UNDERSTANDING SATISFACTION AND LOYALTY TOWARD EDUCATIONAL AR APPLICATIONS AMONG YOUNG ADULTS: AN INTEGRATED UTAUT3-ISSM MODEL WITH SUSTAINABLE CONSUMPTION PRACTICES AS A MODERATOR

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ABSTRACT

The widespread integration of Augmented Reality (AR) technologies into higher education has created new opportunities for more engaging, participatory, and immersive learning processes. However, young adult users of educational AR systems face the challenge of SRV (satisfaction-retention) in AR systems. This research aims to explore the factors that impact the satisfaction and loyalty of users of educational augmented reality applications, combining the UTAUT3 model, Information Systems Success Model (ISSM), and Sustainable Consumption Practices (SCP). The sample consisted of 384 young adults (18 to 34 years old) who had prior exposure to educational augmented reality applications. The proposed relationships were tested through Partial Least Squares Structural Equation Modeling (PLS-SEM). Findings revealed that user satisfaction was greatly influenced by service quality, hedonic motivation, social influence, and the value of service. In addition, the satisfaction of users was positively correlated with loyalty, and this correlation was strengthened by SCP. The present study offers integration of the technology acceptance framework, augmented reality system quality, and sustainability. Thus, the present study has a KOT (Knowledge-Offers-Transfer) function. The results provide suggestions for users, educational institutions, and AR system developers to build more innovative AR-based educational systems.

Keywords: Augmented Reality, UTAUT3, Perceived Satisfaction, Loyalty, Sustainable Consumption Practices, Higher Education

1.0 INTRODUCTION

The application of Augmented Reality (AR) into higher education has intensified alongside the integration of digital technologies into many educational institutions' pedagogy. Educational AR merges the real world with digitally embedded stimuli (animated or graphic/simulative) enhancements, and AR has the power to provide the stimuli that engage users and aid in the understanding of the processes.

Though there tends to be a lack of user loyalty even in the face of increasing educational AR applications, it must be known that the presence of AR learning systems was advantageous to students, despite their inconsistent use. With the fading novelty of AR tools, users tend to abandon them altogether. This shows a need for the study of the satisfaction and loyalty indicators of educational AR applications.

Many research studies evaluating the AR systems focus on the technology, usability, and learning outcomes. However, there has been scant research on the synthesis of fundamental techno-sustainability and service quality of the system, and the technology acceptance model. Also, it seems that the younger generations' ethical and responsible use of the Internet concerns them far more than their long-term loyalty to a particular technology, potentially resulting in a decline of long-term loyalty to a particular teaching tool.

This research aims to create a hybrid model using UTAUT3, the Information Systems Success Model, and Sustainable Consumption Practices. This research identifies satisfaction and loyalty toward educational augmented reality among the 18-34 age group. The findings revealed that satisfaction was the strongest predictor of loyalty and that SCP acted as a moderator in the satisfaction-loyalty relationship.

This research is specifically interested in augmented reality and assesses the sustainability of the technology and system along the entire use spectrum in addition to the system. The findings will benefit educational stakeholders and policy makers as well as augmented reality system developers.

2.0 LITERATURE REVIEW

2.1 Conceptual Foundation of the Study

This study applies UTAUT3, ISSM, ECT, and SCP to devise a novel approach regarding the factors affecting user satisfaction and loyalty regarding Educational AR Applications. To a degree, the post-adoptionbehaviour regarding educational AR applications is understood by assessing the sustainable dimension of technology acceptance, the quality of information systems, and the users' expectations.

UTAUT3 is relevant because it emphasizes the cognitive, emotional, and behavioural dimensions of users and the impact of these dimensions on users' interaction with, and appraisal of, new technologies. Within the framework, the assessment of educational AR applications by users is based on the trade-offs between learning-related ease, perceived usefulness, hedonic utility, and the resources available, along with the social dimension, personal innovativeness, and habit. All these dimensions will impact the use of educational AR applications. Users' satisfaction and loyalty transcend the adoption of the technology.

In this context, the Information Systems Success Model (ISSM) will extend UTAUT3. UTAUT3 will examine users' perceptions of educational AR applications in view of the integration of system, information, and service quality. Thus, the combination of UTAUT3 and ISSM will allow the researcher to assess satisfaction from both the user and the system standpoint.

Expectation–Confirmation Theory (ECT) identifies a connection between user satisfaction and user loyalty after system use. ECT describes the satisfied user as one who has their expectations fulfilled during system use, is more likely to continue using the system, and will recommend the system to other users. Therefore, ECT proposes that user satisfaction precedes user loyalty.

Sustainable Consumption Practices (SCP), which are also included in the proposed model, are a user's post-adoptionbehaviour that is influenced by sustainability and represent a user's satisfaction and loyalty. Satisfaction and loyalty are perceived to be the same; however, in this instance, the user's sustainability concern will most likely define the degree of satisfaction and loyalty. This model suggests users who are advocates for the sustainable and conscientious use of technology and digital resources will have higher satisfaction and loyalty toward Educational AR Applications. Consequently, SCP is incorporated in the model

as a moderating variable that positively impacts the relationship between satisfaction and loyalty.

The main theoretical contribution of this research is integrating these four dimensions in one model. The proposed model is focused on the satisfaction and loyalty of young users of Educational AR Applications and is distinct and novel compared to other models. The proposed model is the synthesis of the technology acceptance model (UTAUT3), the information systems quality model (ISSM), the post-adoption behaviour model (ECT), and sustainability theory (SCP).

