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The Mediating Role of Perceived Ease of Learning in Teacher Readiness to Adopt Blockchain for Educational Assessment

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ABSTRACT

Traditional educational assessment systems in Malaysia face persistent issues such as data security vulnerabilities, lack of transparency, and centralised control, which collectively undermine trust, reliability, and operational efficiency. While blockchain (BC) technology has emerged as a promising solution offering decentralisation, immutability, and enhanced data security, a critical gap exists in understanding teacher readiness to adopt such innovations within the education sector. Most prior research emphasises the technical feasibility of blockchain or user acceptance in non-educational contexts, often overlooking educators' cognitive and pedagogical challenges when learning and using unfamiliar technologies. This study investigates how key attributes of BC relative advantage (RA), compatibility (COM), and complexity (CPX) influence teacher readiness for adoption, mediated by

perceived ease of learning (PEOL). A total of 750 questionnaires were distributed, resulting in 514 valid responses from post-secondary school teachers in the northern region of Malaysia, achieved through a simple and proportionate stratified random sampling technique. Partial Least Squares Structural Equation Modelling (PLS-SEM) reveals that COM and CPX significantly predict teacher readiness, while PEOL is a partial mediator. RA shows no significant direct or indirect effect, challenging assumptions about its centrality in technology adoption models. These findings contribute to the broader goals of Industrial Revolution (IR) 5.0 by highlighting the importance of human-centric, cognitively accessible technological integration strategies in education, particularly for fostering systemic reform in assessment practices.

Keywords: Assessment management, Blockchain in education, Teacher readiness, Perceived ease of learning, Education 5.0.

INTRODUCTION

The evolution of assessment methods reflects a transformative shift aligned with the principles of Industrial Revolution (IR) 5.0, moving from conventional pen-and-paper examinations to more human-centred, technology-enhanced approaches. The emergence of digital platforms, online assessments, and e-portfolios has explored the potential of technology adoption in this domain (Omar & Phung, 2019; Purnama et al., 2021; Wanotayapitak et al., 2019). In Malaysia, initiatives such as the Digital Educational Learning Initiative Malaysia (DELIMa), the 1BestariNet project, and e-submission systems illustrate efforts to harness technology in creating smarter, more inclusive, and sustainable educational ecosystems (Awang et al., 2018; Nasir & Mohd Yunus, 2017). Notably, the school-based assessment (SBA) system, through the School-Based Assessment Management System *[Sistem Pengurusan Pentaksiran Berasaskan Sekolah]* (SPPBS), serves as the country's primary digital platform focused exclusively on technology-based assessment management in schools.

However, traditional digital assessment systems, such as SPPBS, are not without challenges. Issues related to system security, accuracy, trustworthiness, and reliability persist (Doğan et al., 2020; Jani et al., 2018; Mahat et al., 2021; Maslan et al., 2020; Rasheed et al., 2020; Shalatska et al., 2020). In fact, since its introduction in schools until the present time, the SPPBS system has had numerous problems, with various complaints, setbacks, issues and challenges being reported (H. Chin et al., 2019; Naim & Talib, 2014). Additionally, the centralised nature of the current SBA system has raised concerns over data manipulation and lack of integrity. Teachers' proficiency in evaluating students' written work and providing constructive feedback has also been identified as needing improvement (Acharya & Binu, 2018; Ravikumar, 2018). As digital assessment evolves, concerns about data privacy and cybersecurity, especially regarding the online storage and sharing of educational records, have become increasingly prominent (Alshareef, 2022; Isa et al., 2021; Tsai et al., 2022).

These challenges highlight the urgent need for an assessment solution that balances operational efficiency with trust and transparency. One promising alternative is blockchain (BC) technology, which offers decentralisation, immutability, and enhanced security features. These characteristics make it a strong candidate for transforming how educational assessments are managed (Ullah et al., 2021). A blockchain-based assessment management (BAM) system could potentially address many of the limitations found in current platforms while also improving the overall educational experience for both teachers and students (Doğan et al., 2020; Iyer et al., 2020; Tsai et al., 2022; Ullah et al., 2021). Most studies have focused on building BC models and analysing their technical feasibility. However, far less

attention has been given to whether actual users, especially teachers, are ready and willing to adopt such a system (Duan, 2018; Islam et al., 2019; Li et al., 2019; Liang & Zhao, 2020; Mitchell, 2019; Shen & Xiao, 2018; Turkanović et al., 2018; G. Wang et al., 2019). Recent discussions in academic literature have started to recognise a readiness gap between educators and students when integrating new technologies into learning environments. Only a few studies have explicitly focused on teacher readiness for blockchain applications in Malaysian public schools (Kankok et al., 2020, 2021).

Besides, previous research has investigated the elements that impact users' readiness to adopt new technologies. Notable factors in this regard include relative advantage (RA), compatibility (COM), complexity (CPX), perceived usefulness (PU), and perceived ease of use (PEOU) (Davis, 1989; Tornatzky & Klein, 1982). However, with the emergence of BC as a novel technology in recent years, these factors require further investigation, considering the distinct features of BC compared to earlier technologies (Parasuraman & Colby, 2015). In fact, these factors have predominantly been investigated in the contexts of banking, financing, and supply chain management, while the same research on BC readiness in the education context, particularly pertaining to assessment management, remains limited (Alammary et al., 2019; Alshamsi et al., 2022; Falah et al., 2021; Sunny et al., 2022).

Since the distinction between PEOU and perceived ease of learning (PEOL) depends on the age of the technology being introduced and BAM is a new and conceptual system, teachers need to learn the system before using it. Therefore, given that assessment is the most sensitive area within education, it is justifiable to explore the correlation between fundamental BC attributes and readiness through PEOL among teachers. Specifically, this study examines how the BC characteristics, RA, COM and CPX predict readiness outcomes through PEOL. These factors are crucial to understanding for teachers to function optimally during assessments and become more technologically prepared for managing SBA, avoiding the same failure experienced with the acceptance of the SPPBS among teachers, as a readiness study was not conducted to identify the factors that would encourage teacher acceptance before its implementation (H. Chin et al., 2019).

