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Assessing an Innovative Virtual Museum Application using Technology Acceptance Model

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***Abstract*— This study discusses the assessment of a virtual museum application development based on machine learning models for Palembang culture education through the Sultan Mahmud Badaruddin II museum cultural heritage by using the Technology Acceptance Model approach. The application was tested to measure the user acceptance of the application and pre-test and post-test to measure the effect size of the application as a learning media. A total of *N*=32 student participants were involved in testing the Sultan Mahmud Badaruddin II innovative virtual museum application for museum visitors was dominated by students who came to the museum to learn the culture and history of Palembang. Hypothesis testing results show that the perceived usefulness and perceived ease of use variables do not affect the attitude toward the use of the innovative virtual museum application. The attitude toward the use of the variable affects the behavioural intention to use, which directly also has a moderate effect on the actual use of the application where the dependent variables have the value of *R2* > 0.5. The developed app is recommended as alternative learning media during a pandemic where the app testing participants express interest in using the app to enhance the Palembang culture learning experience.**

Keywords—machine learning; Palembang culture education; Sultan Mahmud Badaruddin II; learning enhancement; learning experience

1 INTRODUCTION

A museum is an institution that has roles for education and recreation. Visitors can increase their knowledge about culture, art, and history through museum collections as well as recreation with educational activities in physical museums. The problem arose when the COVID-19 pandemic hit the world. To reduce the spread of COVID-19, the Indonesian government implemented a policy to limit physical activities, including for learning purposes, by establishing rules for learning from home. The Museum was also forced to close due to the large-scale social restriction policy set by the government for organizing activities in public spaces. As a result, many museum visitors in the early days of the pandemic decreased significantly. For example, the Sultan Mahmud Badaruddin II (SMBII) museum decreased to 90% in 2020 compared to 2019 before the pandemic, which had an impact on the low performance of the museum's educational role because the number of visitors was used as an indicator of the performance of the Museum's educational role. The visitor is dominated by the student who can no longer carry out museum learning activities during the pandemic, so of course, it impacts cognitive abilities if there are no alternative media for museum learning that is representative and interesting, like a physical museum.

To overcome the limited access to physical museums, alternative media are needed to implement museum roles for education and attract visitors to use them in museum learning. Information and Communication Technology present the answer to these problems. Various worldwide applications have been developed by museums, web-based, mobile, and robotics [1]. Multimedia applications [2]–[4], Museum Information Systems [5] Augmented and Virtual Reality [6]–[10]digital guides [11]–[14], educational games [15]–[17] part of the strategy management of exhibits and improve the experience of museum visitors [18]. The results of the implementation of the museum application show that information technology and the internet are effective in providing easy access to the museum, providing more interactive and interesting collection information by making the past stored in the museum as if it came back to life and the atmosphere can be felt by visitors through audio and visual technology, especially for museum learning objectives. Many virtual museums are developed based on AR / VR because the collections presented in 3D make the collections look real or alive so that users seem to be in the real environment of the Museum [19], [20].

To develop museum learning media effective in carrying out museum education tasks, smart virtual media are needed that are not only attractive to users but also able to improve students' abilities in museum learning. Smart media will make it easier for users to find information on activities, especially learning [21], to make the quality of life better, especially for recovery after the COVID-19 pandemic [22], [23]. Therefore, an innovative virtual museum application based on museum learning was developed, a branch of science from artificial intelligence that is effectively used for analyzing user profiles of applications or virtual museum visitors to produce information that can be used to provide recommendations in museum learning. Visitors no longer have to come to the physical Museum but simply access the innovative virtual Museum to study museum collections, the Palembang SMBII Museum case study, with added value in the form of a virtual exhibition recommendation that quickly provides information for visitors to explore the exhibition space to reduce the boredom that can arise due to staring at the screen for too long with the presentation of information that is less attractive to visitors.

Digital technology can improve the learning experience using multimedia strategies that facilitate effective learning management, enable individualization and personalization of learning, provide rapid information, stimulate discovery learning and interactive learning models, provide simulation opportunities and problems solving, and improve student abilities [24]. The transformation of a physical museum into a digital museum is necessary to achieve organizational goals. Previous studies reviewed articles regarding existing models of virtual museums and learning media in museums related to the application of machine learning and learning outcome indicators. The search was continued with article metadata in the Scopus and Google Scholar databases, and 1789 articles were selected using the criteria in PRISMA, leaving 11 articles reviewed in full text. The study was complemented by identifying the virtual museum model that has been developed by museums around the world. A review was carried out on 80 existing virtual museums in Indonesia [25] and other countries [26], [27]. Based on these literature review results, it was found that virtual museum models have been developed for some museums in the world for educational purposes. Virtual museum services during the pandemic have been modelled where the content was the main focus of the virtual museum exploration model. Still, the model was not specifically designed for museum educational purposes, so museum learning outcomes are not measurable. Educational applications for exploration purposes [28], [29], and games involved analyzing software requirements that have not integrated the learning outcomes of the Museum. The current virtual museum model can be grouped based on educational content designed based on 2D/3D objects without formulating the learning outcomes to be achieved. In [30] also limited to content that does not yet represent physical museum services for education [31]. The current virtual museum model is limited to the information content of virtual museum services during the COVID-19 pandemic [12]. None have been specifically designed for educational purposes. Applications are modelled only with relevant multimedia content to attract users' interest in exploring the old fashion museum collections. Without evaluating learning outcomes, the effectiveness of museum education through the use of virtual museum applications cannot be measured.

This study discusses the effectiveness of innovative machine learning-based virtual museum application development for Palembang SMBII museum and culture learning. The SMBII museum is a cultural heritage that holds thousands of historical and cultural value collections since the Srivijaya kingdom in the 7th century. The app testing evaluation is carried out using a technology acceptance model (TAM), which has been proven effective in measuring application usability, especially for learning media. Its continuous use by users influences the success of an information system. Previous studies have adapted the TAM to evaluate the success of a learning system [32] influenced by the service quality of the system [33] and its impact on the behavior of museum visitors [34].

