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# Innovative Virtual Museum Conceptual Model for Learning Enhancement During The Pandemic

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***Abstract*— This paper presents the evaluation results of a new conceptual model of a virtual museum for enhancing museum learning during the COVID-19 pandemic. In a pandemic, people cannot carry out learning activities in museums because of museum closure. An innovative virtual museum is needed for presenting information quickly which is interesting, interactive, and relevant to the user's requirement, especially for museum learning which is identical to old fashion collections and is less attractive, especially for millennials. Some museums in the world have shifted the educational role of physical museums to virtual or digital museums. However, it is more than a recreational purpose while the educational role has not been optimized. The new conceptual model proposed in this study integrates learning outcome indicators and machine learning into the development of virtual museum content to produce attractive virtual museums and be able to analyze and assess user knowledge abilities for improving museum learning purposes. The evaluation carried out on testing the hypothesis related to the impact of the proposed virtual museum model development on the performance of museum learning during the pandemic was conducted using the Partial Least Square Structured Equation Model (PLS-SEM) method. The virtual museum usage affects museum learning performance with a significance level of $R^2 > 0.5$, and the model fit level is good where VIF < 3. These findings become strong baselines for museums organization to consider developing digital media of innovative virtual museums for learning enhancement during the COVID-19 pandemic. The innovative conceptual model is expected to be developed into an innovative virtual museum application that will enhance museum learning without having to access physical museums and optimize museum educational role, especially during the COVID-19 pandemic in Indonesia.**

***Keywords*— *Conceptual model, learning enhancement, machine learning, COVID-19***

## I. INTRODUCTION

COVID-19 has spread the world since 2019 and has made a broad impact on various sectors of life. Some sectors that have been impacted during the pandemic for the long term structurally include education and tourism, so they need a strategy to deal with the COVID-19 pandemic. The museum's closure during the pandemic has impacted the performance of the museum's role, especially in education [1]. Students are usually assigned to visit museums to learn about history, art, and culture through museum collections. Visits to physical museums for museum learning purposes have 3 (three) main reasons, namely new learning experience, having fun, and cultivation of positive attitudes [2]. With the existing facilities in the physical museum, the museum's educational role can be carried out there.

During the pandemic, During the pandemic, visitors cannot learn about the museum directly in the physical museum. Therefore, some museums in the world have shifted the role of physical museums to virtual museums so that the role of museums for education can still be carried outs. Information technology and the internet have been proven effective in enabling museums to carry out their roles virtually during the COVID-19 pandemic, where the tourism sector in the world is also affected by restrictions on movement and distance to reduce the spread of COVID-19.

Many virtual museums have been developed with a tourism-based model to attract visitors to visit and learn at physical museums. As a result, during the pandemic, the virtual museum could not enhance museum learning. The existing physical museum for learning purposes has not been modeled in virtual museums well. Several applications have been developed for museum learning purposes but without measuring the level of student learning outcome [3], [4] or just for fun and exploration purposes by presenting 3D content based on augmented reality or virtual reality so that it is more interesting and interactive for students in museum learning [5]. For developing digital learning media effective for museum learning enhancement, the virtual museum must be not only attractive to users but also able to improve students' knowledge abilities. Smart media will make it easier for users to find information on learning activities [6] thus making the quality of life better, especially for post-COVID-19 pandemic recovery.

Innovative media is needed for presenting information that is interesting, interactive, and relevant to the user's requirement, especially in learning the museums which are identical to old fashion collections and are less attractive. Smart media alone is not enough if it is not effective as a learning media. Therefore, for museum learning, it is necessary to develop innovative virtual museum effectively used to enhance museum learning during the COVID-19 pandemic by implementing artificial intelligence (AI). The AI applied in learning media makes the media smarter in understanding users' profiles based on knowledge of machine learning outcomes [7], especially for cultural education and tourism [8]. The COVID-19 pandemic is not yet known to end, so the presence of innovative learning media is expected to enhance museum learning virtually during the pandemic.

## II. LITERATURE REVIEW

This study aims to evaluate the new virtual museum model based on the machine learning method for enhancing museum learning during the pandemic. A literature review was conducted at the beginning to find the method needed for model assessment and validation.

### *A. Digital Technology for Museum Learning*

Internet and mobile technology applications for museum exploration purposes as well as games [9] have not integrated

the learning outcomes of the museum as part of the application requirement. 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. It is also limited to content that does not yet represent physical museum services for education. The current virtual museum design is limited to the information content of virtual museum services during the COVID-19 pandemic [11] none have been specifically designed for learning purposes. Without evaluating learning outcomes, the effectiveness of museum learning through the use of virtual museum applications cannot be measured.

