participants can access the data. In the proof of authority (PoA) algorithm, each node creates new blocks. The earlier defined proof of stake (PoS) could also be used for private blockchain. Moreover, the consortium includes both public and private blockchain networks for verified members. The disruptive technology is mainly about storing data in a tamper resistant distributed environment. This fits well with the effort that librarians have always done, such as storing and exchanging authoritative data. DLT can aid librarians get their work done, particularly in the science publishing world [18]. One latent usage for DLT is to construct timestamped, verifiable types of academic manuscripts. Another possible use of DLT can be in the management of digital rights. Online tools are reproducible implicitly, and this may result in some challenges for universities. Since DLT generates unique records, it can be effectively used to connect digital resources and to demonstrate confirmed scarcity of these resources. It will require an exclusive recognition, control, and transfer of digital materials [19]. Based on these, it can be said that DLT has the potential to play a pivotal role for creating a smart learning environment in the developing economies.

2.2. Blockchain in Education

Smart manufacturing systems through blockchain applications have become the focus of attention of businesses. The recent literature showed that more manufacturing and service sectors are turning into smart operations [20]. The ubiquitous learning environment architecture suffers from vulnerability issues. The disruptive technology preserves its tremendous benefits in creating a smart learning environment. The research work of Rawia Bdiwi [21] proposed a blockchain based new architecture for ubiquitous learning environment that retains the advantages of privacy. The distributed ledger based architecture delivers new opportunities for developing a stable framework for collaborative learning. Within the decentralized topology, it offers data exchange with blockchain with using trust methods. The assessment of this disruptive technology based framework shows its efficacy when delivering ubiquitous learning environment privacy. The study of J.Guo et al. [22] proposed a permission less blockchain based Ethereum network for data protection in online education platforms (such as MOOCs). The proposed system also provide solution to a series of challenges in digital rights management, such as the insecurity of digital certificates and low degree of openness of multimedia learning resources. Another study

by Turkanovic et al. [23] tested the blockchain based framework for high education credit platform. They implemented a prototype open-source Ark decentralized platform which anticipates that several higher education institutes can create an efficient and universal environment to avoid administrative and language barriers. The study of Arenas et al. [24] proposed a blockchain based decentralized system namely credence ledger that stores record of academic qualification that are easily and fast verifiable for education stakeholders. The students do not need to do the whole tedious process each time for documents verification. The blockchain based framework can provide unique hash cryptography value that can quickly verifiable online. The Blockcert is an open standard platform for qualifications and certificates. It includes open-source libraries, tools and mobile apps that enable a decentralized, recipient centered ecosystem for the development of resources based on blockchain information. In conclusion, a decentralized blockchain network can ensure trust, safety, and reliability for handling education data from various educational providers.

2.3. Technology Adoption Models

While many previous studies support the TAM model as a first-rate approach to explaining adoption of the Information System (IS), it is doubtful if the model may be used to evaluate any case of IS acceptance. Many empirical studies have recommended that TAM can be integrated with other theories (e.g., Information System Success Model [25], Constructivism theory [26], and Technology Readiness Index [27]) to cope with the rapid changes in managing information. Researchers have established that the factors used in the acceptance model of technology are simply a subset of features considered for innovation. The convergence of these two mainstream theories may thus give an even stronger theory and outcomes than either standing alone [28]. Therefore, we integrated factors involving the adoption and intent to implement DLT for a smart learning environment. See a summary of previous studies in Table 1.

Table 1. Recent Literature for Technology Adoption Model.