LITERATURE REVIEW

Blockchain Characteristics

The Technology Acceptance Model (TAM) by Davis (1989) is designed to be adaptable to different study contexts by incorporating external variables (X1, X2, X3). Lately, various extensions of the TAM model have been proposed, including the inclusion of external variables to meet the study's context (Ajwang et al., 2021; Farooq et al., 2021; Rahim et al., 2022; Ullah, 2020). These extensions have shown promise in increasing the model's ability to make accurate predictions, and they can be tailored to specific contexts and technologies, providing more nuanced insights into user perception. Additionally, the model meets the three key criteria (parsimony, verifiability & generalisability) for studying a complex system like BC, and its ongoing development offers great potential for both researchers and practitioners for examining a complex system like BC (Abdul Aziz et al., 2020; Cheng, 2019; Chintalapati & Daruri, 2017).

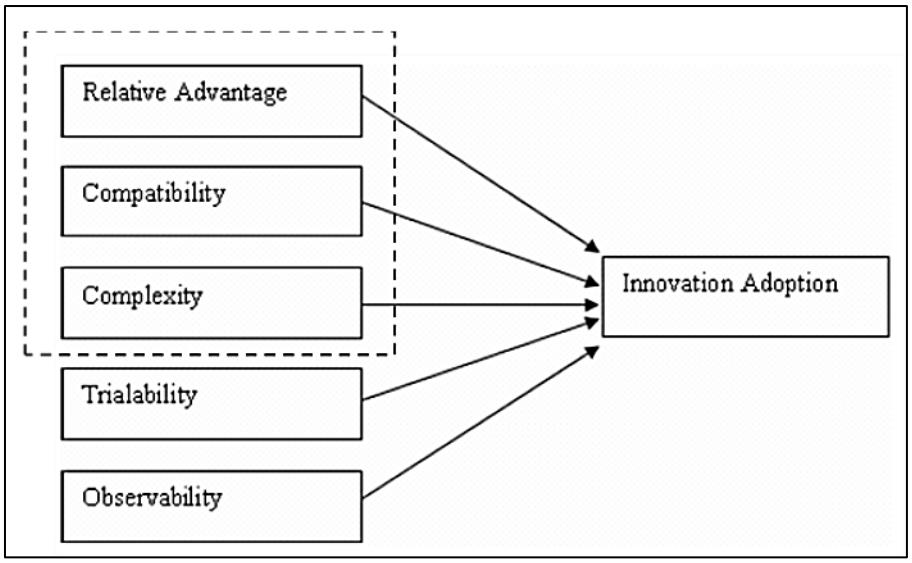
However, Hamid et al. (2016) have noted that the TAM is limited in its ability to predict the readiness of complex and sophisticated technologies, as it primarily focuses on simple technologies. This limitation has been a subject of criticism, as other scholars have pointed out that the model does not incorporate the influence of human and social factors on the readiness to use new technologies like BC.

It is too simplistic, lacking the complexity to understand technology readiness in different contexts fully (Rahman et al., 2017; Shachak et al., 2019). Furthermore, Ajwang et al. (2021) have argued that TAM alone may not be sufficient, and it may be necessary to incorporate additional factors or models to gauge user readiness more accurately. Thus, it might be valuable to integrate TAM and Diffusion of Innovation (DOI) theory in order to achieve a more holistic understanding of technology readiness and adoption (Khoa et al., 2020).

Rogers (1983) presented a theoretical framework that outlines the relationship between perceived innovation characteristics and the adoption of innovations (Figure 1). Scholars found that the predictive power of the five perceived innovation attributes of DOI varies as the attributes measure different adopter perceptions. For instance, RA is a strong predictor of adoption rate, while COM is less influential (Bozbay & Yasin, 2008). It is important to note that the evidence supporting complexity, trialability, and observability as predictors of adoption may vary. In the earlier specific analysis, the evidence suggests weak predictive power for these attributes, except for RA, CPX and COM (Tornatzky & Klein, 1982).

Figure 1

Diffusion of Innovation Theory (Rogers, 1983)



Since RA, COM, and CPX describe specific attributes of BC that influence its readiness, they are currently being studied as key characteristics of BAM. RA is primarily manifested in attributes such as transparency, traceability and immutability (Wang et al., 2022). The studies by Li et al. (2022) and Wang et al. (2022) both investigated the adoption of BC within China's construction industry, offering valuable insights into the factors influencing BC readiness. While both studies agreed on the significant role of RA and COM in promoting BC adoption, they also highlighted distinct aspects of these influences and presented varying perspectives on CPX.

Li et al. (2022) focused on the impact of RA and COM, finding that both significantly influenced BC adoption in the construction industry. RA, representing the perceived benefits such as enhanced efficiency and data integrity, is a critical driver for adoption. COM, which indicates how BAM aligns with existing assessment management practices, also plays a substantial role. Interestingly, they find

that CPX does not significantly impact the BC. They suggested that the RA and COM of BC outweigh the CPX, leading to its acceptance despite its complexities. However, the authors acknowledged a lack of quantitative studies in this area, pointing out the need for more robust empirical research to validate these findings.

Similarly, X. Wang et al. (2022) studied BC adoption in China's construction industry, emphasising the effects of RA and COM, consistent with the findings of Li et al. (2022). However, X. Wang et al. (2022) extend their investigation by exploring PU and PEOU as additional influencing factors. They argued that all RA measurements contribute to its PU. The study highlighted that while RA and COM are crucial, PEOU and PU significantly impact readiness to adopt BC. Nevertheless, they also noted several limitations, such as the voluntary nature of the TAM assumption and the small proportion of respondents familiar with BC. This has prompted the current study to consider using videos to enhance awareness and understanding of BAM technologies before respondents answer the questionnaire.

