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Preserving The Indigenous Musical Instruments of Papuan Using Augmented Reality Technology

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Abstract

This study explores the use of augmented reality (AR) technology as a technology enabling the preservation of traditional Papua musical instruments. It aims to understand factors that influence the adoption of this technology by people living in Papua who are not indigenous Papuans. The use of AR as a tool for cultural preservation is still limited, particularly in the context of Papua, highlighting a research gap concerning the acceptance of AR technology in regions rich in culture but limited in technology adoption. The study employs Design Science Research (DSR) as a research framework. The development and evaluation in the DSR are conducted rigorously and robustly. Once the AR artifact is developed using the UniteAR tool, subsequently it is evaluated employing UTAU2 as a theoretical lens. Particularly in the evaluation stage, it involves 115 non-OAP respondents that are resident but not indigenous Papuans as participants in data collection. The data is analyzed with partial least square structural equation modeling (PLS-SEM). The main findings indicate that the measurement model has good reliability and validity, with an R^2 value of 0.8, meaning that Behavioral Intention and Use Behavior explain 80% of the variability in AR technology adoption. The findings also reveal that performance expectancy, effort expectancy, and facilitating conditions are significant factors driving AR technology adoption among respondents. The implications of this study are highly relevant for the development of strategies using AR technology to introduce and preserve traditional Papua musical instruments. These findings can be used by local governments, indigenous communities, and local content developers to design more effective solutions for enhancing AR adoption in Papua, taking into account key factors influencing public behavioral intentions. Thus, this research not only provides theoretical insights into technology adoption but also strengthens the integration of culture and technology in Papua, opening opportunities for more interactive and engaging cultural preservation.

Keywords: Augmented Reality, Papua traditional musical instruments, PLS-SEM, Technology Adoption, UTAUT 2

I. INTRODUCTION

Indonesia's Papua region is known for its rich cultural heritage, including diverse traditional musical instruments that play a significant role in ceremonies, rituals, and daily life. These instruments, such as Tifa, Pikon, and Guwoto, are not only expressions of art but also of cultural identity, history, and spirituality of the Papuan people [1]. In fact, many of these traditional musical instruments are facing the threat of obsolescence due to rapid modernization, urbanization, and changing preferences among younger generations. The forces of globalization affecting all aspects of life pose serious threats to the preservation and sustainability of the nation's pure cultural values [2]. In addition, the demographic pattern of migration to Papua has inadvertently contributed to an increased population of residents who, despite their geographic presence in the region, may lack familiarity with or engagement in indigenous Papuan musical traditions. These threats present significant challenges to the preservation of cultural artifacts and evidence, thereby creating a substantial disparity in the appreciation and understanding of Papuan traditional cultural heritage within contemporary society.

The preservation of traditional Papua musical instruments faces several challenges. First, there is limited documentation and educational resources available about these instruments. Second, conventional preservation methods often fail to engage audiences, particularly those who are not indigenous Papuans (non-OAP) who may have different motivations and barriers to engaging with indigenous cultural elements. Third, there exists a technological gap in Papua that hinders the adoption of modern solutions for cultural preservation.

To address these challenges, this study proposes the implementation of Augmented Reality technology as an innovative solution for preserving traditional Papuan musical instruments. AR is a technology that integrates virtual objects with real-world elements [3]. With AR, users can interact with and experience a digitally enriched environment [4]. AR holds significant potential in education by enhancing students' understanding, overcoming implementation challenges, and supporting the effective integration of this technology into learning [5]. For instance, AR has been successfully applied to introduce traditional musical instruments, such as the gamelan in East Java [6].

The study employs Design Science Research (DSR) methodology to develop and rigorously evaluate an AR artifact created using the uniteAR tool. The evaluation phase utilizes the Unified Theory of Acceptance and Use of Technology 2. UTAUT 2 is a theoretical framework to examine the attitudes and responses of technology users regarding implementing numerous digital technology innovations [7], [8], [9] and [10].

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The UTAUT 2 variables, namely performance expectancy, attitude, effort expectancy, social influence, and hedonic motivation, are independent ones influencing the habit and facilitating condition variables [11]. Adopting this model will help in understanding users' attitudes and perceptions regarding the use of AR for cultural preservation of traditional Papua musical instruments.