Study	Model Used	Major Findings/Constructs
[29]	Technology Organization Environment	The result showed that competitive pressure, complexity, cost and relative advantage have positive impact during the blockchain technology adoption for SMEs-Malaysia context. However, market dynamics, regulatory support and upper management support were insignificant predictors.
[30]	Unified Theory of Acceptance and Use of Technology	The results showed that perceived expectation had a significant influence on the intention to use DLT for both US and India.
[31]	TAM/TRI/Theory of Planned Behavior	The result showed that TAM constructs namely attitude, perceived usefulness and ease of use had a significant impact on adopting DLT for the supply chain-India context.
[32]	TAM	The findings suggested that (1) strategic orientation, personal characteristics and social influence had a significant impact on blockchain use; (2) perceived usefulness was found to mediate the effects of strategic orientation and social influence; and (3) perceived ease of use was found to mediate the effects of self-efficacy on the intention to use cryptocurrency payments.
[33]	Extended TAM	Individual constructs of the behavior model significantly influenced the intention to use the system while their collective effect was found to be insignificant. The quality of the system and the perceived enjoyment had a stronger influence on the perceived usefulness construct.
[34]	Diffusion of Innovation Theory, the benefit-risk concept, theory of planned behavior, and transaction cost theory	Both perceived benefits and service compatibility had a prominent role in defining behavioral intention, whereas perceived risk, cost, and complexity had no impact on user adoption.

2.4. Technology Acceptance Model

The Technology acceptance model proposed by Fred Davis [35] in order to explore the mechanism of technology adoption through the expectations of the end users. It depends on two specific beliefs irrespective of whether the user is encouraged to acknowledge and

use the information system. Perceived ease of use (PEU) and Perceived usefulness (PU) can influence one's attitude for IS use, which affects user social expectation to utilize a system.

2.5. Diffusion of Innovation Theory

Diffusion of innovation theory was proposed by E.M. Rogers [36], it has gained considerable pragmatic support in defining the adoption of user in a range of disciplines, especially in e-learning. An invention is an entity or knowledge which a person adopt. Accordingly, the diffusion of innovation theory claims that prospective users make decisions to accept or deny Information System based on prejudices they develop about technology [28]. The main constructs considered for this study were Trialability (TRI), Relative advantage (ADV), and Compatibility (COM) [37]. The constructs are further discussed in the next section.

3. Development of Proposed Model

3.1. Proposed Model

In Section 2, we discussed the recent literature regarding technology adoption models. The existing literature on distributed ledger technology uncovers that most of the studies are focused on presenting the opportunities and challenges of implementing blockchain technology. There has been little focus on studying the adoption of distributed ledger technology applications. The present study will be one of the preliminary studies to examine the adoption of blockchain in the education sector. The current study shows how the diffusion of innovation theory can be integrated with TAM. First, as disruptive technology is still in its initial stage, its acceptance would partially be delayed by its privacy challenges [8]. Second, the trialability, relative advantage, and compatibility of DLT were examined in the education sector. The proposed model is shown in the Figure 3.

Figure 3. The Conceptual Model.

3.2. Hypothesis Development

3.2.1. Trialability

Trialability describes how easily potential adopters can explore innovation. The use of DLT in educational institutes is necessary, especially in the pandemic situations. Previous findings on the role of trialability to use IS showed a positive influence on perceived usefulness [28,38]. In addition, trialability may potentially influence users' intention to use IS [39–41]. Therefore, we formulate the following hypothesis:

Hypothesis 1 (H1). Trialability has a positive influence on perceived usefulness of DLT.

Hypothesis 2 (H2). Trialability has a positive influence on perceived ease of use of DLT.

Hypothesis 3 (H3). Trialability has a positive influence on intention to use a DLT.

3.2.2. Relative Advantage

Relative advantage is the extent by which an innovation is considered better than the concept it has substituted. These features are being used to clarify the acceptance of technologies by end users. Our study also considers that relative advantage is a noteworthy factor in the acceptance of DLT for smart learning environment [42]. The literature has consistently showed that perceived relative advantage can influence customers' intention to use technology [38,43,44]. Our review of previous studies indicated that while consumers may experience higher relative benefits, they may also perceive the technology to be of higher utility. Previous findings (e.g., [28,45,46]) indicate that relative advantage can significantly influence perceived ease of use. The following hypotheses were shaped:

Hypothesis 4 (H4). *Relative advantage has a positive influence on perceived usefulness of DLT.*

