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MEASURING PERCEIVED USABILITY OF ARTIFICIAL INTELLIGENCE-BASED QUIZZES IN A VIRTUAL MUSEUM

Shinta Puspasari[1*]; Rendra Gustriansyah[2]; Dwi Asa Verano[3]; Ahmad Sanmorino[4]; Hartini[5]; Ermatita[6]

Department of Informatics [1,2,3]
Department of Information System [4]
Universitas Indo Global Mandiri, Palembang, Indonesia[1,2,3,4]
https://uigm.ac.id/[1,2,3,4]
shinta@uigm.ac.id[1*], rendra@uigm.ac.id[2], dwiasa@uigm.ac.id[3] , sanmorino@uigm.ac.id[4]

Department Computer Engineering[5]
Universitas SIGMA, Palembang, Indonesia[5]
https://sigma.ac.id/[5]
arpi.hartini.my@gmail.com[5]

Department Computer Scinece[6]
Universitas Sriwijaya, Indralaya, Indonesia[6]
https://unsri.ac.id/[6]
ermatita@unsri.ac.id[6]

(*) Corresponding Author
(Responsible for the Quality of Paper Content)

Abstract—*The transformation of modern museums through digital technology offers added value to visitors, especially in the context of education. Virtual museums, in particular, complement physical museums by providing accessibility and enhancing the learning experience. The SMBII virtual museum includes an AI-based quizzes feature designed to assess the knowledge level of visitors regarding the museum's history and collections as an educational feature. In addition to physical museums, virtual museums offer convenience and enrich the learning process for visitors. The quizzes adapts its questions based on the visitor's profile, leveraging AI to tailor content and maximize learning outcomes. This study aims to compare the effectiveness of two widely used usability metrics—System Usability Scale (SUS) and Usability Metric for User Experience (UMUX)—in evaluating the usability of the AI-driven quiz feature within the SMBII virtual museum. The study specifically seeks to determine whether there are significant differences between SUS and UMUX in measuring user perceptions of the quiz's usability. The primary respondents of this study were students, who represent the museum's target audience for educational purposes. Hypothesis testing results show no significant difference between the SUS and UMUX scores (P > 0.05), indicating that both metrics offer similar evaluations of usability. Based on these findings, the study recommends the use of UMUX over SUS for future usability assessments in virtual museum systems, as UMUX is more time-efficient without compromising accuracy. This research contributes to advancing the understanding of usability testing methods for AI-based educational features in virtual museum environments.*

Keywords: *artificial intelligent, , SUS, UMUX, usability, virtual museum*

Intisari— *Transformasi museum modern melalui teknologi digital menawarkan nilai tambah bagi pengunjung, terutama dalam konteks pendidikan. Museum virtual melengkapi keberadaan museum fisik dengan menyediakan aksesibilitas dan meningkatkan pengalaman belajar. Museum virtual SMBII mencakup fitur kuis berbasis AI yang dirancang untuk menilai tingkat pengetahuan pengunjung mengenai sejarah dan*

koleksi museum sebagai fitur pendidikan. Dibandingkan museum fisik, museum virtual menawarkan kemudahan dan memperkaya proses pembelajaran bagi pengunjung. Kuis mengadaptasi pertanyaannya berdasarkan profil pengunjung, memanfaatkan AI untuk menyesuaikan konten dan memaksimalkan hasil pembelajaran. Studi ini bertujuan untuk membandingkan efektivitas dua metrik kegunaan yang banyak digunakan— System Usability Scale (SUS) dan Usability Metric for User Experience (UMUX)—dalam mengevaluasi kegunaan fitur kuis berbasis AI dalam museum virtual SMBII. Studi ini secara khusus berupaya untuk menentukan apakah ada perbedaan yang signifikan antara SUS dan UMUX dalam mengukur persepsi pengguna terhadap kegunaan kuis. Responden utama studi ini adalah mahasiswa, yang mewakili target audiens museum untuk tujuan pendidikan. Hasil pengujian hipotesis tidak menunjukkan perbedaan signifikan antara skor SUS dan UMUX (P > 0,05), yang menunjukkan bahwa kedua metode tersebut menawarkan evaluasi kegunaan yang serupa. Berdasarkan temuan ini, penelitian ini merekomendasikan penggunaan UMUX daripada SUS untuk penilaian kegunaan di masa mendatang dalam sistem museum virtual, karena UMUX lebih hemat waktu tanpa mengurangi keakuratan. Penelitian ini berkontribusi untuk memajukan pemahaman metode pengujian kegunaan untuk fitur pendidikan berbasis AI dalam lingkungan museum virtual