Unified Theory of Acceptance and Use of Technology 3 (UTAUT3)

The Unified Theory of Acceptance and Use of Technology 3 (UTAUT3) develop a model to explain technology users' behavioural response. Traditional technology acceptance models focus mainly on perceived usefulness and ease of use. UTAUT3 goes beyond these areas by incorporating cognitive, social, motivational, and behavioural dimensions, which are relevant to users' adoption assessments. In educational AR technology, all these dimensions and their relevant factors are significant in that AR technology users' satisfaction would largely depend on the features of the AR technology (which to a large extent consists of the users' learning experience and the users' enjoyment as well as the users' social and personal context).

Performance Expectancy and User Satisfaction

Performance Expectancy involves the perception that educational AR applications positively impact learning, appraisals, and the completion of tasks. In the literature, the perception among learners of the usefulness of a given educational technology positively correlates with the satisfaction of those learners since educational technology makes learning tasks less cumbersome. While the presence of positive relationships mentioned has been substantiated in much of technology adoption research, the presence of positive relationships in educational AR is largely missing, especially among the young adult population in Malaysia. For this reason, the study proposes that the level of performance expectancy positively correlates with the satisfaction pertaining to educational AR applications.

H1: Performance Expectancy has a significant positive effect on User Satisfaction.

Effort Expectancy and User Satisfaction

The measure of effort expectancy covers how difficult it is for users to learn and understand educational augmented reality applications. When applications are designed to be easy to understand and use, it improves the learning experience. Other research has established that the use of simple educational technologies increases learner satisfaction because learners are able to focus on the problems of the learning content and not the learner support technologies. Therefore, educational augmented reality applications that have simple and clear designs and easy-to-use navigation are expected to have high user satisfaction.

H2: Effort Expectancy has a significant positive effect on User Satisfaction.

Social Influence and User Satisfaction

Social influence describes the perception users have of support and motivation they receive from peers, instructors, family, and other significant people in relation to the use of educational AR applications. Recommendations from instructors and classmates usually amplify users' confidence in the use of novel learning technologies. Earlier studies show that

the socially positive environments of users' educational technologies improve their confidence and acceptance and, thus, their satisfaction. Hence, it is presumed that the stronger the social influence, the greater the user satisfaction.

H3: Social Influence has a significant positive effect on User Satisfaction.

Facilitating Conditions and User Satisfaction

Facilitating conditions entail the requisite resources and supports, including the requisite technical infrastructure and institutional supports, that allow users to engage with educational AR applications. Potential users of educational technology, such as AR applications, have many barriers to participation. The provision of supportive infrastructure and resources decreases barriers to the use of technology, and, thus, improves user satisfaction. Earlier research provides evidence that enhancing facilitating conditions (the supportive resources and infrastructure) improves user satisfaction, as users need uninterrupted access to educational technologies. Thus, user satisfaction is positively correlated to facilitating conditions.

H4: Facilitating Conditions have a significant positive effect on User Satisfaction.

Hedonic Motivation and User Satisfaction

Hedonic motivation concerns the intrinsic enjoyment and excitement of users from using educational AR applications. AR technologies offer users exciting and pleasurable experiences that transform the traditional methods of Instructional Design. Previous studies have shown that pleasure contributes to the satisfaction of the users, considering that pleasurable experiences of learning encourage users to learn more. Users who consider educational AR applications to be exciting and pleasurable are expected to be more satisfied.

H5: Hedonic Motivation has a significant positive effect on User Satisfaction.

Price Value and User Satisfaction

The price value dimension outlines the trade-offs that consumers of educational AR applications perceive among the monetary, temporal, and physical investments. Users of educational AR applications are more satisfied when the application is perceived to have a high level of educational value relative to the outlay. Earlier studies posit that the positive price value perception entails positive price perception of educational technologies. The extent of price value perception is likely to boost the level of satisfaction of users.

H6: Price Value has a significant positive effect on User Satisfaction.

Habit and User Satisfaction

Habit denotes the likelihood of users continually utilizing educational AR applications after repeated exposures. Interacting with AR technologies often builds an understanding that reduces the ambiguity of the technologies, which builds confidence during learning activities. Existing studies show habitual use of technologies creates positive experiences after the adoption of the technologies and builds satisfaction. Thus, habit is anticipated to have a positive effect on user satisfaction.

H7: Habit has a significant positive effect on User Satisfaction.

Personal Innovativeness and User Satisfaction

Personal innovativeness describes an individual's proclivity for trying new technologies. Users with a higher degree of personal innovativeness tend to have a greater level of curiosity regarding new educational technologies and can adjust to more digital learning environments more readily. Previous research indicates that innovative people tend to be more open to educational technologies and report a higher degree of satisfaction because of their greater search for innovative learning. As a result, it is expected that user satisfaction is positively influenced by personal innovativeness.

H8: Personal Innovativeness has a significant positive effect on User Satisfaction.

2.2 Information Systems Success Model (ISSM)

DeLone and McLean created the Information Systems Success Model (ISSM) to show how system quality, information quality, and service quality influence users' assessments of information systems. Within educational Augmented Reality (AR) applications, quality dimensions define users' learning experiences and satisfaction. ISSM and UTAUT3 have a fundamental difference. While UTAUT3 is concerned with users' psychological and behavioural attributes, ISSM is concerned with the characteristics of the technology, both with respect to service. Therefore, the combination of ISSM and UTAUT3 establishes the bounds and scope of the user satisfaction constructs.

System Quality and User Satisfaction

System quality looks at performance from a technical perspective, focusing on reliability, usability, responsiveness, accessibility, and operational stability of Educational AR Applications. Systems that operate at a high quality create a minimal hassle interaction with the educational content. The literature has shown that more reliable and user-friendly educational systems create better experiences for users and a greater level of satisfaction. Educational AR Applications that are of a higher system quality will create a greater level of user satisfaction.