Hypothesis 5 (H5). *Relative advantage has a positive influence on perceived ease of use of DLT.*

Hypothesis 6 (H6). *Relative advantage has a positive influence on intention to use a DLT.*

3.2.3. Compatibility

Compatibility is the extent by which innovation is viewed as compatible with the end-user's current beliefs, expectations and requirements. The literature showed that compatibility can influence people intention to adopt technology [47,48]. For the cryptocurrency adoption process, compatibility is considered one of the most important factors [49]. Agarwal et al. [50] indicated that the degree of familiarity with related innovations can be positively correlated with the user-friendliness. Consequently, compatibility can potentially influence individual perceived usefulness [51,52]. This led us to propose the following:

Hypothesis 7 (H7). *Compatibility has a positive influence on perceived usefulness of DLT.*

Hypothesis 8 (H8). *Compatibility has a positive influence on perceived ease of use of DLT.*

Hypothesis 9 (H9). *Compatibility has a positive influence on intention to use a DLT.*

3.2.4. Perceived Ease of Use on Perceived Usefulness

Perceived ease of use and usefulness are the two main constructs of TAM [35]. Perceived ease of use is the degree by which a specific IS affirmed to be free of physical efforts. Perceived usefulness is an extent by which a human recognizes the use of a specific technique to progress one's output. Many previous studies have studied TAM and reported that perceived usefulness can accurately predict the adoption of IS [53]. The recent studies on a DLT also confirms that perceived ease of use can influence perceived usefulness [31,32]. Accordingly, we proposed the following:

Hypothesis 10 (H10). *Perceived ease of use has a positive influence on perceived usefulness of DLT.*

4. Methodology

4.1. Survey Instrument

The present study proposed model consists of TAM constructs, namely perceived ease of use, perceived usefulness, and intention of use. The conceptual model shows how the diffusion of innovation theory constructs namely trialability, relative advantage and compatibility can be integrated with TAM. All the survey instruments were developed from the previous literature. We used an online data gathering survey to examine the association between constructs used in the conceptual model. We collected online data using a formal questionnaire that adapts the relevant steps for the pilot testing process and 5 Likert scale [54]. We did not translate the questionnaire into the national language because the target population (experts) working in the education sector of Malaysia can

understand English. The senior experts have tested the wording of the questions during the pilot testing process. The study survey was pretested by sixteen research scholars and twelve IT experts from a combination of educational institutes. Their response has helped us to refine the measures and delete queries not applicable to the study. The requisite changes were then made in wording and format to enhance the quality of the research [55]. The details of the construct measurements are presented in Table 2.

Table 2. Construct Measurements.

Constructs	Codes	Questions	Adapted
Perceived Ease of use	PEU1	The disruptive technology is easy to use at your university	[8,33,35]
	PEU2	You feel distributed ledger technology is faultless	
	PEU3	Blockchain is feasible to do multi task on same time	
	PEU4	The smart contract based distributed ledger system is speedy than traditional education system	
Perceived Usefulness	PU1	It can aid your educational institutes for fast learning	[31,35,56]
	PU2	It can better transparency for Higher education system in Malaysia	
	PU3	It can aid for mutual learning at your university	
	PU4	It can benefit you to reach virtual education on real time	
Compatibility	COM1	Blockchain is suitable for digital credentials	[36,57,58]
	COM2	Blockchain is suitable for verification of student documents	
	COM3	Blockchain is compatible for learner applications at your university	
	COM4	Blockchain is compatible for demonstrative system built at your university	
Relative Advantages	ADV1	The disruptive technology will reduce cost of educational institutes in Malaysia	[36,57,59]
	ADV2	Enhance traceability of digital credentials	
	ADV3	Develop Decentralized platforms like Blockcerts blockchain University	
	ADV4	Helps in virtual education to save time of students especially in pandemic situation like COVID-19	
Trialability	TRI1	Adoption of a blockchain digital identity management system in higher education system of Malaysia	[37,60,61]
	TRI2	To transform the record keeping of digital credentials	
	TRI3	To improve efficiency in existing education system of Malaysia	
	TRI4	To create a disruptive business model in the near future for Higher Education Commission (HEC) of Malaysia	
Intention to Use	BI1	HEC will use blockchain based framework very well in the coming future	[62–65]
	BI2	Design a decentralized collaborative platform for smart learning environment in Malaysia	
	BI3	Create a nonprofit, borderless blockchain based universities in Malaysia	
	BI4	It is predictable that HEC will take benefits from disruptive technology applications in the different domains	