Based on data collected from 115 respondents and analyzed using Partial Least Squares Structural Equation Modeling (PLS-SEM), the research demonstrates that performance expectancy, effort expectancy, and facilitating conditions significantly influence the adoption of Augmented Reality (AR) technology for cultural preservation initiatives. These findings provide valuable insights for governmental authorities, indigenous communities, and content developers to formulate effective strategies that integrate contemporary technology with cultural preservation efforts, ultimately establishing more interactive and engaging methodologies to safeguard Papua's musical heritage.

II. METHODOLOGY

This research uses a quantitative approach. This approach utilizes accurate numerical data collected from the field as a tool for analysis [12].

The study was conducted in Manokwari District, West Papua Province, from June 2023 to January 2024, with the aim of exploring the acceptance of Augmented Reality (AR) technology in introducing traditional Papuan musical instruments. Data was collected through observation, literature review, and questionnaires distributed to non-OAP (Non-Indigenous Papuan) communities.

The research method used to develop and evaluate AR technology is Design Science Research (DSR). This method is a research approach focused on creating a new product, conducting evaluations, and assessing how effective the product is in achieving the predetermined goals. Practically, there are two main stages in the development of this product: creation and evaluation [13].

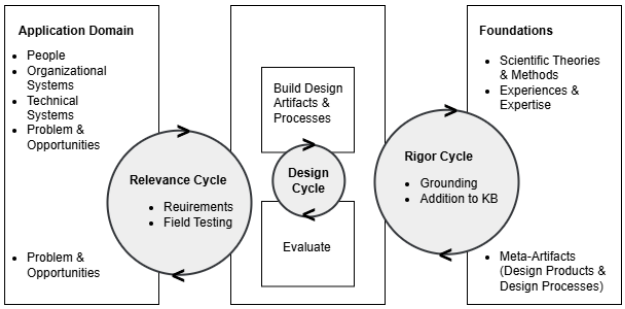

Figure 1. Design Science Research Methodology

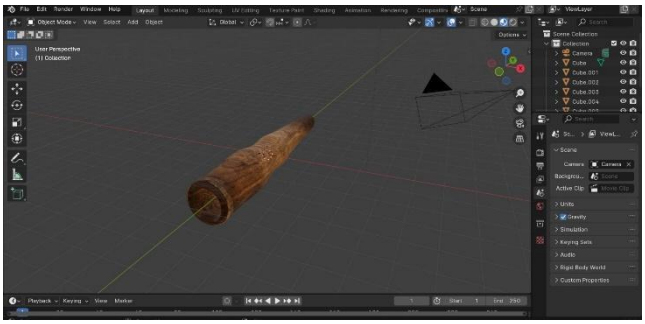

Figure 2. Development of 3D Models

Figure 3. Augmented Reality Scanning Cards

The development of this simple teaching material uses the UniteAR platform, followed by the application of the UTAUT 2 theory, which includes performance expectancy and effort expectancy. Data analysis is conducted using PLS-SEM to evaluate the relationships between variables, the effects of the variables, and the validity and reliability of the data in the model.

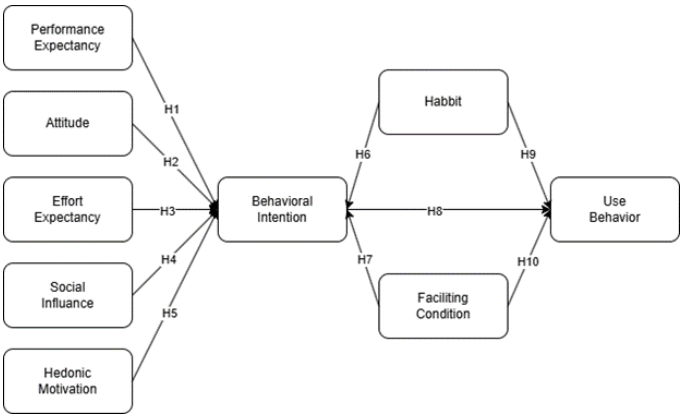

Figure 4. Research Model

The framework of this study uses the UTAUT 2 model. The behavioral intention variable serves as a mediator for the UTAUT 2 variables, namely performance expectancy, attitude, effort expectancy, social influence, and hedonic motivation, which are independent variables influencing the habit and facilitating condition variables. Furthermore, the habit and facilitating condition variables moderate the relationship between behavioral intention and the use behavior variable

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[14]. Based on the framework above, each variable is interconnected. According to [15], the performance expectancy variable has a positive impact on the behavioral intention variable. Therefore, the first hypothesis in this study is:

H1: Performance expectancy has a significant impact on the behavioral intention to use the AR application.