H9: System Quality has a significant positive effect on User Satisfaction.

Information Quality and User Satisfaction

The attributes of accurate, complete, pertinent, clear, and constructive information regarding learning content in educational AR applications refer to the quality of information. Content that is accurate, clear, and relevant to the learner increases the learner’s confidence in the application and helps the learner achieve the learning goal. Past studies indicate that the information in digital learning systems affects users' evaluation of users toward the digital learning systems. The assumption, therefore, is that information quality impacts users’ satisfaction positively.

H10: Information Quality has a significant positive effect on User Satisfaction

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Service Quality and User Satisfaction

The provision of service quality includes supportive and assistive technical services, responsiveness, and active support when users exercise the educational AR applications. Quality supportive service induces a sense of security, solves technical problems and users' cumbersome issues quickly, and improves the learning experience. Service quality is assumed to improve user satisfaction.

H11: Service Quality has a significant positive effect on User Satisfaction.

2.3 Expectation-Confirmation Theory (ECT)

Expectation–Confirmation Theory (ECT) explains users' behaviours toward the acceptance of newer technologies. Compared to their previous experiences, users develop new expectations regarding systems and, accordingly, new experiences. Systems that meet or surpass new expectations achieve confirmation, which results in users' satisfaction. Satisfaction translates to continued use, advocacy, and emotional attachment toward the system.

About the Educational Augmented Reality (AR) Applications, ECT places user satisfaction before user loyalty. Although the acceptance of the technology and the quality of the system shape the preliminary evaluations of users, the primary focus regarding the technology is the satisfaction of the user after the initial use of the system. Educational AR Applications that provide users with the tools to create meaningful and engaging learning experiences are likely to attain user loyalty.

Research in the digital learning, information systems, and instructional technologies sectors indicates that satisfaction and loyalty are positively correlated. Satisfied users commonly use a system more, communicate about the system positively, and develop an emotional attachment to the system. For this reason, the present research argues that user satisfaction positively influences user loyalty for Educational AR Applications.
H12: User Satisfaction has a significant positive effect on User Loyalty.

2.4 Sustainable Consumption Practices (SCP)

Sustainable Consumption Practices (SCP) are all about consuming goods, services, and technologies carefully and wishfully to lessen the negative impacts SCP aims to tackle on society, environment, and economy. SCP is more about the careful consumption and use of technologies and resources. It also caters to the creation of safe and sustainable digital learning spaces, along with the sustainable use of learning resources.

Due to the rising appreciation of environmental sustainability, a substantial population of young adults is exercising their influence over the educational technologies made available to them. Students are choosing digital learning systems that embody supportive educational methods that save resources, along with integrating an environmental sustainability and resource-saving attitude and concern into the process of education. For this reason, focusing on sustainability becomes essential when accounting for the post-adoptive behaviour of users of educational technologies.

It is almost universally accepted that user satisfaction is a direct and important driver of user loyalty, while previous studies indicated that user satisfaction may affect user loyalty to educational technologies differently. The loyalty of users of educational technologies may be determined by their level of satisfaction, as well as their perceptions and values, in particular their concern for the environment and social justice. Educational technologies that resonate with these users' values sustain their loyalty. Users of educational technologies that have a lower sustainability and social justice consciousness may have a less sustained loyalty to the technology, despite being highly satisfied.

This study suggests that, in relation to user loyalty, Sustainable Consumption Practices (SCP) should be considered as a moderating factor rather than a direct predictor. When viewed as a moderating factor, SCP suggests that sustainability-oriented users will demonstrate long-term loyalty towards educational AR applications because of the positive

learning outcomes resulting from these experiences. Also, using SCP in this way to explain post-adoption behaviour helps enrich the literature related to educational technology.

H13: Sustainable Consumption Practices positively moderate the relationship between User Satisfaction and User Loyalty such that the relationship becomes stronger when Sustainable Consumption Practices are high.