4.2. Data Collection

Overall, we received 212 online survey questionnaire from experts working in the education sector of Malaysia and found that the average completion time was approximately 5 min, which is similar to the estimated completion time based on the pilot test. We deleted 14 responses that require less than 1.5 min. In addition, we tested all responses and found that no responses to all item had the same score. Finally, 198 valid response were considered available for subsequent analysis in total. Most of the data were collected from the males representing (67.67%). The maximum data were collected from experts working in IT department representing (43.43%). The majority of employees had more than 5 years of experience working in the educational institute (47.47%). The sample of 198 respondents was found to fulfil the minimum requirement and five observations per parameter [66]. We considered 28 parameters for the structural equation modeling analysis, with a minimum

requirement for a sample size of 165 respondents, as suggested by Wolf et al. [67]. The respondents profile data is presented in Table 3.

Table 3. Demographic Background of users.

Profile		Frequency	Percentage
Gender	Male	134	67.67%
	Female	64	32.33%
Age	22–25	76	38.38%
	26–30	44	22.22%
	31–35	48	24.24%
	36–40	18	9.09%
	41 and above	12	6.06%
Education Sector	Information Technology Department	86	43.43%
	Finance Department	47	23.73%
	Management Department	43	21.71%
	Administration Department	22	11.11%
Experience with digitalization	≤2 years	53	26.76%
	>2 ≤5 years	51	25.75%
	>5 years	94	47.47%

N = 198 (Emails of the respondents were not provided by the request of them).

4.3. Structural Equation Modeling

In this study, we used the partial least square structural equation modeling (PLS-SEM). It is a multivariate technique which assists linear and additive models and widely used in the business management and IS studies [68]. It has been used increasingly in various researches, because of its appropriate in examining composite models for exploratory research [69]. The comparative study of Hwang et al. [70] encouraged the use of PLS-SEM for disruptive technologies. In PLS-SEM, for common method bias issues, the Variance Inflation Factor (VIF) was examined before testing the structural model to find the highly correlated constructs. The findings confirmed that the highest VIF value was 3.3220, below the threshold of 5.00. The VIF values of the inner and outer model are presented in Table 4. Endogeneity can be generated recursively the structural model. We therefore applied a Ramsey regression equation error test and found no endogeneity problem [71].

Table 4. Variance Inflation Factor (VIF) Test Results.

	COM	BI	PEU	PU	ADV	TRI	ADV1	1.5524
COM		2.5312	2.5312	2.7680			ADV2	1.6094
BI							ADV3	1.5640
PEU				3.1359			ADV4	1.2935
PU							BI1	1.6560
ADV		2.0731	2.0731	2.3956			BI2	1.7152
TRI		2.9886	2.9886	3.3220			BI3	2.0555
							BI4	1.8623
							COM1	1.9454
							COM2	2.1660
							COM3	2.1148
							COM4	2.0148
							PEU1	2.2476
							PEU2	1.8461
							PEU3	1.5689
							PEU4	1.6834
							PU1	1.5060
							PU2	1.8987
							PU3	1.6692
							PU4	1.6339
							TRI1	1.8128
							TRI2	2.1518
							TRI3	1.9918
							TRI4	1.8891

Note. BI = Intention to use, COM = compatibility, PEU = perceived ease of use, PU = perceived usefulness, ADV = relative advantage, TRI = trialability.