In the context of organisations in Germany, Austria, and Switzerland, Lustenberger et al. (2021) found that RA significantly influences BC adoption. Despite the complexities associated with BC, organisations adopt the technology if they perceive significant advantages, such as enhanced transparency and efficiency. Unlike in the Chinese construction industry, CPX and COM did not significantly affect adoption in this context. To explain these findings, they aligned them with Li et al. (2022), suggesting that the perceived long-term benefits of BC are strong enough to encourage adoption, even if the technology is complex and requires adjustments to existing practices. This finding emphasised the importance of perceived benefits in driving technological innovation in diverse settings.

In Malaysia, a study by Wong et al. (2019) on BC adoption in supply chain management (SCM) within small and medium-sized enterprises (SMEs) reveals that both RA and CPX significantly influence adoption. SMEs recognise the transformative potential of BC, which can revolutionise traditional SCM methods and enhance efficiency and transparency. However, the complexity of implementing BC also plays a role, indicating that while SMEs are motivated by the potential benefits, they are also cautious of the challenges. This dual effect underscores the need for SMEs to carefully weigh the advantages against the operational complexities of BC adoption.

Focusing on the context of education in Malaysia, Ullah et al. (2021) explored BC adoption in e-learning environments. The study found that RA matters most in BC adoption, highlighting the perceived benefits of BC in enhancing educational processes and outcomes. COM also affects readiness for adoption, suggesting that alignment with existing educational practices is crucial. However, the study did not find CPX to be a significant barrier, indicating that the potential benefits of BC in education outweigh the perceived difficulties (Li et al., 2022; Lustenberger et al., 2021). This finding is particularly relevant for developing economies like Malaysia, where BC can be transformative in advancing educational technologies. Nevertheless, 43.43% of the participants in this study were from the IT department, limiting the generalizability of the findings to users with other backgrounds.

Interestingly, in higher education institutions (HEIs) in Malaysia, Iftikhar et al. (2021) found that RA negatively affects BC adoption due to the BC complexity and lack of expertise in BC technology. While PU positively influences readiness, the CPX and PEOU significantly hinder adoption. The study suggests that the conflict between RA and adoption may be due to the newness of BC technology in education and its complex implementation. This highlights the need for increased expertise and familiarity with BC to overcome adoption barriers in educational contexts.

All reviewed studies underline the importance of RA, COM, and CPX in BC readiness across various contexts, demonstrating that different contexts portray different effects. Results for BC characteristics and additional factors like PU and PEOU diverge. This discrepancy highlights the complex nature of BC adoption and suggests that while RA and COM are crucial, addressing user perceptions and enhancing familiarity with the technology can further facilitate its acceptance. These findings collectively suggest a comprehensive approach to promoting BC adoption, encompassing the tangible benefits and alignment with current practices, user education, and perception management.

Mediating Role of Perceived Ease of Learning

As Davis (1989) stated, technology adoption is directly influenced by individuals' perceptions of PEOU and PU. PEOU refers to an individual's perception of the ease of using a specific technology with minimal physical effort. PU, on the other hand, pertains to how much a person acknowledges that a specific technique can enhance their productivity. Numerous prior investigations have focused on TAM and concluded that PU is a reliable indicator for predicting technology adoption. For instance, Ullah et al. (2021) explored BC adoption behaviour in e-learning and found that PEOU significantly influences the PU of BC applications in the e-learning context. However, as more information became available, the initial belief in BC's safety and benefits slowed. Furthermore, several other scholars have conducted studies in different research settings, demonstrating that PU and PEOU have a significant impact on the behavioural intention to adopt BC (Al-rahmi et al., 2019; Bharadwaj & Deka, 2021; Esfahbodi et al., 2022; Jena, 2022; Md Noh & Amron, 2021; Rahim et al., 2022; X. Wang et al., 2022). The authors altered the same items developed by Davis (1989) to measure PU and PEOU.

However, since the primary goal of the current study is to help teachers learn new technology effectively and predict how challenging it will be, PEOL should be prioritised. It is particularly important in educational assessment settings where retaining assessment records is crucial. PEOL is related to the ease with which individuals can grasp and understand new concepts or information (Shiang Tyng et al., 2023). It refers to the level of difficulty users experience when understanding and navigating a new system or technology within a reasonable amount of time. For elderly users, PEOL emphasises the ability to quickly grasp and utilise innovation (Ahmad et al., 2024; Rini et al., 2024).

Ahmad et al. (2024) conducted a study in Malaysia with 30 elderly participants using focus groups, interviews, and user experience evaluations to explore the elderly user experience with the MySejahtera application. The findings suggest that future research should focus on developing digital health interventions that are not only user-friendly but also effectively support the elderly in learning and adopting new technologies for health management. This finding contradicts an earlier study in the healthcare sector, which found that ease of learning is not affected by age, gender, computer skills and personnel category (Kontogiannatou et al., 2019). However, it is important to note that this comparison may be unfair, as MySejahtera is a health app designed for public use, and the participants in the study were members of the public, whereas the healthcare management systems were built for health personnel and the participants in that study were members of the health sector.

In the context of education, Rini et al. (2024) examined PEOL among high school and vocational teachers in West Sumatra, Indonesia, when using an open-source Learning Management System (LMS) for mobile learning. They found that teachers often struggled due to the LMS not being designed with user-centred principles. Thus, ease of learning is crucial for ensuring that users can effectively and efficiently adopt new technologies, highlighting the importance of intuitive design and user-centred approaches. This means that PEOL is more suitable for examining user readiness for adopting a new

technology like BC. It's a subjective measure that can be influenced by various factors, including relative advantage, compatibility and the complexity of the innovation (Ullah et al., 2021).

