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Modeling blockchain technology in assessment management: the initial readiness investigation

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ABSTRACT

The implementation of the school-based assessment (SBA) came with a system as part of the effort to reduce the workload of teachers in managing the SBA. However, a traditional system is costly and heavily centralized, frequently leading to impediments, delays, irregularities and may even create opportunities for dishonest activities. To enhance the existing traditional system, integrating emerging blockchain technology (BC) is proposed. Given the challenges, complaints, and rejection faced by traditional assessment management systems, this paper presents a conceptual framework based on the technology acceptance model (TAM) and diffusion of innovation (DOI) to examine pre-university teachers' perception of implementation and readiness to adopt BC-based project paper management (BPPM) which is subsequently verified through a qualitative study. This study employs a process that consists of three main steps: a thorough review of existing literature, thematic analysis, and the process of gathering and determining readiness factors. Teachers' perspectives were successfully gathered from 59 pre-university teachers by posting semi-structured questions in a Telegram group of Malaysian pre-university teachers. The study found that most pre-university teachers support the BPPM implementation with the condition that the system can address two primary concerns: server scalability and confidentiality issues. The effectiveness of BPPM implementation depends on its capacity to meet user needs and expectations while delivering clear benefits, along with superiority compared with existing systems.

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1. INTRODUCTION

One significant revolution in educational assessment was the integration of school-based assessment (SBA), aiming to reduce reliance on centralized exams and assess students more comprehensively. SBA involves continuous assessments by teachers, emphasizing critical thinking, problem-solving, and research skills [1]. It promotes student-centered learning, moving away from high-stakes exams to continuous evaluation [2]. Despite its benefits, SBA faces challenges like centralized management issues, lack of teacher proficiency, and potential errors [3]. Technology integration could enhance SBA management, leveraging advancements in assessment data analysis, storage, and retrieval. The shift towards digital platforms and

e-portfolios reflects a broader trend towards technology-driven assessment, although with security and accuracy challenges [4]. Seizing advantageous opportunities and taking appropriate actions to bridge these gaps hold the potential to accelerate the adoption of BC in education in general [5]. Prior to that, in order to prevent the replication of past rejection encountered by educational systems when implementing traditional school-based assessment management systems, it becomes crucial to undertake preliminary readiness research. Thus, this paper aims to develop a conceptual framework to predict the factors influencing teachers' readiness to adopt the blockchain-based project paper management (BPPM).

2. LITERATURE REVIEW

Generally, blockchain technology (BC) is a decentralized cryptographic ledger where data is digitally recorded in interconnected blocks to form an immutable chain. This allows the information to be shared and accessed by individuals who possess the necessary permissions [6]. Generally, there are two different kinds of network sharing, namely centralized and decentralized. Centralized sharing involves data being sent in one direction from a central source. However, security is a concern because if the central source is compromised, all users are affected because all the assessment data is stored on a single server [1].

On the other hand, decentralized BC-based sharing allows for the sharing of complete data, where teachers can exchange information without relying on a central authority who controls the server. It is a peer-to-peer approach that refers to a decentralized networking model where participants in the network, called peers (educational stakeholders–accordingly fit by education authority), can directly interact and exchange resources with one another without relying on a central authority. This is commonly seen in BC, which ensures secure data transfer and prevents misuse [7]. This decentralized structure offers benefits like scalability, fault tolerance, and protection against single points of failure [8]. Most importantly, BC operates in a distributed and decentralized network of computers (nodes) that work together to uphold and validate the accuracy of the data. This decentralized framework removes the need for dependence on a sole central server, thereby minimizing the likelihood of server jams or failures [9].

Within the realm of educational assessment management, numerous scholars have devoted their efforts developing models and prototypes that incorporate BC. However, most of these models primarily concentrate on model development, experimental implementation, and drawing conclusions regarding the practical aspects and potential benefits they offer. Exploration of the readiness to utilize these models has yet to be undertaken. Besides, 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 [10]. 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 project paper management, remains limited [11].

Scholars have employed various technology readiness theories over the past few decades, including the technology acceptance model (TAM), unified theory of acceptance and use of technology (UTAUT), theory of planned behavior (TPB), diffusion of innovation (DOI) and technology readiness index (TRI). Previous study [12] highlighted the narrow perspective of TAM, UTAUT, and related models in understanding the diffusion and use of technology. These models adopt a perspective from social psychology that centers on individual users. They presume a direct causal impact of readiness on actual behavior. The predictors in these models mainly affect usage through usage intention, ignoring the broader socio-technical aspects encompassing technology, organization, and society components. Despite their significant contribution to current knowledge, TAM and UTAUT have been criticized for reaching their top ceiling [13]. According to this perspective, it is crucial to take a broader approach that considers both the technical aspects and the related issues. While TAM primarily focuses on system use, it can provide enhanced predictive power with the inclusion of various supports for extensions, developments, and modifications [14], [15].