5. Results

In the present study, the proposed model was tested by using a two-step method. First, we checked the reliability and validity of the constructs. In the second phase, bootstrapping was applied for the structural path's significance testing.

5.1. Convergent Validity

In the proposed model, when the hypothetical factors established for the analysis closely related with the items used to measure it, a convergent validity test was applied to check the inconsistency between the constructs. Here, seven constructs were evaluated by following the guidelines for checking the validity of the measurement constructs:

- In the first phase, we checked the factor loading for the significance level where the standard value for each item was 0.70 or above [72].
- After checking the loadings, the composite reliability test was applied on all the constructs. The threshold for each construct was 0.70 [72].
- The Average Variance Extracted (AVE) of every construct was tested and the standard value for each construct was 0.50 and above [73].
- Discriminant validity analysis was also examined to find the extent within which measurement constructs in a conceptual model are different from each other [73].

By using the SmartPLS 3.2.8, all the tests were conducted for the study. The factor loading of all the items were found highly significant and above the standard value. The factor loading of the measurement items are shown in Figure 4. The composite reliability and the AVE test values were also found higher than the standard value of (0.7) and (0.5), a strong indicator of reliability. In reflective models, the Cronbach alpha for each construct should be greater than threshold of 0.7 [74]. The construct reliability and AVE results are presented in Table 5. The discriminant validity was also found significant (see Table 6). Consequently, the results of AVE were higher which reflects that all items can be used for the SEM phase.

Figure 4. Measurement Model Loadings.

Table 5. Construct Reliability and Validity.

Constructs	CA	CR	AVE
COM	0.8618	0.9061	0.7069
BI	0.8339	0.8893	0.6678
PEU	0.8189	0.8802	0.6483
PU	0.7948	0.8666	0.6197
ADV	0.7626	0.8492	0.5852
TRI	0.8374	0.8913	0.6723

Note. CA = Cronbach alpha, CR = composite reliability, AVE = average variance extract.

Table 6. Discriminant Validity.

Constructs	COM	BI	PEU	PU	ADV	TRI
COM	0.8408					
BI	0.7000	0.8172				
PEU	0.7283	0.7807	0.8052			
PU	0.7252	0.9340	0.7688	0.7872		
ADV	0.6355	0.7336	0.7248	0.6894	0.7650	
TRI	0.7658	0.7455	0.7622	0.7461	0.8200	0.8200

Note. BI = intention to use, COM = compatibility, TRI = trialability, PEU = perceived ease of use, PU = Perceived usefulness, ADV = relative advantage.

5.2. Structural Model

In the second step to evaluate the structure equation modeling, bootstrapping was applied for the structural path's significance testing. In the bootstrapping method, subsamples (5000) were tested with replacement to check faults, which in turn directed the estimated T-values for significance testing of the proposed model. The bootstrapping procedure approximates data normality for structural models, as shown in Figure 5. Thus, the proposed model quality criteria are presented in Table 7. The findings confirm that independent constructs justified 66.2% of the variation on the intention to use. Consequently, the final decision about hypothesis development is presented in Table 8.

Figure 5. Structural Model.

Table 7. Model Quality Criteria.

Constructs	COM	BI	PEU	PU	ADV	TRI	R Square	R ² Adjusted
COM			0.0935	0.0547				
BI		0.0596					0.6624	0.6573
PEU				0.1092			0.6811	0.6763
PU							0.6827	0.6763
ADV		0.1964	0.1556	0.0340				
TRI		0.0964	0.1116	0.0435				

Note. BI = Intention to use, COM = compatibility, PEU = Perceived usefulness, PU = Perceived usefulness, ADV = relative advantage, TRI = trialability.

Table 8. Hypothesis Testing Results.