***Kata Kunci**: kecerdasan buatan, SUS, UMUX, kegunaan, museum virtual.*

INTRODUCTION

The effective usage of applications is an indicator of software development success. A virtual museum developed to support the performance of physical museums has proven its effectiveness, especially during the COVID-19 pandemic when physical museums are closed for public activities [1]. Even though visitors cannot directly access the museum collection, the presence of digital technology supports the museum's tasks, including augmented reality applications [2], games, quizzes, and virtual tours [3], which can provide different experiences for visitors and increase museum visitors' knowledge [4]. Museum visitors have various backgrounds which allow for a digital divide in application use. Gen-Z visitors with an educational background as students find it easier to accept and utilize applications because they are familiar with digital technology [5]. Different backgrounds can have an impact on user acceptance of virtual museum applications which results in users not wanting to use the application to explore the museum and for learning purposes at the museum. The task of museum education is to introduce the history and collections of museums to increase visitor knowledge and lead to the preservation of historical and cultural values through museum collections [6].

In the virtual museum application, the quiz feature was developed as a learning functionality for users. Museum visitors can find out their level of knowledge regarding the history and collections of the museum by accessing this feature [7]. However, if the questions given repeatedly by the application do not match the user's profile and are less interesting, it can cause boredom and a minimal increase in user knowledge. [8]. Therefore, an AI-based quiz feature was developed in this research and its usefulness was measured according to user perceptions as virtual museum visitors. Its usability is necessary to be measured for the effectiveness of a museum digital transformation indicator implementing AI-based quizzes feature such as SMBII museum. During the pandemic, SMBII museum was closed for public physically that impacts its educational role performance. For overcome this issue, SMBII museum has implemented a web-based digital technology for museum digitalization. The innovative AI based SBMII virtual museum was developed for pandemic recovery strategy. The virtual museum provides information and access for visitors to the museum collection as if they were in the physical museum. This strategy has been proven effective for improving SMBII museum performance during the pandemic [1] also accepted and improved visitor experience measured using technology acceptance (TAM) model [9]. AI provides automated learning capabilities by applications through the application of appropriate algorithms to a problem [10]. In the quizzes feature, AI algorithm is used to cluster profiles of users or virtual museum visitors and based on these results, questions are presented to users that are effective in increasing knowledge after learning through this feature [11].

System usability needs to be measured for it may impact the AI-quizzes feature usage by museum visitors and museum digital transformation success. Several methods have been developed to measure the usability of software [12]. Previous studies have used the TAM model instrument to measure user experience with usability as one of its indicators. Too many indicators are one of the problems with the TAM instrument. If you only want to measure the

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usability factor of a system, then it is necessary to study a minimalist, but effective instrument and it is recommended for further research. Two methods that have similarities are SUS and UMUX. SUS has been proven to have high reliability, validity, and sensitivity. This questionnaire evaluates ease of use and user satisfaction to improve intuitiveness and accessibility. SUS is a powerful tool for evaluating usability. Meanwhile, UMUX is an extraction of the SUS utility[13]. For evaluating the effectiveness of both models in measuring usability of AI- based quizzes feature in supporting SMBII museum educational role, then this study will compare the SUS and UMUX methods with the consideration that SUS has been widely applied and its effectiveness has been tested, UMUX has similar questions in the questionnaire instrument to SUS but with fewer questions than SUS [14]. SUS and UMUX have been proven its effectiveness for measuring system usability in many studies but have never been done for measuring quizzes feature in a virtual museum. In this study, the performance of the two methods will be evaluated to measure the usability of the SMBII virtual museum's AI-based quizzes feature and recommendations for which method is better will be given as a conclusion at the end of this article.

MATERIALS AND METHODS

Measuring the perceived usability of users of the AI-based quiz feature in virtual museum applications needs to be carried out using appropriate methods so that it is effective and also makes it easy for users to fill out the measurement instrument. The SUS and UMUX methods have instruments in the form of questionnaires containing some questions that are similar in assessing the perception of application users but with a different number of questions. Both methods have been proven effective for measuring perceived usability and each has advantages and disadvantages. SUS and UMUX have been proven effective in measuring system usability of many applications in many studies and also SUS instrument has successfully evaluated the SMBII Augmented Reality and virtual tour application. The problem arises when the visitor lacks of time to fill the instrument. That's why another efficient instrument is necessary to be proven relevant with the effectivity as same as SUS.