Based on the consideration, this model's theoretical orientation utilized the theory of TAM in combination with DOI to predict teachers' readiness to use new technologies like BPPM. Although TAM solely centers on system use, it remains a powerful predictive tool that can be extended, developed, and modified to provide even greater insight into user perception of an innovation [15]. The TAM model has been expanded in a number of ways, including by incorporating external variables to align with the context of the study [16], [17]. These alterations have the prospect of enhancing the model's predictive power and can be adapted to particular situations and technology, offering deeper insights into user perception. The model has also been developed to meet the three basic criteria (parsimony, verifiability, and generalizability) for analyzing a complex system like BC [18].

3. CONCEPTUAL MODEL

The study's conceptual model, illustrated in Figure 1 is generally derived from the DOI and TAM. This model consists of eight interconnected factors that influence BPPM readiness among pre-university teachers. It proposes that two DOI constructs, namely relative advantage (RA) and compatibility (COM), will significantly impact the major TAM variables, whereas cardiopulmonary exercise test (CPX) will negatively affect the TAM variables. Besides, the TAM factors of PEOU and PU are expected to correlate positively with the initial trust (INT) of the BPPM. At a deeper level, the study suggests that INT may serve as a mediator between the TAM variables and teachers' readiness to embrace BPPM. Finally, it is anticipated that workload (WL) will moderate the impact of INT on the research target variable.

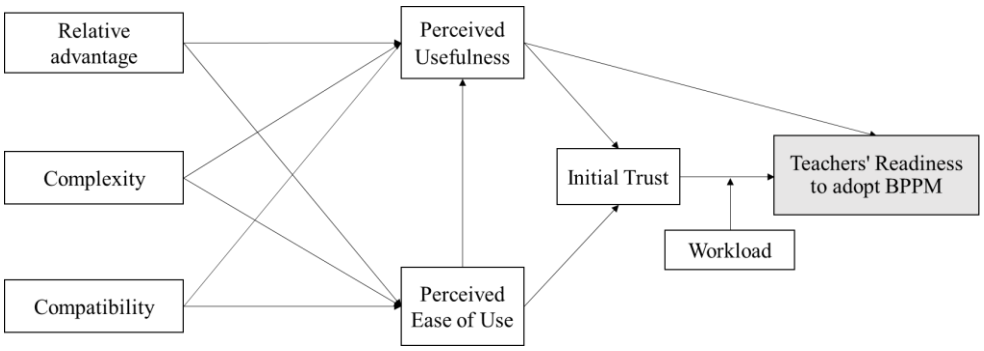

Figure 1. The conceptual framework of the BPPM readiness model

4. METHOD

Similar to numerous previous researches, this project emerged not only from recognized gaps in existing literature but also from subjects that initiated interest and sparked curiosity. Teachers' involvement in teaching and training, along with reflection on teachers' intellectual, experience and current WL in educational settings, contributed to the development of this study. This process consists of three main steps. Initially, a thorough review of existing literature on factors related to blockchain adoption in education was conducted. The second step involved using thematic analysis to classify, identify, and categorize readiness factors. In the final step, the primary factors influencing pre-university teachers' readiness to adopt BPPM were gathered and determined. Subsequent sections will provide detailed explanations of the approach to collecting data, the study's sample, and the technique employed for data analysis.

4.1. Data collection method

In this study, researchers used a qualitative research method called semi-structured questions posted in a Telegram group of Malaysian pre-university teachers to obtain their views and concerns about implementing BPPM. This method was chosen to understand how BPPM can be adopted from different perspectives, which is hard to measure with numbers [19]. Qualitative research is a good way to dig deep into what teachers think and feel, seeing their unique viewpoints rather than just looking at facts [20]. It helped the researchers connect with key people like pre-university teachers who directly interact with the whole education system. Using this approach, the researchers gained a better understanding of the factors influencing pre-university teachers' readiness to adopt BPPM. Such information is crucial for answering research questions. The questions for this study were formulated in alignment with the research goals. The question consisted of one main primary, as the following: "*I seek the perspectives of fellow teachers on the implementation of the pre-university project paper under a system known as the blockchain-based project paper management (BPPM). Specifically, what factors would make teachers willing to adopt this system in student project paper assessment activities?*"

Three experts verified the question to ensure it had good face and content validity. These experts included domain or subject matter experts from both academia and businesses, individuals proficient in the construct being studied and those familiar with the target population for whom the instrument would be used [21]. In this study, the three experts consist of an academician specializing in technology adoption, a senior pre-university teacher directly involved in managing project papers for pre-university students and an officer of educational technology department from the district education office.