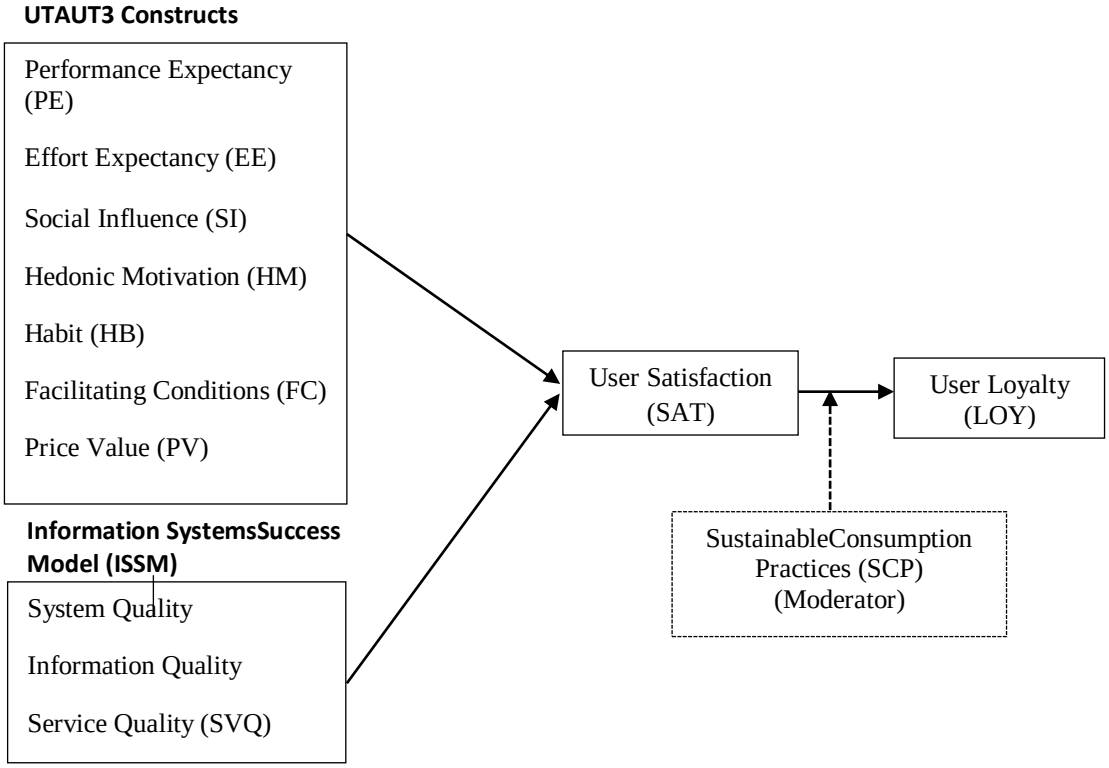


Fig. 1. Proposed Conceptual Framework

3.0. RESEARCH METHODOLOGY

This study used a quantitative research methodology to determine the elements that impact user satisfaction and loyalty to educational Augmented Reality (AR) applications for young adults in Malaysia. A quantitative methodology was applied because the study intended to evaluate the relationships of multiple latent constructs from the Unified Theory of Acceptance and Use of Technology 3 (UTAUT3), the Information Systems Success Model (ISSM), Expectation–Confirmation Theory (ECT), and Sustainable Consumption Practices (SCP), to name a few. To assess these constructs, Partial Least Squares Structural Equation Modelling (PLS-SEM) was used to deal with a variety of constructs and the complexities of mediation and moderation.

A cross-sectional survey design was used to collect data from a single group of respondents at a single time. This design has become standard in research pertaining to information systems and educational technology due to its ability to capture user perception, attitude, and the behavioural response of a population. The design of a structured survey also enabled the researcher to gather a homogeneous sample of data that was sufficient for statistical analysis and validity of the proposed hypotheses.

3.1 Population, Sampling, and Data Collection

The focus group for this study was Malaysian young adults aged 18-34 who have used educational Augmented Reality (AR) Applications. For this study, the researchers used a type of non-random sampling, known as purposive sampling. They distributed an online questionnaire hosted on Google Forms via various university-affiliated and other online networks. Questionnaire responses were checked for quality. Incomplete responses, duplicate submissions, and invalid responses were removed. After cleaning the data, 384 questionnaires remained and were selected for further data analysis. This also surpassed the recommended sample size for PLS-SEM analysis.

3.2 Research Instrument

The primary research tool was a survey with questions adapted from existing scales to the UTAUT3, Information Systems Success Model, User Satisfaction, User Loyalty and Sustainable Consumption Practices (SCP). In order to adapt certain questions to the context of educational Augmented Reality (AR) applications, minor changes were made to the questions, while keeping their original meaning and context.

The survey was composed of two sections. The first section captured demographic data (age, gender, education, and prior experience with educational AR). The second section contained questions related to the study constructs. These questions were scaled on a five-point Likert-type scale ranging from 1 (Strongly Disagree) to 5 (Strongly Agree).

The survey was content validated for clarity, ease of understanding, and bias prior to data collection. Faculty experts in Information Systems, Educational Technologies, Research Methodologies, and Quantitative Measurement reviewed the survey. The survey underwent minor edits for clarity and ease of understanding, while maintaining the original meaning of the research constructs and bias. The research constructs, the number of scale items, and the sources of the scale items are in Table 1.

Table 1. Measurement of Constructs

Construct	No. of Items	Adapted From
Performance Expectancy (PE)	4	Venkatesh et al. (2012)
Effort Expectancy (EE)	4	Venkatesh et al. (2012)
Social Influence (SI)	2	Venkatesh et al. (2012)
Facilitating Conditions (FC)	4	Venkatesh et al. (2012)
Hedonic Motivation (HM)	2	Venkatesh et al. (2012)
Habit (HB)	3	Venkatesh et al. (2012)
Price Value (PV)	3	Venkatesh et al. (2012)
Personal Innovativeness (PI)	3	Agarwal and Prasad (1998)
System Quality (SYQ)	4	DeLone and McLean (2003); Petter et al. (2008)
Information Quality (IQ)	4	DeLone and McLean (2003); Petter et al. (2008)
Service Quality (SQ)	4	DeLone and McLean (2003); Petter et al. (2008)

User Satisfaction (SAT)	5	Bhattacherjee (2001)
User Loyalty (LOY)	4	Oliver (1999); Dick and Basu (1994)
Sustainable Consumption Practices (SCP)	4	Quoquab et al. (2019)

3.3 Data Analysis Technique

Data wereanalysed using Partial Least Squares Structural Equation Modelling (PLS-SEM). SmartPLS was the software utilized to do this analysis. PLS-SEM requires two analyses: the measurement model and the structural model.

The measurement model assessment analysed the indicator reliability, and the measurement model's internal consistency, convergent and discriminant validity were evaluated. Then, the structural model was analysed by assessing the presence of collinearity and the determination coefficient (R^2), and the (f^2), (Q^2), and (SRMR) were evaluated the structural model integration, and hypothesis testing was done using the bootstrapping method.

In addition, moderation analysis was done to evaluate the extent to which Sustainable Consumption Practices (SCP) moderate the association of User Satisfaction with User Loyalty of educational Augmented Reality (AR) applications.