For museum learning purposes, applications that have been developed were museum information systems, recommendation systems, games, augmented and virtual reality. Virtual museum models were developed with AR content for 3D visualization of collections without any evaluation of application performance to improve user knowledge [3] as well as [12] developing AR that is integrated into the information system but does not involve learning outcome indicators. Many virtual museums were developed based on augmented reality (AR) or virtual reality (VR) because the collections presented in 3D make the collections look real or alive so that users feel as if they were in the real environment of the physical museum.

### *B. Machine Learing for Museum Application*

Machine learning is a subset of artificial intelligence that plays an important role in building a "smart" construct enabling intelligent recognition, monitoring, and maintenance automation, enriching the experience of museum visits [13], as well as various other service quality improvement efforts involving Internet of Things technology. Machine learning algorithms have been applied for various purposes including recommendation systems, recognition, and classification of museum collections [14]. The study results show that machine learning implementation provides some benefits, including making it easier for users to find information according to their interests and needs and enriching information regarding the museum collections being explored to provide value-added services that attract visitors to explore the museum. For museum applications, machine learning can understand users through a learning process based on museum visit data which is carried out based on certain algorithms that are coded in the machine so that the information presented from the process effectively attracts the interest of museum [15]. The K-Nearest Neighbor algorithm has been widely applied, and its effectiveness has been proven for collection classification and museum recommendation system in addition to other machine learning algorithms in the form of Convolution Neural Network [13], K-Means [16], and Support Vector Machine [17] which have been developed for various smart museum applications in the world [18].

## III. INNOVATIVE VIRTUAL MUSEUM CONCEPTUAL MODEL

The fact that there are problems in conducting the educational role of physical museums that cannot be carried out optimally during a pandemic where museums are closed or limited to physical activities requires an effective solution. The pandemic forces digital transformation for the adoption of a new normal, which is no longer suitable to use only the number of museum visitors as an indicator to measure museum educational performance.

This study begins with literature review, continued by modeling a new conceptual model of virtual museum, model assessment, and model evaluation at the end of this study. A conceptual model of innovative virtual museums is proposed in this study as a digital transformation of museums for educational purposes during the COVID-19 pandemic. Conceptual models are communication tools between computer systems analysts and users [19] that are made to explain concepts, discuss, and look for relationships between different concepts in formulating a problem.

### *A. Proposed Virtual Musuem Conceptual Model*

In a physical museum, the user experience will be influenced by the application of interactive technology with modules grouped into entertainment, education, aesthetics, and escapism [20]. This study proposed a concept of a smart museum model for museum learning based on the interactive technology conceptual model in the physical museum for educational purposes that integrates learning outcome indicators and machine learning. It has content consisting of two categories of content development aims, namely exploration, and education. Fig.1 illustrates the design of an innovative conceptual model of virtual museum that will be developed into a smart virtual museum to enhance museum learning during the pandemic.

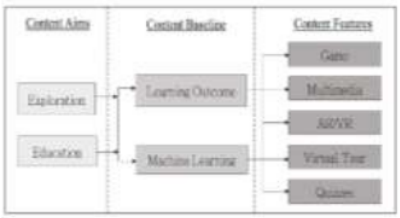


Fig. 1. The proposed virtual museum conceptual model

Exploration aims content is designed to provide users with entertainment, aesthetics, and escapism experience, whereas education aims content is designed for interactive learning purposes. For this purpose, the innovative conceptual model of the virtual museum is formulated with the content features of games, virtual tours, multimedia, AR/VR, and quizzes integrated into the smart virtual museum. The application features that make up the smart virtual museum's content must align with the content base, namely learning outcome indicators and machine learning algorithms formulated at the beginning of the virtual museum development analysis. The application content design will facilitate learning outcomes that have been designed through the formulation of learning outcome indicators and machine learning algorithms that will analyze user capabilities through user profiles and learning assessments carried out by machines on virtual museum applications.

### *B. Model Evaluation*

Previous studies have adapted Technology Acceptance Model (TAM) for evaluating the success of the learning system [21] affected by the quality of system service [22] and gave impact on the behavior of museum visitors [23]. With the SERVQUAL model, it has been proven that museum services affect user satisfaction and have an impact on visitor behavior in the future regarding return visits to the museum.

The quality of e-learning affects the perception of satisfaction and usage of the system [24], which has an impact on the benefits of learning. A factor that affects the quality of e-learning is the quality of e-learning content. Based on the results of the previous study, a research model was designed to evaluate the association between innovative virtual museum model development and museum learning performance enhancement during the pandemic, especially in Indonesia, as shown in Fig.2.