	Relationships	(O)	(M)	STD	T Values	p Values	Decision
H1	TRI- > PU	0.2140	0.2116	0.0785	2.7278	0.0066	Supported
H2	TRI- > PEU	0.3261	0.3333	0.0726	4.4893	0.0000	Supported
H3	TRI- > BI	0.3118	0.3135	0.0754	4.1345	0.00000	Supported
H4	ADV- > PU	0.1606	0.1612	0.0626	2.5682	0.0105	Supported
H5	ADV- > PEU	0.3207	0.3186	0.0678	4.7322	0.0000	Supported
H6	ADV- > BI	0.3708	0.3697	0.0602	6.1589	0.0000	Supported
H7	COM- > PU	0.2191	0.2226	0.0772	3.0342	0.0008	Supported
H8	COM- > PEU	0.2748	0.2708	0.0772	3.5605	0.0004	Supported
H9	COM- > BI	0.2257	0.2268	0.0667	3.3810	0.0025	Supported
H10	PEU- > PU	0.3297	0.3300	0.0764	4.3133	0.0000	Supported

Note. BI = Intention to use, COM = compatibility, PEU = Perceived usefulness, PU = Perceived usefulness, ADV = relative advantage, TRI = trialability O = original sample, M = sample mean, STD = standard deviation.

5.3. Structural Model Assessment

Based on findings, all hypotheses were found statistically significant from the entire ten tested relationships in the final model. The relationship between trialability and perceived usefulness ($\beta = 0.2140$, $T = 2.7278$, $p = 0.0066$), perceived ease of use ($\beta = 0.3261$, $T = 4.4893$, $p = 0.000$), and intention to use ($\beta = 0.3118$, $T = 4.1345$, $p = 0.0000$) was significant. The next association between relative advantage and perceived usefulness ($\beta = 0.1606$, $T = 2.5682$, $p = 0.0105$), perceived ease of use ($\beta = 0.3207$, $T = 4.7322$, $p = 0.0000$), and intention to use ($\beta = 0.3708$, $T = 6.1589$, $p = 0.0000$) was significant. The relationship between compatibility and perceived usefulness ($\beta = 0.2191$, $T = 3.0342$, $p = 0.0008$), perceived ease of use ($\beta = 0.2748$, $T = 3.5605$, $p = 0.004$), and intention to use ($\beta = 0.2257$, $T = 3.3810$, $p = 0.0025$) was supported. Lastly, the correlation between perceived ease of use on perceived usefulness was supported ($\beta = 0.3297$, $T = 4.3133$, $p = 0.0000$). It can be summarized from the above discussion that all constructs showed a significant influence on TAM and adoption of DLT in a smart learning environment.

6. Discussion

6.1. Findings

The results showed that trialability had a significant influence on perceived usefulness, which is supported by the previous studies (e.g., [75,76]). We also found that trialability had a positive effect on perceived ease of use and supported [77–79]. Trialability had a significant influence on intention to use [80–82]. To stimulate employees' intention to use blockchain, developers should pay more attention to the design of creative features and content of DLT for future users. The influence of relative advantage on perceived usefulness [83–85] and ease of use [86–88] was significant. The same was found for the influence of relative advantage on intention to use [89,90]. Compatibility was found to influence perceived usefulness of DLT [91–93], perceived ease of use [75,94], and intention to use and supported by previous studies [45,76,95]. Finally, perceived ease of use showed a significant influence on perceived usefulness during the DLT adoption [84,96,97]. The distributed nature and smart contract base network system for e-learning are viewed as

user friendly, cost saving, ensure trust, speedy, transparent, and immutable, users can find them reliable for handling education data from various education service providers.

6.2. Theoretical Implications

The present study adds to the limited literature on blockchain technology by integrating diffusion of innovation theory with TAM. The statistically validated model constructs derived from the integration of traditional theories by using PLS-SEM technique is found to have great influence. Few empirical studies on the application of DLT have been conducted so far [98]. More specifically, blockchain for the smart learning environment has not been studied in developing economies like Malaysia. This study can act as a preliminary idea for future researchers to deeply analyze the disruptive technology adoption. The present study suggests novel visions on the features driving acceptance of blockchain technology for e-learning systems. For the blockchain enterprises, the finding suggests that their advertising strategies need to concentrate on the potential of blockchain applications in higher education.