4. RESULTS AND FINDINGS

4.1 Preliminary Data Analysis

Before evaluating the measurement and structural models, preliminary checks were conducted to assess the suitability of the dataset for Partial Least Squares Structural Equation Modelling (PLS-SEM). One of the required checks was the data normality test. In this case, the skewness and kurtosis as provided by SPSS were analysed. PLS-SEM does not require the data to be normally distributed in a multivariate sense, though the quality and fit of the data for more elaborate and advanced statistical procedures may benefit from an assessment of the distribution.

As seen in Table 2, none of the skewness values were outside the acceptable ranges of −2 to +2, and the kurtosis values were within the suggested bounds as well. Therefore, the dataset was considered appropriate for the subsequent PLS-SEM analysis.

Table 2.Normality Test

Item	Skewness		Kurtosis	
	Statistic	Std. Error	Statistic	Std. Error
SQ1	-0.326	0.125	-0.750	0.250
SQ2	-0.572	0.125	0.126	0.250
SQ3	-0.568	0.125	0.271	0.250
SQ4	-0.580	0.125	-0.427	0.250
C	-	0.	-	0.

Q1		0.481	125	0.277	250
	C	-	0.	-	0.
Q2		0.565	125	0.057	250
	C	-	0.	0.	0.
Q3		0.613	125	190	250
	C	-	0.	-	0.
Q4		0.543	125	0.129	250
	S	-	0.	-	0.
YQ1		0.388	125	0.608	250
	S	-	0.	0.	0.
YQ2		0.608	125	279	250
	S	-	0.	1.	0.
YQ3		0.967	125	215	250
	S	-	0.	0.	0.
YQ4		0.761	125	710	250
	S	-	0.	3.	0.
I1		1.422	125	320	250
	S	-	0.	-	0.
I2		0.543	125	0.477	250
	S	-	0.	-	0.
I3		0.555	125	0.606	250
	F	-	0.	-	0.
C1		0.531	125	0.350	250
	F	-	0.	0.	0.
C2		0.858	125	837	250
	F	-	0.	0.	0.
C3		0.618	125	059	250
	F	-	0.	0.	0.
C4		0.766	125	087	250
	H	-	0.	0.	0.
M1		0.623	125	101	250
	H	-	0.	0.	0.
M2		0.778	125	491	250
	H	-	0.	1.	0.
M3		0.984	125	113	250
	H	-	0.	-	0.
B1		0.359	125	0.258	250
	H	-	0.	-	0.
B2		0.233	125	0.562	250
	H	-	0.	-	0.
B3		0.521	125	0.097	250
	P	0.0	0.	-	0.
V1		39	125	0.671	250
	P	-	0.	-	0.
V2		0.236	125	0.590	250
	P	-	0.	-	0.
V3		0.288	125	0.672	250
	P	-	0.	-	0.
I1		0.565	125	0.309	250
	P	-	0.	-	0.
I2		0.596	125	0.114	250
	P	-	0.	1.	0.
S1		0.885	125	357	250
	P	-	0.	1.	0.
S2		0.947	125	603	250
	P	-	0.	0.	0.
S3		0.675	125	498	250
	P	-	0.	-	0.
S4		0.619	125	0.205	250
	P	-	0.	-	0.
S5		0.555	125	0.530	250

	P	-	0.	-	0.
I3		0.456	125	0.535	250
	L	-	0.	-	0.
1		0.166	125	0.632	250
	L	-	0.	-	0.
2		0.400	125	0.167	250
	L	-	0.	-	0.
3		0.288	125	0.579	250
	L	-	0.	-	0.
4		0.311	125	0.741	250

4.2 Measurement Model Assessment

The measurement model was examined following the preliminary data analysis to verify the reliability and validity of the measurement model before assessing the structural model. Hair et al. (2022) suggested that several aspects be examined, including the reliability of indicators and dimensions, and the evaluation of convergent and discriminant validity. Assessment of indicator reliability examined outer loadings, whereas evaluation of the reliability of the constructs was conducted using Cronbach's alpha and composite reliability (CP). Convergent validity was assessed using average variance extracted (AVE), and evaluation of discriminant validity was based on the Fornell–Larcker criterion and Heterotrait–Monotrait Ratio (HTMT).

Indicator Reliability

Table 3 shows how outer loadings for all measurement items. Hair et al. (2022) assert that to indicate reliability, the threshold for loading is that the value should be greater than 0.70. Most measurement items met this threshold. However, two indicators, SI1 and SYQ4, had loading values which failed to meet the threshold, and thus were omitted from the measurement model. At the conclusion of the omission of the indicators, the remaining measurement items had outer loading values that were satisfactory.

Table 3.Outer loading

Construct	Items	Outer Loading	Construct	Items	Outer Loading
Service Quality	SQ1	0.794	Habit	HB1	0.934
	SQ2	0.918		HB2	0.892
	SQ3	0.889		HB3	0.902
	SQ4	0.789	Price Value	PV1	0.783
Information Quality (IQ)	IQ1	0.863		PV2	0.914
	IQ2	0.844		PV3	0.929
	IQ3	0.900	Personal Innovativeness	PI1	0.938
	IQ4	0.878		PI2	0.917
System Quality	SYQ1	0.920		PI3	0.797
	SYQ2	0.927	User Satisfaction	SAT1	0.879
Social Influence	SI2	0.918		SAT2	0.820
	SI3	0.889		SAT3	0.830
Facilitating Conditions	FC1	0.875		SAT4	0.819
	FC2	0.866		SAT5	0.825
	FC3	0.857	User Loyalty	LOY1	0.923

	FC4	0.779	LOY2	0.931
Hedonic Motivation	HM1	0.941	LOY3	0.916
	HM3	0.945	LOY4	0.880

After the removal of SI1 and SYQ4, the indicators from Table 2 had outer loadings greater than 0.70. Because there were no other issues with construct reliability, the measurement items with outer loadings were retained for the follow-up study (Hair et al., 2022).