The results of this study are expected to deliver recommendations for stakeholders in the use of innovative virtual museum applications as a medium for improving museum learning experiences during the pandemic, as well as a strategy for restoring post-pandemic museum education performance.

2 METHOD

The development of machine learning-based virtual museum applications in this study adopted a multimedia development life cycle methodology that, at the application testing stage, applied the TAM model and Cohen's formula to measure the effectiveness of the virtual museum developed for Palembang cultural learning through SMBII collections and museum buildings. The MDLC methodology is divided into five stages: Concepting, Designing, Material Collecting, Assembling, and Testing [35].

1) Concepting

At this stage, an analysis of the concept of machine learning-based virtual museum application requirements for Palembang cultural learning is carried out through the collection and building of the SMBII museum. The results of previous studies have tested the hypothesis that it is proven that there is an effect of museum learning performance with the use of machine learning-based intelligent virtual museums for museum learning during the COVID-19 pandemic [36]. The results of the research are a machine learning-based virtual museum conceptual model for cultural learning purposes, especially during the pandemic.

2) Designing

The design based on the innovative virtual museum conceptual model is made with a use case diagram model to model the functionality of the innovative virtual museum app, as illustrated in Figure 1. The use case in the diagram is described in Table 1. The actor or application user is a user who acts as a virtual museum visitor. Visitors can access all app features, namely Tour Guide, Exploration, and Education, where these features have a machine learning use case and learning outcomes as an integral part of the use case.

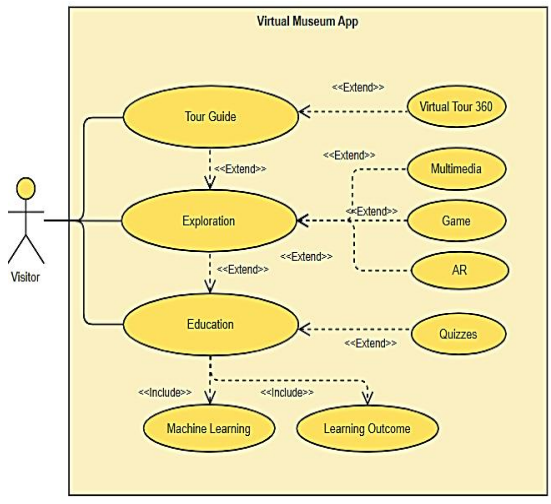

Figure 1. Use case diagram of SMBII museum's virtual tour app

Table 1. Use Case Description

Usecase	Description	Actor
Tour Guide	The virtual museum tour guide has the role of providing information for visitors to explore the virtual museum independently	Visitor
Exploration	Features exploration of virtual museum collections and buildings. Visitors can search or search for information related to the SMBII museum through this feature	Visitor
Education	The museum's educational tasks are implemented in the form of educational features where visitors are presented with several features to improve and measure the cognitive abilities of visitors	Visitor
Machine Learning	Application of machine learning algorithms for visitor profile analysis, the results of which are used to provide some recommendations or predictions in presenting information for visitors to innovative virtual museums	Visitor
Learning Outcome	Features to measure the learning achievement of users, especially students and students	Visitor
Virtual Tour	Virtual tour feature with 360 video technology	Visitor
Multimedia	Multimedia content for informative and interactive presentations	Visitor
Game	Interactive content in the form of games containing Palembang cultural learning content	Visitor
AR	Augmented reality content of museum collection digital objects in a real environment	Visitor
Quiz	A set of questions to measure the cognitive abilities of visitors to the virtual museum	Visitor

3) Material Collecting

The use case in Table 1 will be built into an innovative virtual museum application feature that contains multimedia content or materials. Some of these materials must be collected and some must be reconstructed. Multimedia content requires a variety of tools and methods to obtain it. At the material collecting stage, all application content material as part of the use case in Table 1 is collected so that it is ready to be combined at the next stage.

4) Assembling

At the assembly stage, the innovative virtual museum application content material based on machine learning is assembled into an application that is ready to be run and tested on users. SMBII's innovative virtual museum application is built based on a website that can be accessed by visitors via the internet without space and time constraints.

5) Testing

Testing by users is carried out to measure the effectiveness and efficiency of the machine learning-based virtual museum application built in this study. The test is carried out in a series of stages, as shown in Figure 2. Starting with a pre-test to determine the user's cognitive performance before utilizing the innovative virtual museum application. Users are asked to answer several questions regarding the collection, culture,

and history of Palembang. Then the user is asked to use the application for approximately 30 minutes. After that, users are given a post-test to measure whether there is an increase in their cognitive abilities after using the application to learn Palembang culture through a machine learning-based virtual museum application. Some app features implement machine learning algorithms to present information to users. Based on the results of the pre-test and post-test, measurement of the effect of the application as a learning medium and testing of application user acceptance was carried out using the TAM testing. App effect size measurement ensures that the virtual museum app effectively performs the functions required to enhance cognitive performance. Pre-test and post-test were conducted to measure learning achievement. The results of the TAM test were processed using the Partial Least Square Structural Equation Model (PLS-SEM).