According to [16], the attitude variable has a positive effect on the behavioral intention variable. Therefore, the second hypothesis is:

H2: Attitude has a significant impact on the behavioral intention to use the AR application.

According to [15], the effort expectancy variable has a positive impact on the behavioral intention variable. Therefore, the third hypothesis is:

H3: Effort expectancy has a significant impact on the behavioral intention to use the application.

According to [15], the social influence variable has a positive impact on the behavioral intention variable. Therefore, the fourth hypothesis is:

H4: Social influence has a significant impact on the behavioral intention to use the application.

According to [17], the hedonic motivation variable has a positive effect on the behavioral intention variable. Therefore, the fifth hypothesis is:

H5: Hedonic motivation has a significant impact on the behavioral intention to use the application.

According to [15], the behavioral intention variable has a positive impact on the habit, facilitating conditions, and use behavior variables. Therefore, the sixth, seventh, and eighth hypotheses are:

H6: Behavioral intention has a significant impact on the habit of using the application.

H7: Behavioral intention has a significant impact on the facilitating condition for using the application.

H8: Behavioral intention has a significant impact on the use behavior of the application.

According to [15], the habit variable has a positive effect on the use behavior variable. Therefore, the ninth hypothesis is:

H9: Habit has a significant impact on the use behavior of the application.

According to [15], the facilitating condition variable has a positive effect on the use behavior variable. Therefore, the tenth hypothesis is:

H10: Facilitating conditions has a significant impact on the use behavior of the application.

To determine the sample size, Cohen's table for power analysis is used with the G*Power application [18]. With an effect size of 0.15, a significance level of 5% (95% confidence), and a statistical power of 0.8 with 9 prediction variables, the minimum sample size is calculated to be 114 [19]

III. RESULT AND DISCUSSION

In this study, the analysis was conducted on respondents residing in Manokwari Regency, West Papua Province, from June 1 to June 15, 2024. A total of 115 eligible responses were collected, meeting the minimum required sample size. The demographic analysis revealed that the majority of respondents were female, comprising 56%. The predominant age group was 18 to 34 years, representing 84%, while the most common last education level was high school/vocational school (SMA/SMK), accounting for 69%. The table below presents the respondents' demographics.

Table 1. Description of Respondent Demographics

Demographics	Classification	Percentage
Gender	Male	44%
	Female	56%
Age	18-34 Years Old	84%
	45-54 Years Old	2%
Last Education Level	SMA/SMK	69%
	S2	1%

Source : Data processed by the author, 2024

A. Measurement Model

The evaluation of the measurement model, also referred to as the outer model, involves testing both validity and reliability. Validity is assessed through convergent and discriminant validity, while reliability is evaluated using composite reliability and Cronbach's alpha [20].

This process examines outer loading values and Average Variance Extracted (AVE). The outer loading test focuses on factor loadings, which represent the correlation between indicators and their respective constructs. Factor loadings are deemed valid if their values exceed 0.7 [21].

Additionally, Composite Reliability (CR) and Cronbach's Alpha (CA) tests are performed, and the results are analyzed. These tests determine the consistency of each indicator in measuring its intended construct according to predefined standards. Data is considered reliable if Cronbach's Alpha is greater than 0.6 and remains acceptable within the range of 0.6 to 0.8 [22].

Table 2. Confirmatory Variable Results

Construct	Statement Items	Code	LF
Performance Expectancy CA, CR, AVE = 0.835, 0.884, 0.603	I find it easy to access the application for introducing Papua's traditional musical instruments on my Android phone.	PE1	0.750
	I feel capable of operating the application for introducing Papua's traditional musical instruments on my Android phone.	PE2	0.821
	I feel that this application is easy to learn and can be used anywhere using my Android phone.	PE3	0.783
	I can use all the features of this application well.	PE4	0.756
	I can view Papua's traditional musical instruments in 3D digital form virtually using my Android phone.	PE5	0.772
Attitude CA, CR, AVE = 0.816, 0.891, 0.731	The use of AR in learning about traditional Papua musical instruments is important to me.	A1	0.857
	I am confident that this application can be trusted for the authenticity of its information about Papua's musical instruments.	A2	0.858