Evaluating Internal Consistency Reliability and Convergent Validity

To measure the internal consistency reliability, the values of Cronbach's alpha and composite reliability (CR) were computed. To evaluate the convergent validity, the average variance extracted (AVE) was considered.

Table 4.Internal Consistency Reliability and Convergent Validity

Construct	Cronbach's Alpha	Composite Reliability (CR)	Average Variance Extracted (AVE)
Service Quality	0.875	0.870	0.723
Information Quality	0.892	0.886	0.746
System Quality	0.831	0.824	0.741
Social Influence	0.790	0.780	0.819
Facilitating Conditions	0.871	0.865	0.713
Hedonic Motivation	0.935	0.933	0.882
Habit	0.901	0.895	0.827
Price Value	0.876	0.845	0.765
Personal Innovativeness	0.923	0.869	0.790
User Satisfaction	0.887	0.882	0.680
User Loyalty	0.928	0.927	0.819

From Table 4, since all values of Cronbach's alpha and composite reliability were above 0.70, it shows that internal consistency reliability was satisfactory. Also, all the AVE values were above 0.50; therefore, convergent validity was also satisfied (Hair et al., 2022). Thus, since the measurement model was validated for reliability and convergent validity, it was also justified to be used to assess the structural model.

4.2.1 Discriminant Validity

Discriminant validity tests the empirically distinctive quality for each structure in relation to the remaining structures in the research model. Following the suggestions provided by Hair et al. (2022), the Fornell-Larcker criterion and Heterotrait-Monotrait Ratio (HTMT) were both used to assess the discriminant validity. These two methods show that the latent structures are separable from the other structures in the model.

Table 5. Fornell–Larcker Criterion

	Information Quality	Facilitating Conditions	Habit	Hedonic Motivation	User Loyalty	User Satisfaction	Personal Innovativeness	Price Value	Service Quality	Social Influence	System Quality
Information Quality	**0.864**										
Facilitating Conditions	0.698	**0.845**									
Habit	0.535	0.553	**0.909**								
Hedonic Motivation	0.620	0.691	0.358	**0.939**							
User Loyalty	0.677	0.609	0.684	0.518	**0.905**						
User Satisfaction	0.673	0.633	0.446	0.624	0.534	**0.824**					
Personal Innovativeness	0.565	0.647	0.531	0.607	0.629	0.528	**0.889**				
Price Value	0.600	0.642	0.536	0.517	0.559	0.598	0.621	**0.875**			
Service Quality	0.747	0.708	0.425	0.642	0.589	0.779	0.602	0.577	**0.850**		
Social Influence	0.697	0.684	0.597	0.506	0.624	0.598	0.514	0.614	0.604	**0.905**	
System Quality	0.766	0.647	0.490	0.621	0.641	0.641	0.558	0.582	0.755	0.668	**0.861**

According to Table 5, the square roots of the average variance extracted for each construct are all greater than their corresponding inter-construct correlations. Peralta, Fornell, and Larcker recognized that the constructs in the model of the research do not overlap. Therefore, sufficient discriminant validity is presented (Hair et al., 2022).

Table 6 has the Heterotrait-Monotrait Ratios (HTMT) for the pairs of all model constructs. Table 6 shows that all HTMT values were below the 0.90 threshold (Hair et al., 2022). This indicates a satisfactory level of discriminant validity. The results of the table show that all the model constructs are empirically distinct. This means the measurement model was satisfactory for preparing the structural model.

4.3 Structural Model Assessment

Following the evaluation of the measurement model, the structural model was checked for adequacy to analyse the relationships specified among the latent constructs. Collinearity diagnostics, R^2, f^2, Q^2, SRMR, and other fit statistics were evaluated as per the guidance of Hair et al. (2022).

Table 6. HTMT

	Information Quality	Facilitating Conditions	Habit	Hedonic Motivation	User Loyalty	User Satisfaction	Personal Innovativeness	Price Value	Service Quality	Social Influence	System Quality
Information Quality											
Facilitating Conditions	0.795										
Habit	0.603	0.628									
Hedonic Motivation	0.683	0.768	0.389								
User Loyalty	0.748	0.682	0.755	0.555							
User Satisfaction	0.754	0.718	0.499	0.683	0.585						
Personal Innovativeness	0.639	0.748	0.612	0.653	0.712	0.582					
Price Value	0.687	0.752	0.629	0.573	0.637	0.681	0.720				
Service Quality	0.845	0.811	0.474	0.707	0.651	0.883	0.679	0.674			
Social Influence	0.834	0.837	0.711	0.595	0.730	0.716	0.630	0.763	0.725		
System Quality	0.895	0.766	0.569	0.716	0.733	0.748	0.658	0.694	0.884	0.835	

Collinearity Assessment

Variance Inflation Factor (VIF) was the measure of choice for assessing collinearity among the predictor constructs. In the structural model, as presented in Table 7, all VIF values were below the recommended threshold, meaning there was no concern of multicollinearity.