Furthermore, in educational psychology, this is often discussed in the context of constructivism, a learning theory that emphasises the active role of learners in building their own understanding (Efgivia et al., 2021). Constructivism suggests that learning is an active process where learners construct meaning only through active engagement with the environment. This theory posits that individuals learn best when they can integrate innovation with their existing knowledge, leading to a perception of ease in learning. However, it acknowledges the challenges associated with understanding BC, such as the intricacy of changing users' perceptions and behaviours towards innovation, in addition to the existing evaluation framework that emphasises end results. Therefore, despite aiming to enhance the assessment experience for users, the introduction of innovation in educational assessment may face certain obstacles (Sumarna & Gunawan, 2022).

Shiang Tyng et al. (2023) studied both variables to delve into the development and usability testing of Mathematics E-Learning Visual (MEL-VIS) in assisting primary school students with mathematics in Putrajaya. Their findings indicate that the prototype proves effective, easy to learn and easy to use for primary school mathematics. However, there are certain shortcomings regarding the clarity of the research procedures and the novelty of the study. Clear information regarding the application development process, data collection, and analysis techniques is lacking. Questions arise concerning the statistical analysis and its interpretation, suggesting a need to re-evaluate how the research is conducted.

In comparison, while PEOU focuses on the usability of an innovation, PEOL is more about the cognitive processes involved in acquiring knowledge or skills to use that innovation (Wahyuni et al., 2023). Although very limited sources explicitly discuss the relationship between PEOU and PEOL, it can be inferred that ease of use plays a crucial role in the learning process. A system or tool that is easy to use is more likely to be adopted and learned quickly, as it reduces the barriers to entry and facilitates the acquisition of new skills or knowledge. Both factors are crucial in determining user satisfaction and the effectiveness of educational tools or technologies.

The role of PEOU as a mediator has been explored in various contexts. In Indonesia, Desi and Zaitul (2021) found that PEOU fully mediates the relationship between Effort Expectancy (EE), Performance Expectancy (PE), and Behavioural Intention (BI) in accounting app adoption, with improvements in BI achievable through enhancing PEOU. However, a small sample size and the exclusion of PU limited their study. On the other hand, Fearnley and Amora (2020) demonstrated that in the Philippines, teachers who found LMS easy to use also perceived them as useful, leading to positive attitudes and strong intentions to use LMS, though their findings were limited by a single data collection method.

In the other sector, X. Wang et al. (2022) revealed that in the construction industry, the COM of BC with industry practices enhances its PEOU and usefulness, although their study faced limitations due to a small proportion of respondents familiar with BC and the voluntary nature of technology adoption assumed by the adopted model, TAM. Meanwhile, Ayyoub et al. (2023) found that PU significantly influences users' readiness to use online assessments in Palestinian higher education, while PEOU does not affect this intention. This might be because the authors overlooked the role of POEL in influencing the PEOU or the effect of PEOU itself on readiness is mediated by some other variable (Cen et al., 2023; Iftikhar et al., 2021).

Recent studies on the role of PEOL as a mediator, especially in the context of education, have been very limited. In an effort to develop an educational application, Cen et al. (2023) referred to PEOL as one of the usability dimensions of innovations. They suggested that the dimension is critical in designing and developing educational applications, particularly for primary and secondary school students. They found a significant relationship between PEOL and PEOU in the context of AI educational software, indicating that PEOL directly affects PEOU. Specifically, the findings highlight that the ease of learning dimension directly impacts the software's PEOU. This relationship highlights the importance of designing educational apps with a focus on facilitating a smooth and intuitive learning experience, contributing to overall PEOU for users. Consequently, it emphasises the need to prioritise ease of learning in the design and development of educational apps to enhance the overall user experience.

Thus, that recommends the current study to explore ease of learning as a mediator between innovation features and user readiness to adopt educational technologies. Besides, it is important to address several limitations identified from previous works using a larger sample. Although the current study may not be able to overcome the limitations noted by X. Wang et al. (2022) of having a small proportion of respondents familiar with BC, it employs a video to provide participants with an understanding of the basic features of BC. Additionally, it is an urge to explore contexts where technology adoption may not be entirely voluntary, such as in education.

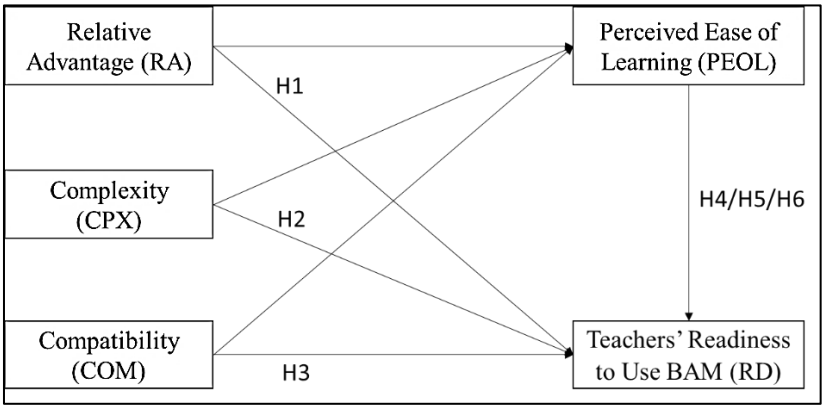
METHODOLOGY

Research Model and Hypotheses

The study's model, illustrated in Figure 2, is generally derived from the DOI, focusing on the factors influencing teachers' readiness to use BAM. The DOI constructs of RA, COM, and CPX are categorised as innovation characteristic factors because they describe the specific attributes of BAM that influence its readiness.

Figure 2

The Research Model



All the characteristics are hypothesised to positively affect teachers' readiness to use BAM (RD), including CPX, because the construct was measured using positively worded statements. The higher CPX scores indicate lower complexity, which could enhance RD and PEOL by reducing cognitive and

technical barriers. Accordingly, six hypotheses were generated, equally divided between direct effects (three hypotheses) and indirect effects (three hypotheses), listed as follows.