This research began with developing an AI-based quiz feature in the virtual museum application from the SMBII museum and continued with usability testing with the SUS and UMUX instruments. Usability testing respondents were *N*=19 where the SUS testing was representative with a minimum number of 15 respondents [15] and proven effective for evaluating the usability of cultural heritage preservation applications [16]. [17]. Respondents were limited to student backgrounds who were the majority of visitors to the SMBII museum who came for learning purposes because the quizzes feature was developed for museum learning purposes. The SUS and UMUX instruments were given to the same respondents to be filled out after the users were asked to utilize the AI-based quiz feature on the SMBII virtual museum application. The instrument was filled by respondents in both situations, supervised and unsupervised after using the AI-quizzes feature of SMBII virtual museum.

After the SUS and UMUX-based usability data were successfully collected, the research continued by testing the hypothesis:

H0: There is a difference between the average scores of the SUS and UMUX measurements;
H1: There is no difference between the average scores of the SUS and UMUX measurements.

The *t*-test was carried out to test the hypothesis above to see whether or not there was a difference between the two test variables with the assumption that there was no difference in the variance value between the SUS and UMUX scores for measuring the usability of the AI-based quizzes feature in the SMBII virtual museum application.

A. System Usability Scale (SUS)

The SUS instrument consists of 10 questions with answers that can be scored on a Likert scale. These questions are divided into positive and negative sentiments and are categorized into usability, namely effectiveness, efficiency and satisfaction [18], as measured by these questions (Table 1). User experience in using the software has been proven and can be measured to determine the usability of the device using the SUS instrument.

Table 1. The SUS Instrument Questionnaire

ID	Questionnaire	Usability	Sentiment
Q1	I think that I would like to use this system frequently	Satisfaction	Positive
Q2	I find this system to be more complicated than it should be	Satisfaction	Negative
Q3	I thought the system was easy to use	Overall	Positive
Q4	I think that I would need the support of a technical person to be able to use this system	Effectiveness	Negative
Q5	I found the various functions in this system were well-integrated	Effectiveness	Positive
Q6	I thought there was too much inconsistency in this system	Effectiveness	Negative

Table 1. The SUS Instrument Questionnaire (Continue)

ID	Questionnaire	Usability	Sentiment
Q7	I would imagine that most people would learn to use this system very quickly	Efficiency	Positive
Q8	I find this system to be time-consuming.	Efficiency	Negative
Q9	I felt very confident using the system	Effectiveness	Positive
Q10	I needed to learn a lot of things before I could get going with this system	Efficiency	Negative

Source : (Research Results, 2024)

The final SUS score is calculated by subtracting 1 from the answer for odd questions. For even questions, subtract 5 from the answer. Add the scores from each question and multiply the total by 2.5. The SUS score formulation is as in Eq. (1),

$$SUSscore=((\sum_{i=1;i=odd}^{10}(x_i) - 1) + 25 - \sum_{i=1;i=even}^{10}(x_i) - 5)) \text{ x } 2.5 \quad (1)$$

where x_i is the answer score to question i.

B. Usability Metric for User Experience (UMUX)

UMUX is used to measure the usability of software with an instrument consisting of 4 questions with descriptions as in Table 2. Each question's answer is measured using a Likert scale (1-5). The number of questions with positive sentiment is balanced with the number of questions with negative sentiment. UMUX has a smaller number of questions than SUS and it can be said that UMUX is a reliable and valid form of instrument compression of the SUS instrument. The formula of UMUX score is described in Eq. (2),

Table 2. The UMUX Instrument Questionnaire

ID	Questionnaire	Usability	Sentiment
R1	This system's capabilities meet my requirements.	Effectiveness	Positive
R2	Using this system is a frustrating experience.	Satisfaction	Negative
R3	This system is easy to use.	Overall	Positive
R4	I have to spend too much time correcting things with this system	Efficiency	Negative

Source : (Research Results, 2024)

$$UMUXscore=(\frac{\sum_{i=1;i=odd}^{4}(x_i)-1)+\sum_{i=1;i=even}^{4} 7-(x_i))}{24})x\ 100 \quad (2)$$

C. Virtual Museum Application

The transformation of a physical museum into a virtual museum based on digital technology is necessary for a museum in the digital era. With digital transformation, museums gain some benefits, especially in achieving organizational goals [19]. Museum visitors get a different learning experience with interactive applications based on digital technology, increasing visitor knowledge, and optimizing museum management to increase competitiveness to maintain the museum's existence [20].