Fig. 2. Research model design

The test was conducted to the research model in Fig.2 to validate the impact of the integration of learning outcome indicators and machine learning on the quality of content and the usage of virtual museums, which will indirectly affect the performance of museum learning as a benefit for the organization. The research model in Fig.2 consists of operational variable definitions described in Table I. Based on the description, it will be tested whether there are associations among variables in the design model based on the indicators that have been defined. The hypotheses that will be tested to support the proposed conceptual model of innovative media for museum learning purposes are as follows,

- H1: Integration of learning outcome indicator affects the content quality of the virtual museums
- H2: Integration of learning outcome indicator affects the usage of the virtual museums
- H3: Content quality affects the use of virtual museums during the COVID-19 pandemic
- H4: Implementation of machine learning algorithm affects the content quality of the virtual museum
- H5: Implementation of machine learning algorithm affects the usage of the virtual museum in the COVID-19 pandemic
- H6: The usage of smart museums affects the museum learning performance in the COVID-19 pandemic

TABLE I. OPERATIONAL DEFINITION OF RESEARCH VARIABLES

| Variable | Indicator | Code | Reference |
|---|---|---|---|
| Learning Outcome (LO) | Learning outcome indicators in smart virtual museum content will be able to measure the user's ability in museum learning | LO1 | [25], [26] |
| | Learning outcome indicators in smart virtual museum content will be able to measure the success of museums role in educating users about museums | LO2 | [25], [26] |
| Machine Learning (ML) | An intelligent application that automatically provides information according to the interest or needs of the user about the museum will make it easier to study and explore the museum. | ML1 | [27], [28] |
| | Intelligent applications that automatically provide information according to the interests or needs of users about museums will provide a new experience for users to learn about museums virtually. | ML2 | [27], [28] |
| Content Qulity (CQ) | Game content in the virtual museum will make learning the museum more interesting and fun | CQ1 | [3], [22], [29] |
| | Multimedia content, Augmented Reality/ Virtual Reality with 2D/3D animation in virtual museums will make museum learning more interesting and fun | CQ2 | [22], [30], [31] |
| | Quizzes content on virtual museums will effectively measure the user's level of knowledge in museum learning | CQ3 | [20], [32] |
| | Virtual Tour Guide content in virtual museums will provide directions that make it easier and more interesting for users to learn about museums | CQ4 | [33]–[35] |
| Usage (US) | Users will suggest using innovative virtual museums with interesting and interactive content to learn about museums during the pandemic and post-COVID-19 pandemic | US1 | [22], [23] |
| | Users will directly access the innovative virtual museum if they want to learn about museums during the pandemic and post-COVID-19 pandemic | US2 | [22], [23] |
| Museum Learning (LE) | Users will access the innovative virtual museum if the physical museum is closed during the pandemic and post COVID-19 pandemic for museum learning | LE1 | [36], [37] |
| | Learning through the innovative virtual museums will be able to increase user knowledge about museums without having to come to physical museums during the pandemic and post-COVID-19 pandemic. | LE2 | [36], [37] |

The evaluation was carried out on the research model to validate the conceptual model's impacts on museum learning performance. Testing was performed on the hypotheses that had been designed, namely H1, H2, H3, H4, H5, and H6, using the PLS-SEM method.

*1) Data Collection Procedure*

*a) Instrument:* The questionnaire instrument was used for data collection to test the hypothesis of the new conceptual model's impact on the museum educational role performance, especially in Indonesia. The research variables that will be measured through the research instrument consist of exogenous variables, learning outcome indicators and machine learning implementation, and endogenous variables quality of content, usage, and museum educational performance with a Likert score scale.

*b) Respondent:* Respondents are prospective users of virtual museums who have or have never visited physical museums or virtual museums. The virtual innovative museum conceptual model will be designed applicable for various user backgrounds for museum education during the pandemic when the museum closes access for learning activities at the museum. Therefore, this study took respondents from various educational backgrounds, ages, gender, occupation, and visits to physical museums. Table II describes the demographics of 100 respondents.