H1 Relative advantage positively influences teachers' readiness to use BAM.
H2 Complexity positively influences teachers' readiness to use BAM.
H3 Compatibility positively influences teachers' readiness to use BAM.
H4 Perceived ease of learning mediates the influence of relative advantage on teachers' readiness to use BAM.
H5 Perceived ease of learning mediates the influence of complexity on teachers' readiness to use BAM.
H6 Perceived ease of learning mediates the influence of compatibility on teachers' readiness to use BAM.

Instrument Design

The study employs a set of instruments to assess all constructs: RA, CPX, COM, PEOL and RD (Table 1). Specifically, PEOL was measured using items adopted from Cen et al. (2023) and Rini et al. (2024). Moore and Benbasat (1991) developed an instrument to measure the constructs of RA and COM, but in order to meet the recent technology and education context, items for those constructs, including CPX, were adopted from the latest technology adoption studies (Chatzoglou & Michailidou, 2019; J. Chin & Lin, 2016; Heidari et al., 2017; Idoga et al., 2022; Li et al., 2022; Mardiputra et al., 2021; Muharam et al., 2024; Shi & Yan, 2016). The dependent variable, RD, is measured using an instrument by Reyes-Mercado et al. (2023), Ullah et al. (2022), Venkatesh and Davis (2000) and Zhang et al. (2020). However, every item originating from these instruments was paraphrased and translated from the English language to the Malay language using the technique of back translation (Brislin, 1970) to ensure alignment with the study's specific context and the characteristics of the respondents. All items for all constructs were measured using a 7-point Likert scale ranging from 1 (strongly disagree) to 7 (strongly agree).

Table 1

Measurement Items

Items	Statement
Relative Advantage (RA)	
RA1	I believe that BAM can make assessment data more accessible to anyone.
RA2	I believe that BAM can make assessment data more accessible anytime.
RA3	I believe that BAM can store assessment data for multiple users.
RA4	I believe that BAM allows all assessment data to be traced to pinpoint its source.
RA5	I believe that BAM allows all assessment data to be traced to verify its source.
RA6	I believe that BAM can provide real-time (instant) tracking of progress over students' assignments.
RA7	I believe that BAM can ensure that assessment data submitted to BAM cannot be changed.
RA8	I believe that BAM can ensure that assessment data submitted to BAM cannot be tempered.
RA9	I believe that BAM can ensure assessment data submitted to BAM cannot be deleted.

(continued)

Items	Statement
Compatibility (COM)	
COM1	I believe that BAM is compatible with the current assessment management requirements.
	I believe that BAM fits the school's existing practice of managing student assessments.
COM2	I believe that BAM fits well with my task of assessment management needs.
	I believe that BAM fits into my behaviour in managing students' assessments.
COM3	I believe that BAM is compatible with assessment management processes.
COM4	I believe that BAM complements my knowledge in managing students' assessments.
COM5	
COM6	
Complexity (CPX)	
CPX1	I believe I have no difficulty using the BAM menus to perform assessment tasks.
CPX2	I believe I have no difficulty working with the BAM.
CPX3	I believe the automation system in BAM is well understood.
CPX4	I believe I find it easy to use the BAM platform.
CPX5	I believe I can interact with the BAM platform without much mental effort.
CPX6	I believe that the BAM platform has a flexible feature.
Perceived Ease of Learn (POEL)	
POEL1	I believe that I can quickly become skilful in learning BAM.
POEL2	I believe that I can easily learn BAM.
POEL3	I believe that I can learn to use BAM quickly.
POEL4	I believe that I can easily remember how to use BAM.
POEL5	I believe that learning to use BAM is very easy.
POEL6	I believe that I will quickly become skilled with BAM.
Teachers' Readiness to Use BAM (RD)	
RD1	I am ready to use BAM in assessment management.
RD2	I predict I will use BAM in assessment management when it is officially launched.
RD3	I will install the BAM platform on my phone once it is officially launched.
RD4	I will recommend that others use BAM once it is officially launched.
RD5	I expect that the Ministry of Education will use BAM in the future.
RD6	I think the Ministry of Education will benefit from using BAM.

Empirical Analysis and Results

The data collection process was conducted between May and July 2024 among post-secondary school teachers in northern Malaysia. Seven hundred and fifty questionnaires were delivered to the chosen teachers through their respective principals via mail or in-person visits using simple random and proportionate stratified random sampling techniques. Accompanying the questionnaire was a letter of permission and a simple guide for conducting the survey provided to the principal, including the procedure for returning the completed questionnaires to the researcher. To account for a low response rate and facilitate data cleaning, the sample size for each state was doubled, and participants could respond either physically or electronically by scanning the QR code on the cover page of the questionnaire form (Brick, 2018; Kloareg & Causeur, 2009). The form was set to accept only one submission per participant to prevent duplicate entries in the digital survey. Of 750 questionnaires, 583 were collected, indicating a response rate of approximately 77.73%. The

collected questionnaires underwent a data refinement procedure to identify and eliminate entries with missing data and outliers. Ultimately, only 514 (68.53%) responses were deemed valid and incorporated into the analysis. This figure significantly surpasses the recommended minimum response rate of 30.0% (Sekaran & Bougie, 2016). This number also meets the rule of ten by Hair et al. (2011) and satisfies the minimum sample size required to employ PLS-SEM analysis.

Measurement Model

All constructs examined in the present study are reflective in nature. Thus, the measurement model was assessed by focusing on construct reliability, convergent validity and discriminant validity (Hair et al., 2017). The assessment of construct reliability, grounded in internal consistency, is determined using α and composite reliability (CR) values, with a specified threshold of 0.70 (Hair et al., 2019). Conversely, the establishment of convergent validity depends on outer loading (indicator reliability) and the Average Variance Extracted (AVE). The prescribed threshold values are set at 0.70 for outer loading and 0.50 for AVE (Hair et al., 2017).