Management of museum entities in the form of people, collections, facilities and policies in museum management will be more effective and efficient by utilizing digital technology. Collaboration that is possible to occur quickly with effective communication promises benefits for museums in increasing competitiveness to achieve organizational goals in carrying out educational and tourism functions in museums. Several museums in the world have proven that digital technology can provide excellence and added value for museums. Digital transformation became a solution when the COVID-19 pandemic spread the world and became the momentum to accelerate the transformation of traditional museums into modern museums based on digital technology [19] [20].

RESULTS AND DISCUSSION

The questionnaires given to *N=30* respondents were all filled out properly so that data processing could be continued using a statistical approach to determine the differences between the SUS and UMUX methods in this research problem. Measuring the usability of the AI-based quizzes feature in the SMBII virtual museum application with the SUS and UMUX questionnaire instruments was carried out with the results represented in Table 3 and Table 4. The average score of SUS = 69.92 and UMUX = 64.58.

Table 3. Usability Measurement Results

Respondent ID	SUS Score	UMUX Score
1	50	50.00
2	72.5	66.67
3	50	50.00
4	57.5	70.83
5	62.5	50.00
6	95	79.17
7	55	50.00
8	77.5	75.00
9	75	62.50
10	47.5	54.17
11	97.5	83.33
12	50	50.00
13	72.5	66.67
14	50	50.00

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Table 3. Usability Measurement Results (Continue)

Respondent ID	SUS Score	UMUX Score
15	57.5	70.83
16	62.5	50.00
17	95	79.17
18	55	50.00
19	77.5	75.00
20	75	62.50
21	47.5	54.17
22	97.5	83.33
23	97.5	83.33
24	85	83.33
25	85	79.17
26	47.5	50.00
27	82.5	75.00
28	50	50.00
29	75	66.67
30	65	66.67

Source : (Research Results, 2024)

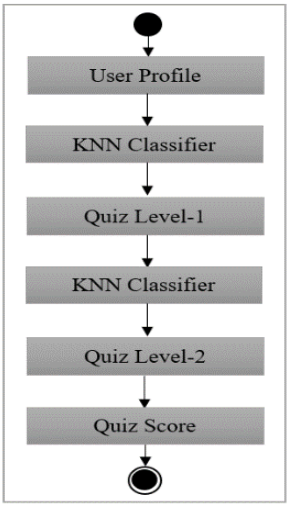
Table 4. Usability Sentiment Measurement Results

Respondent ID	Positive		Negative	
	SUS	UMUX	SUS	UMUX
1	5	5	5	5
2	3.8	4	2	2
3	5	5	5	5
4	3.8	3.5	3.2	1
5	5	5	4	5
6	5	4.5	1.4	1
7	5	4.5	4.6	4.5
8	4	4.5	1.8	1.5
9	4.4	3.5	2.4	2
10	3.6	4	3.8	3.5
11	5	5	1.2	1
12	5	5	5	5
13	3.8	4	2	2
14	5	5	5	5
15	3.8	3.5	3.2	1
16	5	5	4	5
17	5	4.5	1.4	1
18	5	4.5	4.6	4.5
19	4	4.5	1.8	1.5
20	4.4	3.5	2.4	2
21	3.6	4	3.8	3.5
22	5	5	1.2	1
23	5	5	1.2	1
24	4.4	5	1.6	1
25	5	5	2.2	1.5
26	4.2	4	4.4	4
27	4.4	4.5	1.8	1.5
28	5	5	5	5
29	5	5	3	3
30	4.4	5	3.2	3

Source : (Research Results, 2024)

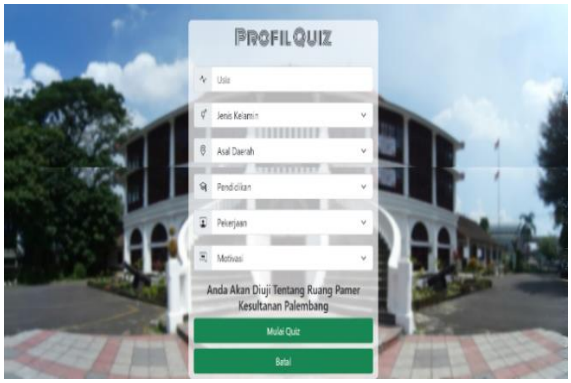
A. AI-Based Quizzes Feature in SMBII Virtual Museum