*c) Data Processing*

For testing the hypotheses that have been formulated, the data collected using a questionnaire instrument were processed using the PLS-SEM Method. PLS-SEM was used in the analysis of the proposed conceptual model because a dependent variable, usage, was influenced by other dependent variables, namely content quality. PLS-SEM allows the sample in small quantities that may not normally be distributed. Research model evaluation was conducted by measuring variable indicators of the innovative conceptual model proposed in this study. SmartPLS was used to process the questionnaire results by doing bootstrapping using 500 repeat samples,

TABLE II. RESPONDENT DEMOGRAPHICS

| Factor | Critera | Percentage |
|---|---|---|
| Gender | Male | 57% |
| | Female | 43% |
| Age | <21 | 19% |
| | 21-30 | 29% |
| | >30 | 51% |
| Education | Under Graduate | 76% |
| | Post Graduate | 23% |
| Museum Visit | Ever | 70% |
| | Never | 30% |
| Occupation | Student | 35% |
| | Teacher/ Lecturer | 14% |
| | Employee | 26% |
| | Museum Staff | 3% |
| | Others | 21% |

## IV. RESULTS AND DISCUSSION

### A. Mesurement Model Test

The procedure began with testing the reliability and validity of the proposed research 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. This test has been carried out for various educational learning system models using PLS-SEM in the previous study [29], [30]. The Measurement model test was conducted using the following five stages:

- Calculate the value of outer loading as an indicator of reliability. The loading factor determines the loading value of each construct indicator, where the construct indicator loading factor must be the largest for the corresponding construct. If it meets the threshold criteria, then all construct variables are confirmed reliable or have good consistency,
- Calculate the value of Cronbach's Alpha and Consistency Reliability (CR) as an indicator of reliability consistency,
- Calculate the value of Average Variance Extracted (AVE) for convergent validity indicators,
- Analyze the indicator for each construct that meets the threshold value for each measurement result, where the threshold of outer loading factor > 0.7, AVE > 0.5, and Cronbach's Alpha > 0.6,
- Determine the level of suitability of the designed model, calculate the value of the variance inflation factor (VIF), which measures the collinearity of the constructs where the threshold value is < 5.0.

The results of the five stages above are described in Table III, where the path diagram illustration of the research model test results is shown in Fig. 3. Bootstrapping results show that the new conceptual model has a collinearity value below the threshold with VIF < 2.5 for each construct that builds the model. Model fit assessment is carried out using the Standardized Root Mean Square Residual (SRMR) ≤ 0.0.8. The calculation results show that the SRMR value score = 0.067 confirms the goodness of the new conceptual model designed in this study. If all indicators are of good value, then it is appropriate to proceed to the structural model assessment stage for hypotheses testing.

TABLE III. CONSISTENCY RELIABILITY AND CONVERGENT VALIDITY MEASUREMENT RESULTS

| Constructs | Item | Outer Loading | Cronbach's Alpha | CR | AVE |
|---|---|---|---|---|---|
| LO | LO1 | 0.936 | 0.855 | 0.933 | 0.874 |
| | LO2 | 0.934 | | | |
| ML | ML1 | 0.895 | 0.756 | 0.891 | 0.804 |
| | ML2 | 0.899 | | | |
| CQ | CQ1 | 0.852 | 0.888 | 0.922 | 0.748 |
| | CQ2 | 0.853 | | | |
| | CQ3 | 0.886 | | | |
| | CQ4 | 0.868 | | | |
| US | US1 | 0.901 | 0.776 | 0.899 | 0.817 |
| | US2 | 0.907 | | | |
| LE | LE1 | 0.893 | 0.766 | 0.895 | 0.810 |
| | LE2 | 0.907 | | | |

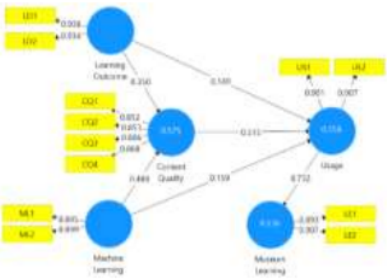

Fig. 3. The path diagram of research model test results

### B. Structural Model Assessment

The structural model assessment shows the relationship between the constructs along with the indicators and the coefficients of the inner model, which is illustrated in Fig. 4. The path that forms the structural model in Fig. 4 shows a direct relationship between the variables in the research model. The evaluation was based on the value of $R^2$ to assess the hypotheses H1, H2, H3, H4, H5, and H6. The value of $R^2$ shows association strength between the dependent variable and the independent variable (endogenous and exogenous). Hair et al. (2017) divided three interpretations of the strength

of the association of a variable with a cut-off of 0.75, 0.5, and 0.25, which means substantial, moderate, and weak [38].