Ultimately, in order to confirm the distinctness of a particular construct from others, discriminant validation was carried out by reviewing cross-loadings, the Fornell-Larker criterion, or the Heterotrait Monotrait Ratio (HTMT). To establish discriminant validity, the outer loadings of the indicators on the corresponding construct must exceed all loadings on other constructs, the square root of AVE (√AVE) should exceed latent variable correlations (Fornell-Larker criterion), or HTMT should be less than 1.0 (Hair et al., 2019; Henseler et al., 2016).

By executing the PLS algorithm on SmartPLS 4.0, it was discovered that all constructs had AVE values greater than 0.5, indicating they passed the cut-off threshold. There was a construct, namely RA, with the second-lowest AVE value (0.637) due to less satisfactory inner loadings for items RA1 and RA7, with loading values of 0.517 and 0.699, respectively. However, when item RA1 was removed, the loading value for RA7 increased to 0.706, a very satisfactory value as it exceeds 0.7 (Hair et al., 2014). Therefore, item RA7 remained, and RA1 was removed, updating the AVE value to 0.688.

Subsequently, an evaluation of the reliability of all the constructs was conducted. The findings indicated that the minimum values for α and CR were 0.877 and 0.902, respectively, suggesting a notable level of internal consistency. Moreover, an assessment of the constructs' validity was carried out by examining convergent and discriminant validity. The investigation illustrated robust convergent validity for each construct, as evidenced by the favourable AVE scores (ranging from 0.661 to 0.897) and factor loadings (ranging from 0.706 to 0.954). The analysis of construct reliability and convergent validity in this study is summarised in Table 2.

Table 2

The Analysis of Measurement Model Content

Construct	Indicator (ITEM)	Factor Loading	α	CR	AVE	Construct Reliability	Convergent Validity
COM	COM1	0.901	0.963	0.970	0.844	Achieved	Achieved
	COM2	0.915					
	COM3	0.935					
	COM4	0.931					
	COM5	0.933					
	COM6	0.896					
CPX	CPX1	0.880	0.952	0.962	0.808	Achieved	Achieved
	CPX2	0.896					
	CPX3	0.893					
	CPX4	0.927					
	CPX5	0.919					
	CPX6	0.878					
PEOL	PEOL1	0.939	0.969	0.975	0.867	Achieved	Achieved
	PEOL2	0.938					
	PEOL3	0.944					
	PEOL4	0.936					
	PEOL5	0.943					
	PEOL6	0.885					
RA	RA2	0.802	0.926	0.939	0.688	Achieved	Achieved
	RA3	0.833					
	RA4	0.888					
	RA5	0.872					
	RA6	0.874					
	RA7	0.706					
	RA8	0.839					
	RA9	0.806					
RD	RD1	0.918	0.965	0.972	0.853	Achieved	Achieved
	RD2	0.943					
	RD3	0.925					
	RD4	0.944					
	RD5	0.903					
	RD6	0.908					

The Fornell-Larcker criterion in SEM helps confirm that constructs are theoretically and empirically distinct and that their indicators accurately measure what they are intended to measure. Based on the Fornell-Larcker criterion, all constructs demonstrate good discriminant validity since the square root of the AVE for each construct is higher than its correlations with other constructs. This suggests that each construct is distinct from the others in the model (see Table 3).

Table 3

Analysis of Fornell-Larcker Criterion

	COM	CPX	PEOL	RA	RD
COM	**0.919**				
CPX	0.736	**0.899**			
PEOL	0.738	0.821	**0.931**		
RA	0.747	0.613	0.603	**0.829**	
RD	0.793	0.733	0.789	0.625	**0.924**

In the final stage, discriminant validity was evaluated by utilising the HTMT criterion as proposed by Franke and Sarstedt (2019). It is recommended that the HTMT values should not exceed 0.85 for the more rigorous standard, while a more flexible standard suggests that they should not surpass 0.90. The data presented in Table 4 illustrates the HTMT analysis, revealing that most constructs demonstrate good discriminant validity, with HTMT values below the stricter threshold of 0.85. However, there are some borderline cases, particularly between CPX and PEOL (0.853), where the HTMT values slightly exceed 0.85 but remain below the lenient criterion of 0.90. This suggests that while these constructs are distinguishable, they are closely related, potentially indicating some overlap. Overall, the constructs are generally distinct as the values are below 1.0 (Henseler, 2017). In conclusion, the validity assessments collectively demonstrate that the measurement items exhibit both validity and reliability.

Table 4

Analysis of Heterotrait Monotrait Ratio

	COM	CPX	INT	PEOL	PU	RA	RD
COM							
CPX	0.768						
PEOL	0.762	0.853	0.797				
RA	0.784	0.649	0.714	0.632	0.709		
RD	0.822	0.763	0.770	0.816	0.849	0.655	

Structural Model and Mediation Analysis

Hypothesis testing for H1 to H3 reveals mixed results. According to Table 5, H1 (RA - RD) is not supported, as its effect is insignificant ($\beta = 0.017$, $p > 0.05$, $f^2 = 0.000$), indicating that RA does not significantly influence RD directly. Conversely, H2 (CPX - RD) is supported with a strong direct effect ($\beta = 0.600$, $p < 0.05$, $f^2 = 0.199$), suggesting that CPX is a critical factor in determining readiness, with a medium effect size. Similarly, H3 (COM - RD) is supported with a significant direct effect ($\beta = 0.428$, $p < 0.05$, $f^2 = 0.238$), highlighting that COM plays an essential role in influencing readiness, also with a medium effect size.