4.2. Context of the study

As this study focuses on understanding the perceptions and practices of a particular group of pre-university teachers, the qualitative approach of ethnography is ideal. This method enables researchers to explore behavior patterns and practices deeply within specific groups; and minimum sample size of 30 to 50 respondents is recommended [22], [23]. The question has been posted in the Telegram group of 442 pre-university teachers and this study has successfully extracted views from 59 teachers in the group. Telegram application is becoming popular in education because it has several features that facilitate the student-teacher feedback process and encourage educational stakeholders' engagement. Teachers also use the app as one of the learning platforms to facilitate online learning [24]. In fact, the Telegram application has recently become familiar among government agencies in Malaysia. Additionally, it has been empirically observed that the target population consists of individuals who possess similar characteristics because they are subjected to the same education policies implemented by the education authority. Teachers often exhibit homogeneity in a population due to factors such as educational requirements, standardized training, and shared professional development [25]. It is worth noting that the majority of Malaysian teachers are trained and recruited through a standardized procedure overseen by the ministry of education [26]. These factors contribute to a common knowledge base and instructional practices among teachers, resulting in similarities within the profession. Therefore, teachers' view from the platform is highly useful to achieve the objective of the study.

4.3. Data analysis

The qualitative content analysis method was applied to examine the open-ended question about feedback and recommendations regarding the BPPM implementation strategy. A total of 59 responses were collected from 59 pre-university teachers and categorized into four themes based on their provided input. The responses are assigned with codes based on implementation suitability. Those not appropriate for implementation are coded as 1, while those suitable for implementation are coded as 2. Additionally, views that are suitable for implementation but only if there are no server issues are coded as 3, and only in the absence of confidentiality issues are coded as 4.

Then, the comment and feedback are analyzed using a thematic analysis approach. Thematic analysis is employed to categorize the data and formulate corresponding themes to address the research questions in this study. This thematic analysis begins with the initial stage of data analysis and is followed by an advanced process, which involves entering the code construction phase and concludes with the data presentation section in the form of matrices or tables, networks, concept maps, flowcharts, diagrams, to facilitate readers in examining the obtained research findings. Additionally, this study also employs three types of coding, namely i) open coding; ii) axial coding; and iii) selective coding to obtain research findings that are aligned with the study's theory at the end of the data analysis process [27]. These three types of codes are also referred to as descriptive coding, which aims to gather all codes initially, then through the coding process based on topics, and finally synthesize to form a concept or theme, namely analytic coding [28].

5. RESULTS AND DISCUSSION

The results are presented in two approaches according to the study's objective. First, the findings on pre-university teachers' opinions of the suitability of BPPM implementation are presented. In this section, teachers' nuanced viewpoints on the applicability and effectiveness of BPPM in their project paper management are thoroughly investigated. Second, the same technique is used to present the findings regarding the factors impacting teachers' readiness to use BPPM. This section goes further into the issues that influence teachers' willingness and ability to incorporate BPPM into their project management practices.

5.1. Suitability of BPPM implementation

Table 1 presents the pre-university teachers' perception of the suitability of BPPM in assessment practice. Their feedback included teachers who agreed with other teachers' comments in their responses. As a result, a total of 59 teachers responded to the question. However, only 44 responses were considered for this study to align with the objective and subsequently categorized into four themes based on their responses. The findings show that the majority of pre-university teachers provided favorable feedback on the BPPM Implementation. Overall, the pre-university teachers agreed that BPPM is practical and should be implemented in managing pre-university assessment data (25%). Apart from that, nineteen respondents (43%) expressed that the BPPM implementation is suitable if the system has no confidentiality and server issue (11%). This implies that most pre-university teachers support the BPPM implementation with the condition that the system can address two primary concerns: server scalability and confidentiality issues. This result supports the finding of previous study where teachers' perceptions of project paper management practices slightly varied depending on the subject or domain they taught [29].