Table 7.Collinearity Statistics (VIF)

	VIF		VIF
SQ1	1.944	HB1	3.195
SQ2	3.774	HB2	2.764
SQ3	3.100	HB3	2.435
SQ4	1.640	PV1	1.546
IQ1	2.057	PV2	2.982
IQ2	2.172	PV3	3.115
IQ3	2.881	PI1	2.985
IQ4	2.432	PI2	3.000
SYQ1	2.007	PI3	1.798
SYQ2	2.664	SAT1	2.600
SYQ3	1.716	SAT2	2.082
SI2	1.690	SAT3	2.107
SI3	1.690	SAT4	1.950
FC1	2.610	SAT5	2.089
FC2	3.121	LOY1	3.797
FC3	2.400	LOY2	3.963
FC4	1.707	LOY3	3.363
HM1	4.027	LOY4	2.487

HM3	3.459

R^2 measures the explanatory power of the structural model. As shown in Table 8, the model accounts for a substantial portion of the variance for the endogenous constructs of User Satisfaction and User Loyalty. The model, therefore, provides a good degree of explanatory power.

Table 8. Coefficient of Determination (R^2)

Endogenous construct	**R^2**	**Relationship**
User Satisfaction	0.668	Moderate
User Loyalty	0.286	Weak

Examine Effect size (f^2) to assess the contribution of each exogenous construct to the endogenous variables individually. In accordance with Cohen (1988), effect sizes ranging from small to large mean that some constructs have a greater practical effect on Perceived Satisfaction than others.

Table 9. Effect Size (f^2)

Independent Construct	Dependent Construct	f^2	Effect Size
Service Quality	User Satisfaction	0.288	Medium
Information Quality	User Satisfaction	0.004	No Effect
System Quality	User Satisfaction	0.004	No Effect
Social Influence	User Satisfaction	0.012	No Effect
Facilitating Conditions	User Satisfaction	0.003	No Effect
Hedonic Motivation	User Satisfaction	0.047	Small
Habit	User Satisfaction	0.005	No Effect
Price Value	User Satisfaction	0.036	Small
Personal Innovativeness	User Satisfaction	0.007	No Effect
User Satisfaction	User Loyalty	0.400	Large

Table Service Quality had a medium effect on User Satisfaction (f^2 = 0.288). User Satisfaction had a large effect on User Loyalty (f^2 = 0.400). The effects of Hedonic Motivation and Price Value were small. The effects of Information Quality, System Quality, Social Influence, Facilitating Conditions, Habit, and Personal Innovativeness were negligible.

Predictive Relevance (Q^2)

The relevance of prediction for the structural model was determination was through the blindfolding procedure. For Hair et al. (2022), Q^2 values above zero affirm the structural model suggests predictive relevance for the endogenous constructs. As shown in Table 10, the Q^2 values of User Satisfaction (0.620) and User Loyalty (0.385) were both above zero, which confirms the model demonstrates adequate predictive relevance.

Table 10.Predictive Relevance (Q^2)

Construct	Q^2
User Satisfaction	0.620
User Loyalty	0.385

The Model Fit

The overall model fit was assessed using the Standardized Root Mean Square Residual (SRMR). Hair et al (2022) propose that SRMR values below 0.08 indicate a good model fit. In other cases of exploratory PLS-SEM investigations of more complicated research models, SRMR values in the range of 0.08 to 0.10 can still be deemed satisfactory. As shown in Table 11, the SRMR value was 0.110, thus capturing an acceptable level of model fit for the suggested structural model.

Table 11. Model Fit (SRMR)

	Standardized Root Mean Square Residual (SRMR)
Model Fit	0.110

4.4 Hypothesis Testing

Proposed hypotheses were bootstrapped in SmartPLS. Coefficients, t values, and p-values were analysed. According to Hair et al. (2022), considerable hypotheses had p-values under 0.05. Table 12 shows the results of the hypothesis tests.

Table 12.Hypothesis Testing Results

Hypothesis	Relationship	β	t-value	p-value	Decision
H1	Information Quality → User Satisfaction	0.069	1.226	0.110	Not Supported
H2	System Quality → User Satisfaction	-0.066	1.291	0.098	Not Supported
H3	ServiceQuality →User Satisfaction	0.560	10.167	<0.001	Supported
H4	Social Influence →User Satisfaction	0.104	1.997	0.023	Supported
H5	Facilitating Conditions → User Satisfaction	-0.062	1.078	0.140	Not Supported
H6	Hedonic Motivation → User Satisfaction	0.192	4.136	<0.001	Supported
H7	Habit → User Satisfaction	0.058	1.535	0.062	Not Supported
H8	Price Value → User Satisfaction	0.162	4.055	<0.001	Supported
H9	Personal Innovativeness→User	-0.072	1.652	0.049	Supported*

	Satisfaction				
H10	User Satisfaction → User Loyalty	0.534	13.956	<0.001	Supported

Table 12 shows that Information Quality and System Quality had an insignificant effect on User Satisfaction. It also shows that Social Influence, Service Quality, Hedonic Motivation, Price Value, and Personal Innovativeness had a significant negative effect on User Satisfaction. There was a (β = -0.072, p = 0.049) negative record of relationship between User Satisfaction and Personal Innovativeness, meaning that the increase of Personal Innovativeness increased the User dissatisfaction.

4.5 MODERATION ANALYSIS

The SmartPLS bootstrapping procedure was employed to analyse the moderating effect of Sustainable Consumption Practices (SCP) between User Satisfaction and User Loyalty. The interaction effect was deemed significant based on the standardized path coefficient (β), the t and p values. Table 13 illustrates the results of the moderation analysis.