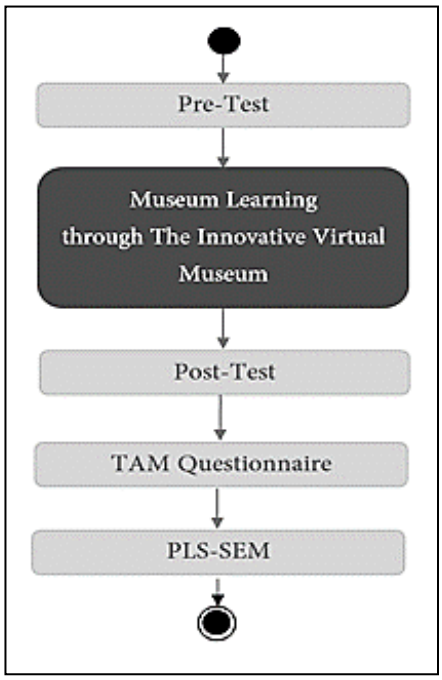

Figure 2. The workflow of an innovative virtual museum app testing

The TAM model, as illustrated in Figure 3, measures various factors that influence actual system usage, namely Perceive of Use and Perceive of Usefulness, attitude toward using, and behavioral Intention to use, which will be evaluated with a case study of the innovative SMBII virtual museum. TAM consists of five variables that are used to measure the success of an information system: perceive usefulness and perceive ease of use as the dependent variable, attitude toward use, behavioral intention to use, and actual usage as the dependent variable.

- Perceive Usefulness is a measurement used to determine the perceptions of the individual to the technology considering the easiness of its usage. Perceived Ease of Use relates to the extent to which users believe that technology is easy to use and without constraints.
- Perceive Ease of Use is a measurement for determining individual perceptions that technology can improve individual performance. When individual performance has increased, it means that there is a positive influence in adopting technology, and individual behavior will also be affected positively.
- Attitude Toward Use is the behavior of users influenced by the strongest belief in online learning apps. The use of the app will be affected by the level of acceptance of the app.
- Behavioral Intention to Use is defined as the behavior of the user's interest in utilizing technology or in this study an innovative virtual museum application for museum learning, especially during the pandemic.
- Actual Usage is defined as a measure of how often users use technology or in this study an innovative virtual museum application for SMBII museum learning.

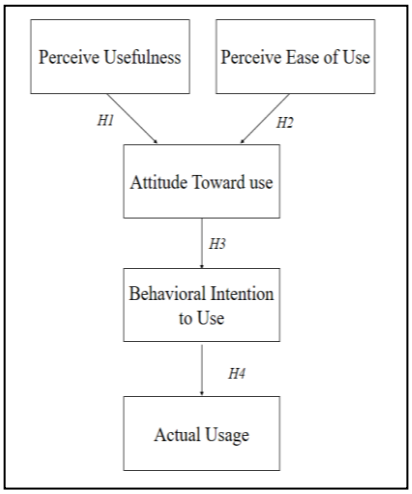

Figure 3. Technology acceptance model (Davis, 1989)

The research model based on TAM model illustrated in Figure 3 consists of operational variable definitions described in Table 2. Furthermore, it will be tested whether there are associations among variables in the research model. Some hypotheses were formulated based on the TAM model, H1, H2, H3, and H4 as follows:

- H1: Perceived Usefulness affects attitude toward use SMBII's innovative virtual museum
- H2: Perceive Ease of Use influences attitude toward the Use of SMBII's innovative virtual museum
- H3: Attitude Toward Use influences behavioral to use SMBII's innovative virtual museum
- H4: Behavioral Intention to Use affects the actual usage of SMBII's innovative virtual museum

Table 2. TAM Variables Definition

Variable	Definition	
	Indicator	*Code*
Perceive Ease of use	SMBII Innovative Virtual Museum Application is easy to use	U1
	The SMBII Innovative Virtual Museum application is not complicated to use	U2
	To use the SMBII Innovative Virtual Museum application, no special skills are required	U3
	The SMBII Innovative Virtual Museum application can be used anytime	U4

	The SMBII Innovative Virtual Museum application can be used anywhere	U5
Perceive Usefulness	The SMBII Innovative Virtual Museum application can increase motivation to learn Palembang's history and culture	F1
	The SMBII Innovative Virtual Museum application was able to improve my understanding of Palembang's history and culture	F2
	The SMBII Innovative Virtual Museum application can make it easier for me to learn the history and collection of Palembang cultural objects	F3
	The SMBII Innovative Virtual Museum application makes me think creatively about learning about museums and Palembang culture	F4
Attitude Toward Using	I have a positive reaction to SMBII's innovative virtual museum application	A1
	I feel happy to learn about Palembang culture and museums through this innovative virtual museum application	A2
Behavioral Intention to Use	I am trying to use the SMBII Innovative Virtual Museum application to improve my knowledge related to Palembang culture and history	B1
	I plan to use the SMBII Innovative Virtual Museum application in the future	B2
	I hope that the use of the SMBII Innovative Virtual Museum application will continue in the future	B3
	I intend to continue using the SMBII Innovative Virtual Museum app	B4
	I hope that the use of the SMBII Innovative Virtual Museum application will continue in the future	B5
Actual Usage	I use the SMBII Innovative Virtual Museum application at school as well as at home and elsewhere	C1
	When there are Palembang history and culture subjects, I take the time to use the SMBII Innovative Virtual Museum application	C2
	Overall, I am satisfied with learning by using the SMBII Innovative Virtual Museum application	C3
	Overall, I am satisfied with learning by using the SMBII Innovative Virtual Museum application	C4

PLS-SEM is applied for processing carried out with the following steps as a model measurement:

- Step-1: calculate the value of outer loading as an indicator of reliability. The loading factor is to determine the loading value of each construct indicator where the construct indicator loading factor should be the largest for the corresponding construct. If it meets the threshold criteria, then all construct variables are declared reliable or have good consistency,
- Step-2: Calculate the value of Cronbach's Alpha and Consistency Reliability as internal indicators of consistency reliability,
- Step-3: Calculate the Average Variance Extracted (AVE) value for the convergent validity and Fornell-Larcker indicators,
- Step-4: Analysis of indicators for each contract that meets the threshold value for each measurement result, where the value of the threshold outer loading factor > 0.7, AVE > 0.5, Cronbach's Alpha > 0.6,
- Step-5: Analysis of discriminant validity with the correlation matrix of the Fornell-Larcker method. The matrix shows the square root value of AVE, which shows the correlation between constructs in rows and columns. The value in the top row of each column must be the largest or in other words, the value on the diagonal of the matrix is greater than the value in the corresponding column so that it is said to have sufficient discriminant validity,
- Step-6: To determine the level of fitness of the model, the variance inflation factor (VIF) value indicator is used which measures the collinearity of the constructs where the threshold value is < 5.0. [32]. If the indicator is of good value, then it is appropriate to proceed to the structural model assessment stage by performing the bootstrapping method for hypothesis testing.