Table 1. Pre-university teachers' perception of the suitability of BPPM implementation

Theme	Code	*f*	%
Not suitable to be implemented	1	9	20
Suitable to be implemented	2	11	25
Suitable to be implemented if the system has no server issue	3	5	11
Suitable to be implemented if the system has no confidentiality issue	4	19	43
	Total	44	100

5.2. Factor influencing pre-university teachers to adopt BPPM

This segment includes thematic discoveries that contribute to the identification of the primary elements influencing BPPM readiness within the pre-university program. Pre-university teachers indicated crucial aspects that necessitate attention and consideration for BPPM implementation, impacting the embrace of innovation. Most pre-university professionals agreed with the feedback and recommendations that the BPPM readiness model, developed in accordance with the DOI and TAM integration, is acceptable for examining the elements that affect teachers' readiness to employ blockchain in educational evaluation. Those elements are discussed in sub-section.

5.2.1. Relative advantage

Pre-university teachers highlight that the relative advantages of the system, like its capability to solve server issues, effective evidence disposal procedures and promised immutability of the assessment data, play crucial roles in adopting technology in education. However, in line with the study [30], which security and confidentiality of assessment environment seem to be the major priority among teachers for successfully implementing BPPM. Teachers provided insights on the advancements made by teenagers in ICT, particularly in cloud-based and blockchain technologies. One teacher acknowledged this progress, highlighting the importance of system reliability, uptime, and speed. Another participant emphasized the benefits of the system, underlining the need for secure assessment information. However, they cautioned against open access, expressing concerns about potential disputes among teachers from different regions during student assessment [30]. The variability in scoring by different teachers was also mentioned. To address this, they suggested restricting access to scoring and evidence to specific parties.

5.2.2. Compatibility

Participants emphasized the importance of ensuring the BPPM suitability for all subjects and the need for compatibility between the system and the existing regulations. This result builds on the finding [31], which demonstrated that teachers' opinions of project paper implementation differed slightly in accordance with the subject or area they taught. A teacher disagrees and raises concerns about its impact on the WL for the history subject [29]. They stressed that the current confidential nature of assessment scores, managed by the education authority, is maintained without issues. The teacher noted that due to the sensitive nature of exam scores, access is limited to authorized individuals, ensuring confidentiality. Furthermore, another teacher highlighted the importance of following the rules and regulations, specifically regarding the disposal of evidence. They pointed out that evidence is safeguarded under the official secrets act (OSA) regulations, necessitating a comprehensive procedure from initiation to disposal. In this regard, the educational authority should be the primary reference for all matters related to this process. It was highlighted that while the implementation is possible, it must align with current assessment needs and be in line with security standards. It is emphasized by a teacher that any system should address existing requirements and potential vulnerabilities that could compromise both educational ethics and confidentiality [32].

5.2.3. Complexity

Teachers emphasized that the issue with the server is a significant challenge, causing disruptions and adding complexity to the BPPM system. A teacher emphasized that BPMM could create pressure for all teachers, particularly for those who are less familiar with technology [5]. The pressure arises from the need to review student work, handle various data, and complete students' assessment. This feedback is supported by a participant who highlights that unfamiliarity of a person with certain technology could lead to rejection because of low understanding. The teacher is not comfortable spending extended periods on the laptop as they also need to manually count every word in student essays for accuracy. The teacher stressed that the current manual method is more comfortable and convenient. Additionally, a teacher still believes in the traditional way because of unfamiliarity with blockchain technology [33]. The teacher believes using pen and paper is the best approach because there's a risk of confidential material leaking through digital means. The teacher emphasized that for marking purposes, the option to upload materials individually is already available. However, they personally prefer the traditional method, especially considering their age. Using pen

and paper enables straightforward student responses and offers the advantage of authentic writing, along with the ability to track changes through printed and edited materials.

Besides, it is also emphasized that the BPPM must be designed to simplify teachers' assessment tasks. If there are any problems, the app should provide instant solutions so teachers can solve them. A teacher suggests that server challenges remain a persistent issue, though efforts should have been made to address it by now [34]. The teacher added that, currently, e-submission is employed for coursework marks, with the primary challenge being server congestion. While recognizing the importance of embracing innovation, they highlighted the necessity for comprehensive research, development, and support for teachers' self-troubleshooting in this implementation. They emphasized the critical step of establishing a functional system before proceeding further.