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Construct	Statement Items	Code	LF
	I believe this application helps people become familiar with Papua's musical instruments.	A3	0.849
Effort Expectancy CA, CR, AVE = 0.827, 0.896, 0.742	I understand and recognize the sounds of Papua's musical instruments using this application.	EE1	0.859
	I obtain comprehensive information about Papua's musical instruments through this application.	EE2	0.855
	I find it effortless to operate the features of this application.	EE3	0.870
Social Influence CA, CR, AVE = 0.861, 0.906, 0.709	This application is suitable for all age groups.	SI1	0.768
	I use this application because my friends recommended it.	SI2	0.892
	I feel many people will use this application.	SI3	0.892
	Saya tahu aplikasi ini dapat membantu saya dalam mengenal alat-alat musik Papua.	SI4	0.809
Facilitating Condition CA, CR, AVE = 0.819, 0.893, 0.737	There are clear and understandable guides for viewing Papua's musical instruments using Augmented Reality (AR).	FC1	0.827
	I receive assistance when facing difficulties using AR to learn about Papua's musical instruments.	FC2	0.939
	This application is highly suitable for learning about Papua's musical instruments.	FC3	0.805
Behavioral Intention CA, CR, AVE = 0.705, 0.871, 0.772	I intend to continue using this application for learning about Papua's traditional musical instruments.	BI1	0.893
	This application provides interesting and easy-to-understand features.	BI2	0.864
Use Behavior CA, CR, AVE = 0.868, 0.920, 0.792	I enjoy using this application to learn about Papua's musical instruments.	UB1	0.841
	I repeatedly use this application to understand Papua's traditional musical instruments.	UB2	0.897
	I consistently use this application to explore Papua's musical instruments.	UB3	0.930
Hedonic Motivation CA, CR, AVE = 0.895, 0.927, 0.761	I feel happy using the Papua Musical Instrument Recognition application with Augmented Reality.	HM1	0.857
	I feel entertained when using this Papua musical instrument learning medium.	HM2	0.902
	This application increases my curiosity about Papua's musical instruments.	HM3	0.881
	This AR application makes me eager to learn more about Papua's culture.	HM4	0.847
Habit CA, CR, AVE = 0.832, 0.900, 0.751	I feel the need to use this application to learn about Papua's musical instruments.	H1	0.888
	I desire to continue using this application to understand Papua's musical instruments.	H2	0.912
	Using this application enhances my knowledge of Papua's musical instruments.	H3	0.795

Source : Smart PLS 4

It can be observed that the confirmatory variable results fall within the valid category and can proceed to the next step. Furthermore, the Average Variance Extracted (AVE) values indicate that each variable exceeds 0.5, meeting the validity criteria.

The Cronbach's Alpha and Composite Reliability values also show that all variables are above 0.7, indicating that the constructs measured have good reliability. This means the indicators are consistent and reliable for measuring latent variables [22].

Next, we will examine the cross-loading using the Fornell-Larcker criterion by comparing the square root of the AVE values, which should be greater than the correlation between the construct and other constructs [23].

Table 3. Discriminant Validity

	A	BI	EE	FC	H	HM	PE	SI	UB
A	0.855								
BI	0.771	0.879							
EE	0.760	0.788	0.861						
FC	0.696	0.784	0.719	0.859					
H	0.723	0.783	0.677	0.670	0.866				
HM	0.748	0.822	0.644	0.634	0.862	0.866			
PE	0.766	0.794	0.788	0.661	0.680	0.691	0.777		
SI	0.681	0.672	0.641	0.713	0.636	0.580	0.729	0.842	
UB	0.800	0.865	0.696	0.774	0.823	0.803	0.683	0.659	0.890

Source : Smart PLS 4

B. Structural Model

Structural model analysis is essential for understanding the relationships between variables within a model. This study will evaluate the magnitude and significance of these relationships to test the proposed hypotheses [24]. The tests conducted include the R-Square test and hypothesis testing.

1) R-Square

The R−Square evaluates how well independent variables explain the variability of dependent variables. A higher R−Square value indicates a better model in explaining this variability. In PLS−SEM, an R^2 value ≥ 0.67 indicates strong predictive power [25].