6.3. Practical Implications

This study shows that the conceptual model has a strong explanatory power ($R^2 = 0.6624$ and R^2 adjusted = 0.6573), reflecting a 66.24 percent variance of the purpose to use. Moreover, a variation of ($R^2 = 0.6811$ and R^2 adjusted = 0.6763) was shown by the perceived ease of use towards disruptive technology. Subsequently, a highest variation of ($R^2 = 0.6827$ and R^2 adjusted = 0.6763) was shown by the perceived usefulness. The emerging economies have commenced to investigate the disruptive technology adoption in education management [99]. The capability of covering a full set of higher education domains would be highly valuable for decision makers. The implementation of distributed ledgers for online learning would bring a level of transparency and traceability in the traditional education sector. For example, DLT can help users to get the distance education quickly and thereby contribute to the higher education sector of developing economies.

7. Conclusions and Future Work

In conclusion, the current study integrates the diffusion of innovation theory with technology acceptance model for the acceptance of a DLT in education management. The most vital part of this research is to empirically study the technology adoption models for developing states. In defining what a blockchain is, how it operates, and demonstrating the advantages of running tests with smart contracts, much time had to be placed into the demonstrations held. This revealed that the user interface and guidelines were not sufficiently successful, and that the public was aware of disruptive technology. In answer to RQ01, based on the results, it is specified that compatibility, trialability, and relative advantage shows significant influence during a DLT adoption. Pertaining to RQ02, the present study results show that relative advantage matters most during the disruptive technology implementation. From the results, it is suggested that the conceptual model grips a noteworthy descriptive influence. The major overall influence of the model verifies the significance of the advanced model. For blockchain technology executing experts, the existing research suggests valuable visions for developing disruptive technology solutions.

This study still has some limitations. Blockchain technology is comparatively a new idea, few organizations know about it. The present study sample size is considered only from developing economies. In the future, cross-cultural studies with other developed countries like US, UK, and other some important factors, such as local regulations, can be considered to better understand the proposed model. Our finding indicates more adoption of blockchain for e-learning in the organizations over time, a longitudinal study for this development will be of more interest. Second, blockchain is actually not a standalone technology. In the present analysis we did not examine the blockchain integration with other technologies for security and privacy purposes. In the future, blockchain integration with big data, artificial intelligence and internet of things can be considered for better

understanding. Third, we only focused on the integration of diffusion of innovation theory with TAM. In upcoming research, researchers may consider combining other theories. Finally, public awareness about the advantages of DLT seemed to halt the belief they are absolute and safer. Further studies may investigate what a smart contract would look like for further assessment, such as group based smart contracts and self-assessment. It would be great to examine the role of micropayment in online education systems with the support of digital currencies for building a better learning reputation.

Author Contributions: Conceptualization, N.U. and W.M.A.-R.; methodology, N.U., A.I.A. and W.M.A.-R.; software, N.U. and W.M.A.-R.; validation, A.I.A., O.A. and F.M.A.; formal analysis, N.U. and W.M.A.-R.; investigation, W.M.A.-R., A.I.A., and O.A.; resources, N.U.; data curation, A.I.A., F.M.A. and O.A.; writing—original draft preparation, N.U. and W.M.A.-R.; writing—review and editing, N.U., A.I.A., and W.M.A.-R.; visualization, A.I.A., O.A. and F.M.A.; supervision, W.M.A.-R.; project administration, A.I.A., and O.A.; funding acquisition, A.I.A. All authors have read and agreed to the published version of the manuscript.

Funding: The authors extend their appreciation to the Deanship of Scientific Research at King Saud University for funding this work through research group no (RG-1438-062).

Institutional Review Board Statement: No applicable.

Informed Consent Statement: No applicable.

Data Availability Statement: No applicable.

Acknowledgments: The authors extend their appreciation to the Deanship of Scientific Research at King Saud University for funding this work through research group no (RG-1438-062).

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

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