To evaluate the mediation hypotheses, the bootstrapping method recommended by (Preacher & Hayes, 2008) was employed. Significant mediation was determined when the confidence interval did not cross zero. Results showed that COM -> PEOL -> RD ($\beta = 0.213$, $p < 0.05$) and CPX -> PEOL -> RD ($\beta = 0.474$, $p < 0.05$) were significant, with their confidence intervals not crossing zero, supporting

hypotheses H4 and H5. However, the mediation path RA -> PEOL -> RD (β = 0.026, p > 0.05) was not significant, as its confidence interval crossed zero, leading to the rejection of hypothesis H6. Regarding effect sizes (f^2), COM -> PEOL -> RD showed a small effect (f^2 = 0.182), while CPX -> PEOL -> RD demonstrated a medium effect (f^2 = 0.225). In contrast, the effect size for RA -> PEOL -> RD was minimal (f^2 = 0.000), indicating no practical significance.

Table 5

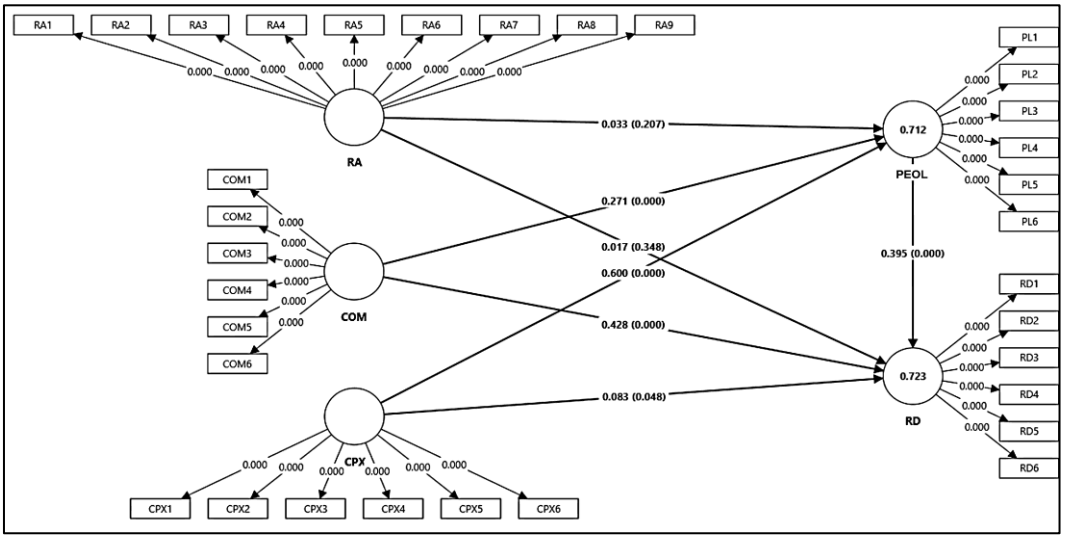
The Result and Hypothesis Testing

Hyp.	Rel.	Std. Beta	Std. Dev.	t-value	p-value	PCI LL	PCI UL	f^2	Supp.
H1	RA – RD	0.017	0.044	0.391	0.348	-0.052	0.091	0.000	No (None)
H2	CPX – RD	0.600	0.050	1.664	0.048	0.002	0.167	0.199	Yes (Medium)
H3	COM - RD	0.428	0.055	7.760	0.000	0.333	0.518	0.238	Yes (Medium)
H4	COM – PEOL –	0.107	0.025	4.202	0.000	0.066	0.150	0.011	Yes (Small)
H5	RD	0.237	0.036	6.637	0.000	0.181	0.299	0.056	Yes (Small)
H6	CPX – PEOL - RD	0.026	0.016	0.802	0.211	-0.013	0.041	0.000	No (none)
	RA – PEOL – RD								

The R^2 coefficient serves as an indicator of the predictive precision of a model and is determined by squaring the correlation between observed and predicted outcomes of a particular independent variable. Values of R^2 amounting to 0.75, 0.50, and 0.25 are classified as significant, moderate and low, correspondingly (Hair et al., 2017). Figure 3 displays varying levels of explanatory power, as indicated by their respective R^2 values. The construct PEOL has an R^2 of 0.713, which is classified as moderate, meaning that the construct explains 71.3% of the variance. RD falls into the same range, with R^2 values of 0.623, meaning that the construct explains 62.3% of the variance.

Figure 3

The Structural Model



Structural Model and Mediation Analysis

Hair et al. (2011) proposed PLSpredict, a holdout sample-based procedure that generates case-level predictions on an item or a construct level using PLSpredict with a 10-fold procedure to examine predictive relevance. According to them, strong predictive power is indicated when all item differences (PLS-LM) are lower, while lack of predictive relevance is suggested when all are higher; moderate predictive power is inferred when the majority is lower, and low predictive power when the minority is lower. Analysis of Table 6 reveals that most PLS-SEM RMSE values are lower than those of LM RMSE, with positive PLS-LM differences for most RD items and some PEOL items. This suggests that the model demonstrates moderate predictive power, as most item differences favour PLS-SEM while a few items show higher errors than LM. However, weaker predictive performance is observed for items such as PEOL6 and RD5, which may benefit from further refinement.

Table 6

Result of PLSpredic

Item	Q^2predict	PLS-SEM_RMSE	LM_RMSE	PLS-LM
PEOL1	0.665	0.657	0.669	-0.012
PEOL2	0.614	0.713	0.727	-0.014
PEOL3	0.619	0.718	0.735	-0.017
PEOL4	0.611	0.715	0.723	-0.008
PEOL5	0.634	0.693	0.700	-0.007
PEOL6	0.529	0.821	0.823	-0.002
RD1	0.549	0.856	0.826	0.030
RD2	0.550	0.845	0.820	0.025
RD3	0.523	0.914	0.892	0.022
RD4	0.546	0.854	0.839	0.015
RD5	0.478	0.904	0.915	-0.011
RD6	0.520	0.830	0.819	0.011

DISCUSSIONS

This paper investigates whether PEOL influences BAM's characteristics (RA, COM, CPX) on RD. The findings show that, among the three BAM characteristics, PEOL does not mediate the relationship between RA and RD, while the other two characteristics, CPX and COM, do. Since the direct effect between RA and RD was also insignificant, this implies that RA does not have a meaningful influence on RD, either directly or indirectly, through PEOL. The lack of significant effects (both direct and indirect) suggests that RA, in this context, may not be a strong determinant of BAM's readiness. Teachers might not perceive the unique benefits of adopting BC technology for project paper management as especially "advantageous" regarding readiness. Instead, factors like COM and CPX seem more influential in shaping users' perceptions of BAM readiness.