5.2.4. Usefulness

The primary focus of teachers' views revolved around the efficiency and benefits of the BPPM. This serves as a practical approach to collect their insights on the key elements influencing BPPM readiness within the pre-university program. The primary themes within this scope revolved around the potential performance improvements resulting from the benefits of this innovation. Teachers perceive the BPPM to have a dual impact, namely ubiquity and the promotion of paperless practices [35]. They believe that the introduction of the BPPM would lead to its widespread presence and accessibility across various contexts. Simultaneously, teachers anticipate that the BPPM would initiate a move from traditional paper-based methods to a more environmentally friendly and efficient approach to managing educational processes. Acknowledging the advantages of the proposed innovation, a teacher highlighted that it offers paperless solutions, high accessibility, the convenience of reviewing work at any location and time, seamless interaction between students and teachers, and simplified error correction. This teacher's perspective can be taken into consideration, indicating that the BPPM should offer benefits to improve the efficiency of teachers' assessment tasks.

5.2.5. Ease of use

The user-friendliness of a BPPM is influenced by several key factors that shape its overall accessibility and effectiveness. One fundamental factor is the level of technological understanding among users [17]. If the system's interface and functions are designed in a way that aligns with users' technological proficiency, it enhances their ability to navigate and utilize the system efficiently [17]. However, in line with previous research [29], that a respondent hastily jumped to the conclusion that the BPPM might increase teachers' workload, even though the teacher has not yet experienced how the system operates. Furthermore, ease of access is also a pivotal element for the BPPM [36]. A user-friendly BPPM should enable seamless access from various devices and locations, ensuring teachers and administrators can interact with the system effortlessly. This accessibility contributes to the system's friendliness by accommodating diverse user preferences and work environments. A teacher replied, Additionally, the inclusion of rubric-friendly functionalities can significantly impact the friendliness of the BPPM. If the system incorporates adaptable and customizable rubrics, educators can align assessment criteria with their specific needs, making the process smoother and more tailored to individual contexts.

5.2.6. Trust

According to most pre-university teachers, they mostly stress that top priority should be given to maintaining confidentiality during assessments, which must be carried out in a secure environment. While some teachers are comfortable implementing BPPM as a new technology, overlooking security features would be a significant error [30]. Teachers stressed that candidate scores are confidential. Evidence needs to be kept confidential, and it is wondering if the system where all parties can access the information. On the other hand, teachers seem to have a positive perception, especially if this innovation can easily overcome this issue. Underlining the viability of the system, the teacher stressed the importance of implementing viable security measures to limit access solely to relevant teachers and students. They suggested seeking input from authority officers to effectively overcome worries related to possible score and material leaks, preventing potential setbacks in the future. Furthermore, a key factor in building trust and encouraging students to use BPPM is making sure that the assessment activities are efficient, effective, and transparent within a secure environment. It is important for the system to be secure and free from threats.

5.2.7. Workload

Thematically, two primary issues were extracted from teachers' comments and recommendations, both of which are related to workload. Teaching interruptions and server failures were identified as factors influencing teachers' job pace [29]. Teachers disagree because not all assessment activities are suitable for BPPM implementation. It slows down the review process for students. Teachers prefer face-to-face

interactions as students grasp the material better. This system just adds to teachers' workload and time. Furthermore, server failures also contribute to the teachers' workload as they have to spend more time on assessment activities. The second issue is that BPPM could potentially become an additional task, as teachers see the innovation possibly overlapping with their existing responsibilities. In these cases, teachers view BPPM as an extra workload if the system cannot deliver effectively.

5.3. Research implication

This research contributes additional worth to the current body of knowledge by highlighting the primary factors that hinder the effective integration of innovation within the educational assessment. The study offers valuable real-world perception of the implementation of BPPM in pre-university program in Malaysia. The challenges faced when adopting BC as new technology, especially in education, encompass various factors, including benefits such as advantages and superiority offered by the technology, technical aspects of the systems such as users' efforts to utilize it, and the system's complexity. Hence, the conclusions drawn from this finding provide valuable recommendations for researchers to investigate further using a quantitative approach.

6. CONCLUSION

The paper aims to provide insights into the validation of the newly developed conceptual model, which is built upon the DOI and TAM, by involving pre-university teachers in their readiness to adopt BPPM for assessment activities. This is valuable for researchers interested in exploring the elements that contribute to the teacher's readiness to adopt blockchain technology in educational assessment using different approaches within different contexts and among various groups of people. To sum up, the study's objective is to address an existing research gap. To the best of the researcher's knowledge, no previous studies have outlined the factors that lead to adopting a blockchain-based system in educational assessment. The effectiveness of BPPM implementation depends on its capacity to meet user needs and expectations while delivering clear benefits, along with superiority compared with existing systems such as the school-based assessment and management system (SPPBS). Consequently, the study's results will offer insights for policymakers, particularly the education authority, to confirm the general rule of blockchain technology in education.

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