6) Distributing

Distribution includes socializing the use of innovative virtual museum applications through the exhibition as well as training for physical museum visitors and students who will use the museum as a media for culture learning. The website-based virtual museum application can be directly accessed by application users without requiring installation on their devices.

3 RESULTS AND DISCUSSION

This research developed an innovative virtual museum application based on machine learning for culture learning purposes, especially during the COVID-19 pandemic when physical museums limit access to student visits. Website technology-based apps can be accessed without limitations on distance, space, and time by museum visitors who freely utilize virtual museums with the advantage of applying machine learning models to provide information that is expected to meet user requirements or interests and interactively as a learning media.

3.1 SMBII Innovative Virtual Museum Application Interface

A machine learning-based virtual museum app has been developed with content featuring tour guides, education, and exploration. This feature contains a machine learning model used to analyze user profiles. One of its features is exhibition tour recommendations that apply machine learning models for museum visitor profile analysis to present exhibition recommendations that may meet their interests. The display of the virtual guide feature is illustrated as shown in Figure 4. Virtual museum visitors are presented with the option to choose a multimedia guide where guidance will be presented in various media formats to guide visitors to explore the virtual museum independently or take advantage of the tour recommendation feature that applies machine learning models in recommending the SMBII museum exhibition. The museum learning process is continued with the presentation of information related to exhibition rooms and museum

collections which are presented through the virtual tour feature and some other features to improve the user's cognitive performance. The next feature presents exploratory content for the collection and building of the SMBII museum cultural heritage (Figure 5). Visitors can learn about Palembang's history, art, and culture through the information presented in the form of a collection list that makes it easier for users to browse and learn about Palembang culture.

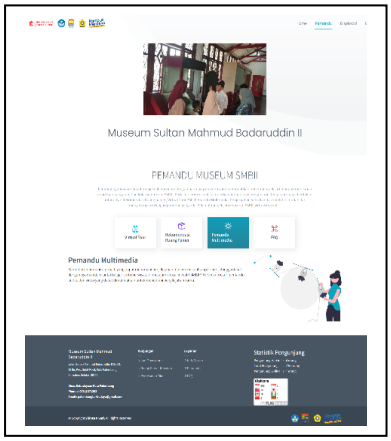

Figure 4. SMBII virtual guide screenshot

The next app feature is education. In this feature, users are presented with game and AR content that specifically aims to measure the user's cognitive performance related to Palembang culture (Figure 6). Educational games are presented to provide an interactive learning experience to effectively reduce boredom in virtual culture learning while being able to increase user knowledge. In addition to interactive games, visitors can do virtual exploration by choosing the virtual tour feature which presents 360-degree video technology that allows visitors to explore all spaces of the museum exhibition, as if they were in a physical museum. Navigation can be done by the user in 360 degrees by following the direction of the hotspot on the application with an interface as illustrated in Figure 7.

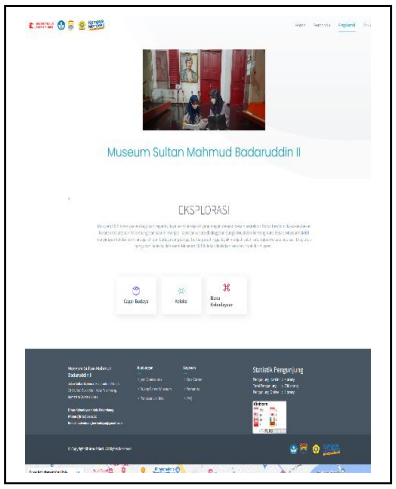

Figure 5. SMBII innovative virtual museum exploration screenshot

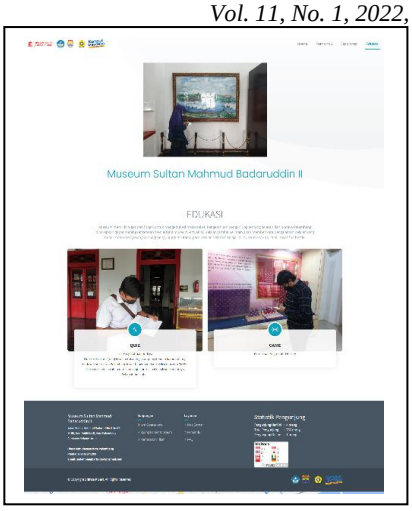

Figure 6. SMBII innovative virtual museum education screenshot

Figure 7. SMBII innovative virtual museum virtual tour 360 screenshot

To measure the cognitive abilities of virtual museum visitors, the quiz feature is designed with an interface as shown in Figures 8 and Figure 9. Users are asked to enter profile data (Figure 8). Then the machine learning model will analyze the data to get the category of questions that match the user profile on the level-1 quiz. For example, as the results of the analysis of user profiles are illustrated in Figure 8, the user will be asked about the Palembang Sultanate exhibition collection. The list of level-1 quiz questions is presented with an interface design as shown in Figure 9. Users are asked to choose an answer that is considered correct. From the response to the wrong answer, the application will provide learning the correct answer to the question. Users can learn to correct mistakes in answering questions which is expected to improve their knowledge or cognitive performance. At the end of the quiz, the total score that the user has obtained at each level will be displayed. The quiz is divided into 2 levels, where level-1 users will be asked questions in the form of images from the SMBII museum collection and level-2 users will be given narrative questions related to the culture and history of Palembang.