The development of the AI-based quizzes feature in the SMBII virtual museum application has produced a quiz menu application interface for SMBII museum learning purposes. This feature provides practice questions for users at 2 levels. At level-1 visitors are presented with questions in image format while at level-2 in text format based on user profile analysis processed by KNN classifier (Figure 1). Figure 2 (a-f) below illustrates the interface design of the quizzes feature. The KNN algorithm processes profile data inputted by the user illustrated by the flowchart in Figure 1 and through an interface such Figure 2a, then recommends exhibition rooms that match the user's profile analyzed by KNN classifier based on age, regional origin, gender, education, and motivation for visiting the museum. Questions at level-1 will be displayed with a timer which is the limit for completing all questions at level-1 for 1 minute (Figure 2b). The question was selected based on KNN classifier analysis on user profile. If the answer entered by the user is wrong, the application will provide the correct answer so that the user gets new knowledge (Figure 2c). If the answer entered is correct, an interface will appear such Figure 2d with the total score shown to the user at the end of the quiz for each level (Figure 2e). Users can decide to repeat quiz level-1 or continue to level-2 (Figure 2f). The KNN algorithm will classify the user's knowledge level based on level-1 answers to display level-2 questions.



Source : (Research Results, 2024)

Figure 1. AI-based quizzes flowchart in the SMBII virtual museum application



(a)

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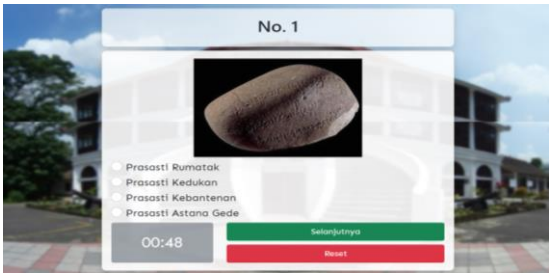
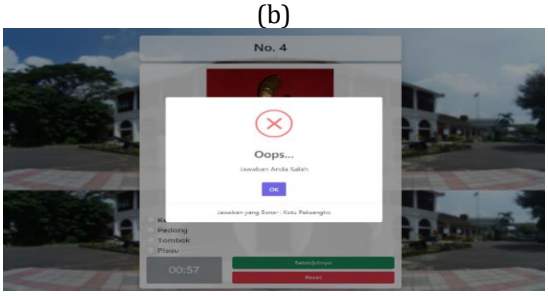
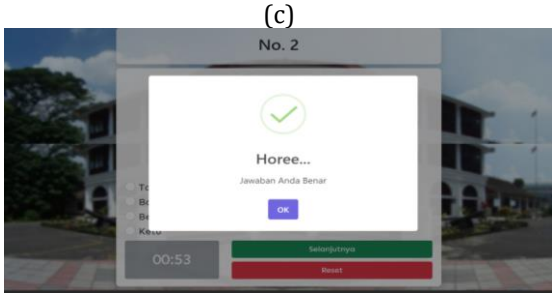


(b)



(c)



(d)

(e)

(f)

Source : (Research Results, 2024)

Figure 2. (a-f) AI-based quizzes feature interface in the SMBII virtual museum application

B. SUS vs UMUX Performance Evaluation for AI-Based Quizzes Feature Usability Measure

The number of respondents should be between 16-4 to 16+4 for valid test results based on previous studies [17]. In this study, the respondents were *N*=30 where the SUS testing was representative with a minimum number of 15 respondents and proven effective for evaluating the usability of cultural heritage preservation applications in previous studies [15][16]. Respondents were limited to student backgrounds who were the majority of visitors to the SMBII museum who came for learning purposes because the quizzes feature was developed for museum learning purposes. The following Table 5 presents the results of the *t*-test to test hypothesis *H0* which states that there is no difference in the average SUS and UMUX scores in assessing the usability of the AI-based quizzes feature in the SMBII virtual museum application. The *t*-test will prove the difference between the SUS and UMUX measurement scores.