Table 4. R-Square Test Result

Variable	R-Square
Behavioral Intention	0.840
Use Behavior	0.818

Source : Smart PLS 4

Based on the table above, the R^2 value of the behavioral intention variable is 0.840, indicating that performance expectancy, attitude, effort expectancy, social influence, and hedonic motivation collectively predict 84% of the behavioral intention variable, demonstrating strong predictive power. Similarly, the R^2 value of the use behavior variable is 0.818, meaning that habit and facilitating conditions predict 81% of the use behavior variable, also showing strong predictive power.

The R^2 value of 0.840 for the behavioral intention variable indicates that performance expectancy, attitude, effort expectancy, social influence, and hedonic motivation influence users' intention to use AR technology by 84%. This emphasizes that perceived benefits, ease of use, social influence, hedonic

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motivation, and users' positive attitudes toward AR media are critical in encouraging their interest in utilizing this technology, particularly for introducing Papua's musical instruments.

The R^2 value of 0.818 for the use behavior variable suggests that habit and facilitating conditions influence usage behavior by 81%. The more accustomed users are to AR technology and the better the support available, the greater the likelihood they will consistently use this technology. Therefore, creating a supportive environment, such as providing tutorials or supporting tools, is essential to reinforcing the use of AR technology in learning about local culture.

2) Hypothesis Testing

The p-value represents the probability of obtaining the same or more extreme results if the null hypothesis is true. If the p-value < 0.05, the results are considered statistically significant, leading to the rejection of the null hypothesis. The t-statistic measures how far the parameter estimate deviates from the null hypothesis in standard error units. A t-value greater than the critical value indicates that the results are statistically significant [26].

Table 5. Hypothesis Testing Result

Hypothesis	Variables	P-Values	T-Statistics	Description
H1	Performance Expectancy → Behavioral Intention	0.035	2.105	Accepted
H2	Attitude → Behavioral Intention	0.935	0.082	Rejected
H3	Effort Expectancy → Behavioral Intention	0.128	1.523	Rejected
H4	Social Influence → Behavioral Intention	0.421	0.804	Rejected
H5	Hedonic Motivation → Behavioral Intention	0.000	3.647	Accepted
H6	Habit → Behavioral Intention	0.874	0.159	Rejected
H7	Facilitating Condition → Behavioral Intention	0.000	3.560	Accepted
H8	Behavioral Intention → Use Behavior	0.000	4.226	Accepted
H9	Habit → Use Behavior	0.000	3.984	Accepted
H10	Facilitating Condition → Use Behavior	0.084	1.730	Rejected

Source : Smart PLS 4

Based on the results from Table 5, it was found that H1, where the performance expectancy variable and the behavioral intention variable are accepted, because the T-statistic value is greater than 1.96, specifically 2.105, and the P-value is less than 0.05, specifically 0.035. This means that a person's performance expectancy has a significant influence on behavioral intention. This aligns with the study by [15], which states that a person's performance expectancy significantly influences their behavioral intention.

Next, H2, where the attitude variable and the behavioral intention variable are not accepted, because the T-statistic value is less than 1.96, specifically 0.082, and the P-value is greater than 0.935, specifically 0.082. This means that a person's attitude does not have a significant influence on their behavioral intention. This contradicts the study by [16], which states that a person's attitude significantly influences their behavioral intention.

Then, H3, where the effort expectancy variable and the behavioral intention variable are not accepted, because the T-statistic value is less than 1.96, specifically 1.523, and the P-value is greater than 0.935, specifically 0.128. This means that a person's effort expectancy does not have a significant influence on behavioral intention. This aligns with the study by [15], which states that effort expectancy has a significant influence on behavioral intention.

Next, H4, where the social influence variable and the behavioral intention variable are not accepted, because the T-statistic value is less than 1.96, specifically 0.804, and the P-value is greater than 0.05, specifically 0.421. This means that social influence does not significantly affect behavioral intention. This aligns with the study by [15], which states that social influence does not significantly influence behavioral intention.

Then, H5, where the hedonic motivation variable and the behavioral intention variable are accepted, because the T-statistic value is greater than 1.96, specifically 3.647, and the P-value is less than 0.05, specifically 0.000. This means that a person's hedonic motivation has a significant influence on behavioral intention. This contradicts the study by [17], which states that hedonic motivation does not significantly influence behavioral intention.