The next feature includes machine learning model is the virtual tour recommendation (Figure 10). Visitors who don't know the purpose of exploring the SMBII museum can take advantage of this feature to speed up the search that, hopefully, will reduce boredom in virtual exploration because of the many exhibition rooms presented, namely seven SMBII museum exhibitions. Users are asked to enter their profile data, then the machine learning model will analyze the data and the output is given in the form of exhibition

recommendations according to their profile. For example, the machine learning results recommend the Palembang sultanate exhibition be explored by visitors. If users follow these recommendations, they will be directed to the Palembang sultanate exhibition, where users can then enjoy 360-degree virtual tour technology for personal navigation exploration.

Figure 8. SMBII innovative virtual museum quiz feature screenshot

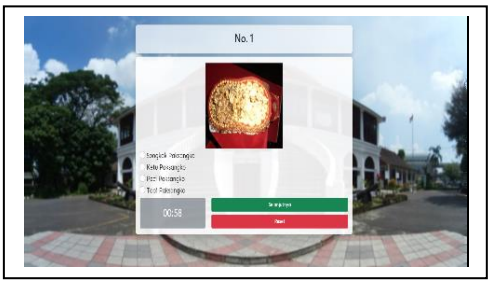

Figure 9. SMBII innovative virtual museum level-1 quiz feature screenshot

Figure 10. SMBII innovative virtual museum recommendation feature screenshot

3.2 Evaluation of SMBII Innovative Virtual Museum Application

3.2.1 *Data Collecting:* The questionnaire instrument was used in collecting data for testing hypotheses H1 to H4 and measuring the user's cognitive performance. There are two types of questionnaires based on the purpose of the questionnaire. The first questionnaire contains some questions related to the SMBII museum. This questionnaire is a pre-test and post-test of learning by utilizing machine learning-based virtual museum applications or SMBII's innovative virtual museums. Furthermore, the second questionnaire is designed to measure variables in the research model that adopts TAM. The research variables that will be measured through the research instrument consist of variables with indicators defined in Table 3. The TAM questionnaire is divided into two parts, namely the section to obtain demographic information of respondents and the section to obtain data on respondents' perceptions about the use of the SMBII innovative virtual museum application. Respondents were asked to give an assessment based on their perception with a Likert scale where the answers Strongly Agree = 5, Agree = 4, Neutral = 3, Disagree = 2, and Strongly Disagree = 1. Questionnaires were given to respondents as participants who were asked to use the application for less than 30 minutes for SMBII museum learning. Respondents took samples of students as the category of visitors who dominated the total of visitors to the SMBII museum who came for museum learning purposes. The demographics of respondents or participants *N*=32 who are participants in testing machine learning-based virtual museum applications consist of some characteristics, namely age, education, and regional origin, with the percentages presented in Table 3. Research respondents are students who are the dominant category of visitors to the physical museum. SMBII museum where more than 60% of museum visitors in 2019 were students.

Table 3. Demography of Participant

Factors	*Criteria*	*Frequency*
Gender	Male	22
	Female	10
Age	< 21	8
	21-30	24
Origin	Palembang	21
	South Sumatra	9
	Sumatra	1
	Others	1

On average, students make visits to the SMBII museum with the motivation to learn as part of the assignments given by their teachers. However, during the pandemic, these activities can no longer be carried out in museums due to the closure of the museum and the policy of studying at home. Students were chosen as the sample because their educational background dominates the visitors to the SMBII museum who visit the museum for learning purposes.

3.2.2 *Data Processing:* Data processing was carried out on the results of the pre-test and post-test to measure the effect size of machine learning-based virtual museum applications as SMBII culture learning media, especially during the pandemic. For TAM measurement, processing of the data that has been collected through questionnaires is carried out using the Partial Least Square Structured Equation Model (PLS-SEM) method. Questionnaires containing questions about the SMBII museum and collections were given to each participant *N*=32 and were divided into two levels of questions. Level-1 questions contain text-based questions about the collection and history of the SMBII museum related to Palembang culture, while level-2 contains image-

based questions. For level-2, respondents were asked to name the pictures of the museum collections displayed. Testing with a list of questions containing 35 questions about Palembang culture related to the SMBII museum. Then the scores were normalized to 0 to 100, and the results of the pre-test and post-test are presented in Table 4, where *M* = mean and *SD* = Standard Deviation.

Table 4. Pre-Test and Post-Test Experimental Results

Test	*M*	*SD*
Pre-test	32.41	14.51
Post-test	57.95	21.42

3.2.3 *Measurement Model Test*: The hypothesis testing procedure begins with the process of testing the reliability and validity data of the proposed model. The reliability test aims to determine the consistency of the instrument used, while the validity test aims to determine whether a variable measured through the questionnaire instrument has a strong correlation with other variables. Table 5 & Table 6 describe the results of validity and reliability measurement of the SMBII innovative virtual museum application TAM with some indicators showing that the data obtained are valid and reliable. Figure 11 illustrates the path diagram of the results of data processing with PLS-SEM. After knowing the valid and reliable data, the process of testing the HI, H2, H3, and H4 hypotheses can be carried out. The next step is to conduct bootstrapping for hypothesis testing.