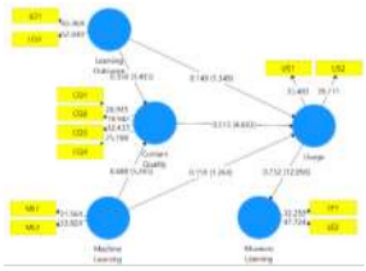

Fig. 4. Structural model bootstrapping results

The $R^2$ value results (Table IV) show moderate associations between LO, ML, CQ, US, and LE construct variables. The value of $f^2$ in Table V is also reviewed with cut-off indicators of 0.02, 0.15, and 0.35, which means that exogenous variables have a small, medium, or strong effect on endogenous variables if excluded from the model. The processing results show a moderate impact of LO and ML on CQ if one of them is excluded from the research model (Table V). The bootstrapping method for testing produced some path coefficients described in Table VI. The test is carried out with a significant value of confidence level $\alpha = 0.01$ so that the t-stat value must be > 2.58 to indicate a significant effect of a variable. The results of bootstrapping on the test data to determine whether the formulated hypothesis can be supported or not are represented in Table VI. Moderate relationships between learning outcome indicators and machine learning integration with the virtual museum content quality are supported by the H1 and H4 hypotheses. The quality of the content affects the usage of the virtual museum application. It impacts the museum's educational role performance, and its significance is proven through support for H3 and H6. However, learning outcome indicators and machine learning algorithm implementation do not directly affect the usage of virtual museums. These results are indicated by rejecting H2 and H5, where the p-value is > 0.01.

TABLE IV. $R^2$ VALUE RESULTS

| Constructs | $R^2$ |
|---|---|
| Content Quality (CQ) | 0.575 |
| Usage (US) | 0.558 |
| Museum Learning (LE) | 0.536 |

TABLE V. $F^2$ VALUE RESULTS

| Constructs | $f^2$ |
|---|---|
| Content Quality (CQ)-LO | 0.176 |
| Content Quality (CQ)-ML | 0.343 |
| Usage (US)-LO | 0.026 |
| Usage (US)-ML | 0.026 |
| Usage (US)-CQ | 0.255 |
| Museum Learning (LE)-US | 1.157 |

TABLE VI. HYPOTHESES TESTING RESULTS

| | Path | *β* | t-stats | *p*-values | Support | VIF |
|---|---|---|---|---|---|---|
| H1 | LO->CQ | 0.350 | 3.441 | 0.001 | Accepted | 1.637 |
| H2 | LO->US | 0.149 | 1.305 | 0.192 | Rejected | 1.925 |
| H3 | CQ->US | 0.515 | 4.525 | 0.000 | Accepted | 2.351 |
| H4 | ML->CQ | 0.488 | 5.167 | 0.000 | Accepted | 1.637 |
| H5 | ML->US | 0.159 | 1.185 | 0.237 | Rejected | 2.197 |
| H6 | US->LE | 0.732 | 12.942 | 0.000 | Accepted | 1.000 |

The results of hypotheses testing show that there are impacts of integrating learning outcome indicators and machine learning implementation with the content quality of a digital museum for learning performance improvement. The development of a new virtual museum model will directly impact the usage of virtual museums and indirectly impact the museum learning enhancement, particularly during the COVID-19 pandemic. It means that the development of virtual museums with AR/VR, games, multimedia, quizzes, and virtual tour content for museum learning purposes can affect the usage of virtual museum applications and have an impact on museum learning performance during the pandemic and also is expected to be able to enhance the role of physical museums after the COVID-19 pandemic. An attractive and interactive virtual museum for learning art, culture, and history at the museum affects the user's interest and knowledge. These two factors can be used as new indicators of museum learning performance measured through an innovative virtual museum development based on the new conceptual model proposed in this study, where the quizzes content feature will measure the user's museum knowledgeability level matched to the learning outcomes indicator and enhanced by machine learning for delivering learning content match to user profiles.

## V. CONCLUSIONS

This study proposed a concept of a virtual museum for museum learning purposes modeled with content aims as exploration and education with AR/VR, games, virtual tours, multimedia, and quizzes content features, as well as content baselines of learning outcome indicators and machine learning implementation. Hypotheses testing was conducted according to the research model variables to determine the user's perception of the proposed innovative virtual museum model for enhancing museum learning. Hypotheses were tested using data collected by conducting questionnaire instruments with various demographic backgrounds of the respondents in Indonesia and then processed using the PLS-SEM method. The testing results show that the integration of learning outcome indicators and machine learning implementation as the content baseline of virtual museums as digital media for learning affected the content quality of virtual museums, while content quality has a moderate effect on the usage of virtual museums. The usage affects museum learning performance with a significance level of $R^2 > 0.5$, and the model fit level is good where VIF < 3. These findings become strong baselines for museums organization to consider developing digital media in the form of innovative virtual museums for learning enhancement during the COVID-19 pandemic and as a physical museum recovery strategy after the pandemic in Indonesia through the application development of the proposed conceptual model.

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