Moreover, the insignificant role of RA in its direct and indirect effects warrants a re-evaluation of RA's role. It could be that RA is less relevant to the perception of innovation readiness in this context. Therefore, interventions aimed at improving CPX and COM might benefit more from addressing these factors than from emphasising the superiority of the BAM. Besides, this result might also lead to theoretical adjustments, suggesting that RA may not be essential in contexts where users prioritise the system's complexity and ease of integration with existing practices over perceived benefits.

It also implies that ease of learning is not important in shaping how RA impacts teachers' readiness to adopt innovation in educational assessment management. Teachers' perceptions of the advantages of BAM, such as improved transparency, security, and reliability, do not depend on how easy the system is to learn. In contrast, their perceptions of BAM's COM and CPX depend on ease of learning. Therefore, even if the BAM is advantageous in theory, teachers do not feel ready to adopt it because they are not motivated to overcome the learning curve. Understanding BAM's superiority means little to teachers, as Malaysian teachers already use multiple systems for their tasks. However, it may change their perception if the system provides significant support, especially in easing their core tasks.

In addition, the insignificance of RA may be influenced by a lack of familiarity or limited exposure to blockchain-based applications in the educational setting. As blockchain is still considered a relatively novel technology in Malaysia's school system, teachers may not fully understand or relate to its benefits. This unfamiliarity can lead to underappreciation of its relative advantage, thus weakening its impact on readiness. Moreover, contextual differences such as workload, digital infrastructure limitations, and training availability may overshadow the perceived benefits of BAM, making RA less influential than practical concerns represented in other constructs like COM and CPX.

Unlike RA, the mediation effect of PEOL between COM and PU is significant. It indicates that when teachers perceive the BAM system as compatible with their existing project paper management practice, they are likelier to learn it. For example, if the BAM aligns well with familiar processes in managing project papers, teachers will likely find it easier to navigate as they do not need to adapt to a new way of working. This shows that for an innovation to be ready to be adopted by teachers, it must integrate seamlessly with their existing workflows. Similarly, CPX significantly influences teachers' perceptions of BAM readiness primarily through their ease in learning it. High complexity can be a barrier to adoption, making a system harder to learn. When CPX is perceived as manageable by ease of learning, users are more likely to find the system useful. If the learning experience is simplified, even a complex system can be adopted because users feel they can manage it effectively.

These findings also significantly contribute to the literature by emphasising the role of PEOL as a mediator between RA, COM, CPX, and RD in the context of BAM adoption. Unlike PEOU, which has been extensively studied (Desi & Zaitul, 2021; Fearnley & Amora, 2020), PEOL explicitly addresses the ease with which users can learn and adapt to a new system. Indeed, it has been considered a vital usability dimension for educational innovations, directly impacting user readiness (Cen et al., 2023). Although some prior studies, such as by X. Wang et al. (2022) have demonstrated the significant role of COM in enhancing both ease of use and usefulness, their works mainly focused on the direct relationships between those factors. On the contrary, this study extends those previous works further by empirically proving how PEOL mediates the relationship, thus providing a clearer explanation of how COM, CPX and RD are connected in an educational assessment setting.

In sum, by focusing on PEOL, the study emphasises the importance of designing BC-based solutions that enable natural assessment experiences, ensuring that teachers can quickly adapt to the system without significant cognitive challenges. This supports the adoption of BAM and addresses practical adoption barriers, filling a gap in the current literature that often overlooks PEOL as a distinct and influential construct in initiating educational technology adoption.

CONCLUSION

This study provides the groundwork for future research into BC-based assessment readiness. However, the generalizability of the study's results is subject to certain limitations, which present opportunities for further exploration. This study only addresses BAM readiness among post-secondary school teachers. Since SBA is set to be further enhanced and full exam-based assessment will no longer be an option in Malaysia's educational assessment system, follow-up research could explore the factors that trigger interest among teachers who implement different types of SBA. For example, the perceptions of teachers who teach SBA for primary school may differ from those who teach secondary school and certainly differ from those involved in the current study. Future studies could also investigate the role of other influencing factors, such as cultural and institutional differences, in shaping teachers' readiness to adopt blockchain-based systems. Comparative research across different regions or countries would offer valuable insights into how varying educational policies and technological infrastructure impact adoption readiness. Longitudinal studies tracking teachers' readiness over time could provide a deeper understanding of how exposure, training, and systemic changes influence blockchain integration in education. Finally, exploring the perspectives of other stakeholders, such as students, parents, and policymakers, would create a holistic understanding of the ecosystem required to successfully implement BC-based solutions in education.

From a practical standpoint, educational institutions and policymakers should consider developing targeted training programs to improve teachers' familiarity and confidence with blockchain technology. These programs should focus not only on technical skills but also on demonstrating the relevance and benefits of blockchain in simplifying assessment tasks. In terms of policy, integrating blockchain-readiness modules into teacher professional development frameworks could foster a more supportive environment for innovation adoption. Providing incentives, such as certification, digital infrastructure support, or time allowances for system training, may further encourage teacher participation. Moreover, aligning blockchain-based tools with existing educational workflows and reducing system complexity could enhance perceived compatibility, which this study found to be a critical driver of readiness. By addressing these practical and policy aspects, implementing BC-based solutions in education can be more sustainable and teacher-friendly.

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