Table 5. Validity and Reliability Measurement Results

Constructs	*Item*	*Outer loading*	*Cronbach's Alpha*	*CR*	*AVE*
Perceive Ease of use	U1	0.70	0.80	0.86	0.86
	U2	0.81			
	U3	0.84			
	U4	0.76			
	U5	0.59			
Perceive Usefulness	F1	0.93	0.93	0.95	0.95
	F2	0.92			
	F3	0.95			
	F4	0.81			
Attitude Toward Using	A1	0.91	0.84	0.93	0.93
	A2	0.95			
Behavioral Intention to Use	B1	0.83	0.89	0.92	0.92
	B2	0.86			
	B3	0.88			
	B4	0.90			
	B5	0.70			
Actual Usage	C1	0.85	0.84	0.89	0.89
	C2	0.87			
	C3	0.72			
	C4	0.82			

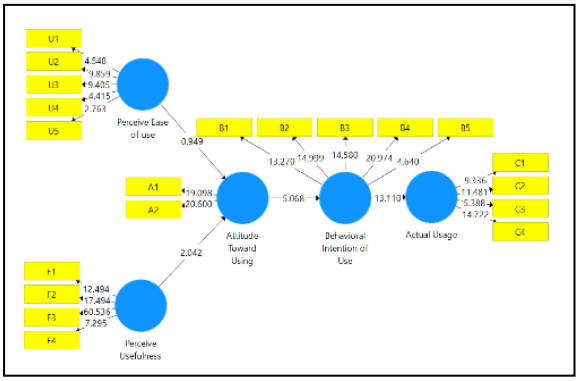

Figure 11. The path diagram of research model test results

Table 6. Fornell-Larcher Discriminant Validity Measurement Results

	U	F	A	B	C
U	0.745				
F	0.836	0.904			
A	0.704	0.747	0.928		
B	0.625	0.86	0.723	0.838	
C	0.618	0.691	0.487	0.615	0.818

Structural Model Test: The structural testing procedure of the model shows that there is a relationship between the indicators on the construct variables in the TAM model of the SMBII innovative virtual museum application. The path that forms the structural model in Figure 12 shows a direct relationship between the variables in the research model. Hypotheses H1 to H4 are evaluated based on the value of R^2 which indicates the strong or weak relationship between the dependent variables in the model, namely attitude toward using (A), the behavioral intention to use (B), and actual usage (C). From Table 7, it is known that the R^2 value of each dependent variable is > 0.5 which indicates a moderate relationship between the dependent variables. Furthermore, based on the value of f^2 in Table 8, it is known that the Attitude Toward Using variable has a strong influence on the behavioral intention to use variable. The behavioral intention to use variable has a strong effect if it is removed from the actual usage variable where the value of f^2 > 0.35. Perceive Usefulness has a medium effect and perceived ease of use has a small effect on the attitude toward using variable. The bootstrapping process for testing produced some path coefficients shown in Table 9. The test is carried out with a significant value of confidence level α = 0.01 that the t-stat value must be > 2.58 to indicate a significant effect of a variable. It shows that H3 and H4 are supported but H1 and H2 are rejected. Moderate relationships between the behavioral intention to use and actual usage, and between attitude toward using and behavioral intention to use are supported by hypothesis testing results. Meanwhile, the weak association between

perceive usefulness and perceive ease of use with attitude toward using is not supported by the hypothesis testing result.

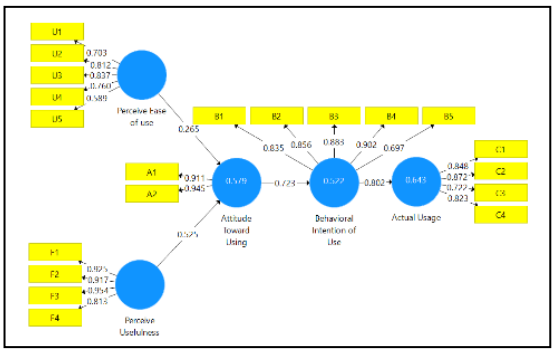

Figure 12. The Structural model bootstrapping results

Table 7. R^2 Value Results

Constructs	R^2
Attitude Toward Using (A)	0.579
Behavioral Intention to Use (B)	0.522
Actual Usage (C)	0.643

Table 8. f^2 Value Results

Constructs	f^2
Behavioral Intention to Use (B) - A	1.09
Actual Usage (C) - B	1.80
Attitude Toward Using (A) - U	0.05
Attitude Toward Using (A) - F	0.20

Table 9. Hypotheses Testing Results

H	Path	β	t-stats	*p*-values	Support	VIF
H1	F->A	2.042	1.837	0.067	Rejected	3.316
H2	U->A	0.949	0.861	0.390	Rejected	3.316
H3	A->B	5.068	5.410	0.000	Accepted	1.000
H4	B->C	13.11	12.319	0.000	Accepted	1.000

3.3 Limitation and Recommendation

This study has a limit on the number of participants in the TAM test, 32, due to the pandemic situation and demographic variations of participants who are not yet representative of museum visitors where SMBII museum visitors and regional backgrounds, ages, and education are more diverse with visitors dominated by students. This fact is the basis for limiting application testing to participants with a dominant age of 20-30 and student status. It is also recommended that testing can be carried out outside the laboratory with a larger number of participants so that other factors that might affect the user acceptance can be measured.

With a strong relationship proven by the support of hypotheses H3 and H4 based on TAM assessment results, it is recommended to use the innovative virtual museum applications for learning enhancement, especially in pandemic situations because students are interested in using these applications to enhance culture education anywhere without having to visit the museum at the same time has a strong effect on improving student's cognitive performance.

4 CONCLUSION

This study discusses an innovative virtual museum application based on a machine learning model development for Palembang culture learning through the collection and building of the SMBII museum cultural heritage. The Multimedia Development Life Cycle methodology is used for developing the SMBII innovative virtual museum application which begins with analyzing the innovative virtual museum conceptual model to produce a virtual museum model concept design that will be constructed with a web-based programming language into an application that can be widely accessed by the user via the Internet. To ensure the acceptance effectiveness of the machine learning-based virtual museum application that has been developed, application testing is carried out based on Technology Acceptance Model (TAM) approach. A total of *N*=32 participants were involved in testing the SMBII innovative virtual museum application.

The testing of hypotheses based on the TAM model resulted in support for the H3 and H4 hypotheses while H1 and H2 were rejected. These results indicate that the variable perceive usefulness and perceived ease of use do not affect the attitude toward using the innovative virtual museum application, while the variable attitude has an effect on behavioral intention to use which directly also has a moderate effect on the actual usage of the application. Each dependent variable has a value of $R^2 > 0.5$.