Table 5. The *t*-Test Results

Statistics	SUS	UMUX
Mean	68.92	64.58
Variance	300.29	166.13
Observations	30	30
Pooled Variance	233.21	
Hypothesized Mean Difference	0.00	
df	58.00	
t Stat	1.10	
P(T<=t)	0.28	
t Critical	2.00	

Source : (Research Results, 2024)

The results of the *t*-test assuming there is no difference in the average value of the usability measurement score with the SUS and UMUX instruments show a score of *P(T<=t)* = 0.20 > 0.05. If the value of *P(T<=t)* > 0.05 then it can be concluded that hypothesis *H0* is accepted. The results in Table 5 show that there is no difference between the SUS and UMUX score values. Next, we will compare the questions with positive and negative sentiments on the SUS and UMUX instruments with the results presented in Table 6 and Table 7. The *t*-test results in Table 6 show value of *P(T<=t)* > 0.05, so it can be concluded that there is no difference between the average positive sentiment usability scores of the SUS and UMUX questionnaires. The same fact is also known based on the results of the *t*-test for the usability score of negative sentiment (Table 7), which obtained a value of *P(T<=t)*= 0.49. This information shows that there is no difference between the usability of the negative sentiment of the SUS and UMUX instrument questionnaires.

Table 6. The *t*-Test Results of Positive Sentiment Usability

Statistics	SUS	UMUX
Mean	4.55	4.52
Variance	0.28	0.30
Observations	30	30

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Statistics	SUS	UMUX
Pooled Variance	0.29	
Hypothesized Mean Difference	0.00	
df	58.00	
t Stat	0.26	
P(T<=t)	0.79	
t Critical	2.00	

Source : (Research Results, 2024)

Table 7. The *t*-Test Results of Negative Sentiment Usability

Statistics	SUS	UMUX
Mean	3.04	2.77
Variance	1.89	2.67
Observations	30	30
Pooled Variance	2.28	
Hypothesized Mean Difference	0.00	
df	58.00	
t Stat	0.70	
P(T<=t)	0.49	
t Critical	2.00	

Source : (Research Results, 2024)

C. Limitation and Recommendation

The quizzes feature was developed to support the education role at SMB II museum. For that, the respondents are limited to visitors who aim to study at the museum. The educational background of respondents is homogeneous, namely students from Gen-Z who are already accustomed to using internet technology so it cannot be generalized to various educational backgrounds and ages. Next study, the quizzes feature in the virtual museum application can also be offered to museum visitors with non-student backgrounds who come to the museum not for learning purposes and may interested in enhancing their knowledge while accessing the virtual museum. Further research will be conducted to overcome this limitation expands the respondent pool include longitudinal studies, and explore the impact of the AI-based quizzes feature on different user groups. It may refine the usability of virtual museum applications and better understand user experiences in museum learning.

Based on the test results, it is recommended to use the UMUX instrument to measure the perceived usefulness of the quiz feature for learning purposes compared to SUS. The UMUX instrument was proven to be no different in effectiveness from the SUS for measuring user perceptions regarding the experience of using the quizzes feature in virtual museum applications for learning purposes. Users who are busy with the learning experience through the quizzes feature by answering several questions presented at two levels will find it easier to fill out the instrument which only consists of 4 UMUX questions compared to 10 SUS questions. The validity and consistency of answers to the questions asked in the instrument will be better maintained if respondents are asked to spend less time answering questions that they consider to be tiring and of no benefit to the user.

CONCLUSION

This research aims to compare the performance of SUS and UMUX to measure the perceived usability of the quizzes feature in the SMBII virtual museum which implements the AI algorithm. SUS and UMUX have been proven its effectiveness for measuring system usability in many studies but have never been done for measuring quizzes feature in a virtual museum. The quiz feature was developed for learning purposes for visitors to the SMBII virtual museum by applying an AI algorithm which has proven its effectiveness in increasing user knowledge. The learning experience provided by the quizzes feature needs to be measured to determine the level of usefulness of the feature from the user's perspective by measuring its usability. User acceptance of the application will be an indicator of the success of developing the SMBII virtual museum application, especially the quizzes feature to support the museum's education role.

The experimental results show that there is no difference in assessment scores between SUS and UMUX instruments with the *t*-test showing $P > 0.05$. These results reinforce that with fewer instruments, UMUX has the same performance as SUS where questions with positive or negative sentiment in UMUX are effective in representing all questions with the same sentiment as the SUS instrument questions. The results need improvement in respondent limitation for larger sample sizes, wider visitor background in age and other demography heterogeneity to enhance the generalization findings in future studies. The usability measure results give feedback for the app development for improving user experience in future studies. UMUX is recommended to be used to measure usability compared to SUS in terms of time efficiency for museum visitors to fill out the assessment instrument and may be evaluated its effectiveness for measuring system usability in other museums and domains such as tourism that has wider users in future research.

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