Next, H6, where the habit variable and the behavioral intention variable are not accepted, because the T-statistic value is less than 1.96, specifically 0.159, and the P-value is greater than 0.05, specifically 0.874. This means that user habits do not significantly influence behavioral intention. This contradicts the study by [15], which states that user habits significantly influence behavioral intention.

Then, H7, where the facilitating condition variable and the behavioral intention variable are accepted, because the T-statistic value is greater than 1.96, specifically 3.560, and the P-value is less than 0.05, specifically 0.000. This means that supporting facilities have a significant influence on behavioral intention. This contradicts the study by [15], which states that supporting facilities do not significantly influence users' behavioral intentions.

Next, H8, where the behavioral intention variable and the use behavior variable are accepted, because the T-statistic value is greater than 1.96, specifically 4.226, and the P-value is less than 0.05, specifically 0.000. This means that a person's behavioral intention has a significant influence on use behavior. This aligns with the study by [15], which states that a person's behavioral intention significantly influences use behavior.

Then, H9, where the habit variable and the use behavior variable are accepted, because the T-statistic value is greater than 1.96, specifically 3.984, and the P-value is less than 0.05,

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specifically 0.00. This means that user habits significantly influence user behavior. This aligns with the study by [15], which states that user habits significantly influence use behavior.

Finally, H10, where the facilitating condition variable and the use behavior variable are not accepted, because the T-statistic value is less than 1.96, specifically 1.730, and the P-value is greater than 0.05, specifically 0.084. This means that supporting facilities do not significantly influence use behavior. This aligns with the study by [15], which states that supporting facilities do not significantly influence use behavior.

C. Practical Implications

Based on the research results, the significant influence between behavioral intention and use behavior highlights the importance of enhancing users' intentions to drive the actual use of the AR application in introducing Papua's musical instruments. This effort can be made by ensuring that the application is user-friendly, has features that meet users' needs, and provides real benefits in understanding traditional musical instruments. By increasing the intention to use, this application can become a more effective educational technology medium that supports the preservation of Papua's culture.

Additionally, the influence of facilitating conditions on behavioral intention and habit on use behavior indicates that application providers need to ensure adequate technical support and create a consistent, repeated user experience. Features such as application stability, device compatibility, and clear usage guides can help increase users' intentions. On the other hand, habits formed through routine interactions with the application can encourage sustained usage, making users more familiar with and attached to this technology in their daily activities.

Furthermore, the significant influence of hedonic motivation and performance expectancy on behavioral intention underscores the importance of providing an enjoyable experience while meeting users' expectations. Developers can add interactive elements such as gamification, attractive interface design, and creative features that make the learning process more enjoyable. Additionally, ensuring the application is effective and efficient in helping users understand Papua's musical instruments will enhance performance expectancy. With a combination of enjoyable experiences and tangible benefits, the AR application can become the primary choice for the community in learning about local culture.

IV. CONCLUSION

This study successfully identified the significant influence of performance expectancy, facilitating conditions, and hedonic motivation on behavioral intention in the use of Augmented Reality (AR) technology. These results indicate that AR adoption is strongly driven by factors related to users' expectations of its performance, the availability of supporting conditions, and the enjoyment derived from its use. The R-Square value of 0.8 further confirms that 80% of the variability in use behavior can be explained by behavioral intention, underscoring the critical role of these factors. However, attitude, effort expectancy, and social influence did not show a significant impact on behavioral intention, suggesting the need for further investigation into these aspects. This study has achieved its objective of identifying key factors influencing AR adoption and provides valuable insights for developing AR applications aimed at preserving Papua's traditional culture. By addressing these findings, developers can better design AR solutions that meet users' expectations and needs, ultimately supporting cultural preservation efforts.

V. LIMITATION AND SUGGESTION

This study has several limitations, including the fact that the respondents only represent the non-OAP group, limiting the generalizability of the findings. Additionally, The cross-sectional methodology provides only a single time point assessment, failing to capture longitudinal changes in user intentions and behaviors. The insignificant results for the The insignificant results regarding Attitude, Effort Expectancy, and Social Influence factors necessitate further model or measurement evaluation.

Future research is recommended to involve OAP respondents for greater demographic representation and employ longitudinal approaches to track behavioral changes over time. Investigation of additional variables such as cultural factors and AR content quality is advised, alongside qualitative methods to better understand the insignificant factors identified in this study.

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