The innovative virtual museum application is recommended as a culture learning media during a pandemic where participants express interest in using the application wherever and whenever necessary to learn Palembang culture, especially in a pandemic situation with limited access to physical museums. Furthermore, machine learning-based virtual museum applications are expected to enhance cultural learning for museum visitors not only during the pandemic but also became a post-pandemic recovery strategy. For future research, the machine learning model performance for user profile analysis need to be improved as will optimize the innovative virtual museum effectiveness in culture education.

AUTHOR'S CONTRIBUTION

The first author contributed to the article's content details writing. The second author ensures the original research ideas about the development of machine learning based virtual museum applications. The third author is also supervised in terms of article writing methods and contents.

COMPETING INTERESTS

Complying with the publication ethics of this journal, the authors of this article declare that this article is free from Conflict of Interest (COI) or Competing Interest (CI).

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REFERENCES

[1] S. Puspasari and E. Ermatita, "A Survey of Data Mining Techniques for Smart Museum Applications," *J. Inform.*, vol. 9, no. 1, pp. 33–42, 2021, doi: https://doi.org/10.5772/53989.

[2] Y. Luo, "On the Information Application of Multimedia Technology in Museum," in *Proceedings - 2020 5th International Conference on Communication, Image and Signal Processing, CCISP 2020*, 2020, pp. 299–303, doi: 10.1109/CCISP51026.2020.9273468.

[3] S. Schwan, S. Dutz, and F. Dreger, "Multimedia in the wild: Testing the validity of multimedia learning principles in an art exhibition," *Learn. Instr.*, vol. 55, no. November 2017, pp. 148–157, 2018, doi: 10.1016/j.learninstruc.2017.10.004.

[4] R. Quattrini, R. Pierdicca, M. Paolanti, P. Clini, R. Nespeca, and E. Frontoni, "Digital interaction with 3D archaeological artefacts: evaluating user's behaviours at different representation scales," *Digit. Appl. Archaeol. Cult. Herit.*, vol. 18, no. April, p. e00148, 2020, doi: 10.1016/j.daach.2020.e00148.

[5] D.-S. Kim, J.-Y. Lee, B. S. Chun, G.-Y. Hwang, W. K. Paek, and B.-K. Byun, "Introduction of SMEP: Sharing and exchange system of natural history collection," *J. Asia-Pacific Biodivers.*, vol. 14, no. 3, pp. 299–301, 2021, doi: 10.1016/j.japb.2021.07.003.

[6] P. Kyriakou and S. Hermon, "Can I touch this? Using Natural Interaction in a Museum Augmented Reality System," *Digit. Appl. Archaeol. Cult. Herit.*, vol. 12, no. November, pp. 1–9, 2019, doi: 10.1016/j.daach.2018.e00088.

[7] A. Poce, F. Amenduni, C. De Medio, M. Valente, and M. R. Re, "Adopting Augmented Reality to Engage Higher Education Students in a Museum University Collection: the Experience at Roma Tre University," *Information*, 2019, [Online]. Available: https://www.mdpi.com/2078-2489/10/12/373.

[8] G. Wang, Z. Lu, Y. Zhang, Y. Qian, H. Zhao, and D. Liu, "Application of mixed reality technology in education with the case of a huangmei opera cultural education system," *Proc. 2nd Int. Conf. Comput. Sci. Educ. Informatiz. CSEI 2020*, pp. 301–305, 2020, doi: 10.1109/CSEI50228.2020.9142502.

[9] M. Milosz, S. Skulimowski, J. Kęsik, and J. Montusiewicz, "Virtual and interactive museum of archaeological artefacts from Afrasiyab – An ancient city on the silk road," *Digit. Appl. Archaeol. Cult. Herit.*, vol. 18, no. January, 2020, doi: 10.1016/j.daach.2020.e00155.

[10] F. Z. Kaghat, A. Azough, M. Fakhour, and M. Meknassi, "A new audio augmented reality interaction and adaptation model for museum visits," *Comput. Electr. Eng.*, vol. 84, 2020, doi: 10.1016/j.compeleceng.2020.106606.

[11] H. Candello, M. Pichiliani, M. Wessel, and ..., "Teaching Robots to Act and Converse in Physical Spaces: Participatory Design Fictions with Museum Guides," *Proc. ...*, 2019, [Online]. Available: https://dl.acm.org/doi/abs/10.1145/3363384.3363399.

[12] P. Gutowski and Z. Klos-Adamkiewicz, "Development of e-service virtual museum tours in Poland during the SARS-CoV-2 pandemic," *Procedia Comput. Sci.*, vol. 176, pp. 2375–2383, 2020, doi: 10.1016/j.procs.2020.09.303.

[13] S. Schmidt, G. Bruder, and F. Steinicke, "Effects of virtual agent and object representation on experiencing exhibited artifacts," *Comput. Graph.*, vol. 83, pp. 1–10, 2019, doi: 10.1016/j.cag.2019.06.002.

[14] T. Teslyuk, "A mobile museum guide application," *CEUR Workshop Proc.*, vol. 2631, pp. 314–326, 2020, [Online]. Available: https://www.scopus.com/inward/record.uri?partnerID=HzOxMe3b%5C&scp=85088879409%5C&origin=inward.

[15] C. Chang, M. Chang, and J. S. Heh, "National Palace Museum Adventure—A Mobile Educational Role-Playing Game for Museum Learning," *... Learn. Environ. Technol.*, 2015, [Online]. Available: https://link.springer.com/chapter/10.1007/978-3-662-44659-1_11.

[16] L. Argyriou, D. Economou, and ..., "360-degree interactive video application for Cultural Heritage Education," *... Learning ...*. westminsterresearch.westminster.ac …, 2017, [Online]. Available: https://westminsterresearch.westminster.ac.uk/item/q28q0/360-degree-interactive-video-application-for-cultural-heritage-education.

[17] I. Malegiannaki and Daradoumis, "Analyzing the educational design, use and effect of spatial games for cultural heritage: A literature review," *Comput. Educ.*, vol. 108, pp. 1–10, 2017, doi: 10.1016/j.compedu.2017.01.007.

[18] V. Kamariotou, M. Kamariotou, and F. Kitsios, "Strategic planning for virtual exhibitions and visitors' experience: A multidisciplinary approach for museums in the digital age," *Digit. Appl. Archaeol. Cult. Herit.*, vol. 21, no. December 2020, p. e00183, 2021, doi: 10.1016/j.daach.2021.e00183.

[19] Z. He, L. Wu, and X. R. Li, "When art meets tech: The role of augmented reality in enhancing museum experiences and purchase intentions," *Tour. Manag.*, 2018, [Online]. Available: https://www.sciencedirect.com/science/article/pii/S0261517718300475.

[20] F. Serravalle, A. Ferraris, D. Vrontis, A. Thrassou, and M. Christofi, "Augmented reality in the tourism industry: A multi-stakeholder analysis of museums," *Tour. Manag. Perspect.*, vol. 32, no. July, 2019, doi: 10.1016/j.tmp.2019.07.002.

[21] J. Kasperiuniene and I. Tandzegolskiene, "Smart learning environments in a contemporary museum: a case study," *J. Educ. Cult. ...*, vol. 2020, no. 2, pp. 353–375, 2020, [Online]. Available: http://yadda.icm.edu.pl/yadda/element/bwmeta1.element.ojs-doi-10_15503_jecs2020_2_353_375.

[22] L.-A. Casado-Aranda, J. Sánchez-Fernández, and A.-B. Bastidas-Manzano, "Tourism research after the COVID-19 outbreak: Insights for more sustainable, local and smart cities," *Sustain. Cities Soc.*, vol. 73, no. July, p. 103126, 2021, doi: 10.1016/j.scs.2021.103126.

[23] F. Bandarin, E. Ciciotti, M. Cremaschi, G. Madera, P. Perulli, and D. Shendrikova, "After Covid-19: A survey on the prospects for cities," *City, Cult. Soc.*, vol. 25, no. July, p. 100400, 2021, doi: 10.1016/j.ccs.2021.100400.

[24] M. D. Abdulrahaman *et al.*, "Multimedia tools in the teaching and learning processes: A systematic review," *Heliyon*, vol. 6, no. 11, p. e05312, 2020, doi: 10.1016/j.heliyon.2020.e05312.

[25] L. Banun, "Exploring Museum Through Virtual Tour," *Indonesian Ministry of Education and Culture*, 2021. https://kebudayaan.kemdikbud.go.id/seru-di-rumah-lewat-virtual-tur-museum/ (accessed Aug. 16, 2021).

[26] A. Wilson, "10 of the world's best virtual museum and art gallery tours | Cultural trips | The Guardian," *The Guardian.com*, 2020. https://www.theguardian.com/travel/2020/mar/23/10-of-the-worlds-best-virtual-museum-and-art-gallery-tours (accessed Aug. 16, 2021).

[27] J. West, "The 75 Best Virtual Museum Tours - Art, History, Science," *upgradedpoints.com*, 2021. https://upgradedpoints.com/travel/best-virtual-museum-tours/ (accessed Aug. 16, 2021).

[28] M. Lo Turco and E. C. Giovannini, "Towards a phygital heritage approach for museum collection," *J. Archaeol. Sci. Reports*, vol. 34, no. PA, p. 102639, 2020, doi: 10.1016/j.jasrep.2020.102639.

[29] D. A. Loaiza Carvajal, M. M. Morita, and G. M. Bilmes, "Virtual museums. Captured reality and 3D modeling," *J. Cult. Herit.*, vol. 45, pp. 234–239, 2020, doi: 10.1016/j.culher.2020.04.013.

[30] Z. Sun, K. Wang, and Z. Li, "Construction of Educational Resources and Design of Learning Activities in Facilitating Museum Education," *2019 Int. Jt. Conf. ...*, 2019, [Online]. Available: https://ieeexplore.ieee.org/abstract/document/9066377/.

[31] C. M. Bolognesi and A. A. D. Aiello, "Learning through serious games: a digital design museum for education," in *The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences*, 2020, pp. 83–90, doi: 10.5194/isprs-archives-XLIII-B5-2020-83-2020.

[32] D. Al-Fraihat, M. Joy, R. Masa'deh, and J. Sinclair, "Evaluating E-learning systems success: An empirical study," *Comput. Human Behav.*, vol. 102, no. March 2019, pp. 67–86, 2020, doi: 10.1016/j.chb.2019.08.004.

[33] Theresiawati;, H. B. Seta, A. N. Hidayanto, and Z. Abidin, "Variables Affecting E-Learning Services Quality in Indonesian Higher Education :," *J. Inf. Technol. Educ. Res.*, vol. 19, pp. 259–286, 2020.

[34] V. V Daskalaki *et al.*, "Service quality , visitor satisfaction and future behavior in the museum sector Service quality , visitor satisfaction and future behavior in the museum sector," *J. Tour. Herit. Serv. Mark.*, vol. 6, no. 1, pp. 3–8, 2020.

[35] S. Puspasari, Ermatita, and Zulkardi, "Machine Learning for Exhibition Recommendation in a Museum's Virtual Tour Application," *Int. J. Adv. Comput. Sci. Appl.*, vol. 13, no. 4, pp. 404–412, 2022, doi: https://doi.org/10.14569/IJACSA.2022.0130448.

[36] S. Puspasari, E. Ermatita, and Z. Zulkardi, "Innovative Virtual Museum Conceptual Model for Learning Enhancement During The Pandemic," in *11th Electrical Power, Electronics, Communications, Control, and Informatics Seminar (EECCIS)*, 2022, pp. 0–5.