Table 13. Moderation Analysis

Hypothesis	Relationship	β	Standard Deviation	t-value	p-value	Decision
H13	Sustainable Consumption Practices × User Satisfaction → User Loyalty	0.070	0.017	4.216	0.000	Supported

The data in Table 13 shows that the moderating effect of Sustainable Consumption Practices (SCP) on the relationship between User Satisfaction and User Loyalty was significant (β = 0.070, t = 4.216, p < 0.001). Hence, H12 was supported. Accordingly, the results denoted that Sustainable Consumption Practices influence the positive relationship between User Satisfaction and User Loyalty. This further means that users who exhibit a higher degree of sustainable consumption practices will remain loyal to educational Augmented Reality (AR) applications. This loyalty is exhibited if users are satisfied with the learning experience.

Figure 2 displays how Sustainable Consumption Practices (SCP) moderate the relationship between User Satisfaction and User Loyalty. When Sustainable Consumption Practices are high, User Satisfaction and User Loyalty tend to be positively correlated to a greater extent. When Sustainable Consumption Practices are low, User Satisfaction and User Loyalty are less likely to be positively correlated. This means that users of educational Augmented Reality (AR) applications who exhibit more Sustainable Consumption Practices are more likely to remain loyal to the educational AR applications if they are satisfied with the learning experience.

5. DISCUSSION

This study investigated user satisfaction and loyalty with educational Augmented Reality (AR) applications among young adults and the factors that affect them. Specifically, this research unified the theory of the acceptance and use of technology 3 (UTAUT3), the Information Systems Success Model (ISSM), and Sustainable Consumption Practices (SCP). The results indicate that these three combined elements (the technological quality, the motivation factors, and sustainability) have a significant impact on the user experience and the continued use of educational AR applications

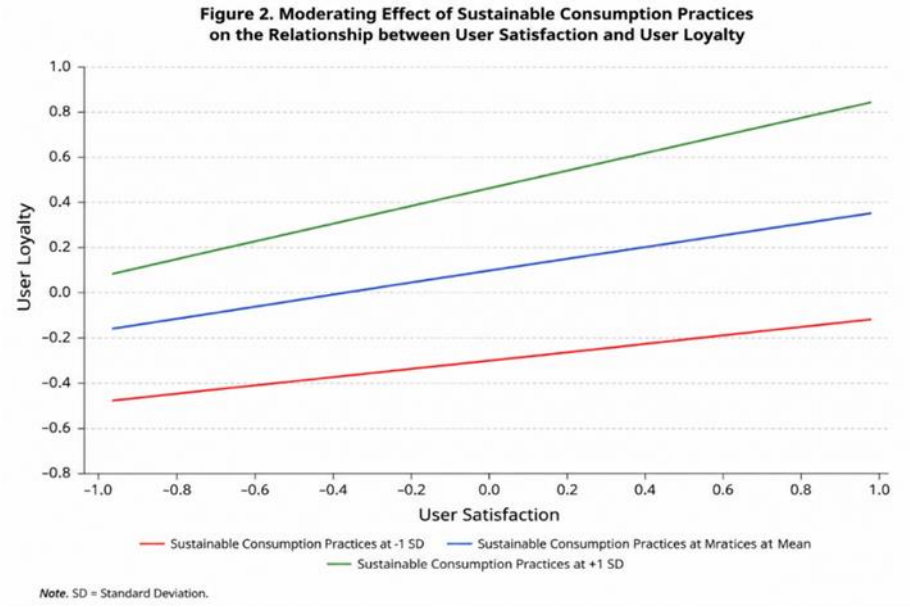


Fig 2. Moderating Effect of Sustainable Consumption Practices on the Relationship between User Satisfaction and User Loyalty

5.1 UTAUT3 Constructs and User Satisfaction

The study revealed that not all UTAUT3 constructs influenced User Satisfaction. Social Influence, Hedonic Motivation, and Price Value positively impacted User Satisfaction. The other constructs did not have a statistically significant impact.

The influence Social Influence had indicated that positive user satisfaction with the Educational Augmented Reality Applications stems from the praise and/or feedback given by friends, colleagues, educators, family, and/or significant others. This positive user satisfaction of Educational Augmented Reality Applications aligns with the UTAUT3 theory, which positions Social Influence as one of the main factors of new technology acceptance and user satisfaction in the educational domain, where most of the learning is done in a group (collaborative) manner.

Hedonic Motivation impacted User Satisfaction positively too. This shows that user satisfaction of Educational Augmented Reality Applications is greater when the learning process is enjoyable and interesting. User satisfaction and learning is likely to be maximized when Educational Augmented Reality Applications provide playful and engaging immersive learning.

Price Value positively impacted User Satisfaction too. This means that users of Educational Augmented Reality Applications feel satisfied when the learning outcomes justify the costs associated with the service and/or the monetized learning. Educational Augmented Reality Applications that are affordably priced and that offer high-quality instructional augment are likely to meet user satisfaction.

On the contrary, Performance Expectancy, Effort Expectancy, Habit, and Facilitating Conditions had little to no relationship with User Satisfaction. The results indicate that young adults may have sufficient digital skills and technology knowledge. Therefore, User Satisfaction may not depend on the easy-to-use and facilitation features of the educational AR application. Rather, User Satisfaction of the educational AR application may be dependent on the emotional, social, and perceived value aspects.

5.2 Information Systems Success Model (ISSM) Constructs and User Satisfaction

From the ISSM constructs, only Service Quality had a positive relation with User Satisfaction. Information Quality and System Quality did not demonstrate any statistically significant relation.

Despite System Quality and Information Quality not significantly relating to User Satisfaction, Service Quality remains significant. This relates to the likelihood of the influence service, system, and support provision of Educational AR on the satisfaction of users. If service, system, and support provision facilitates the service and system with support and assist users, service providers will obtain a positive satisfaction response.

From the discussion, System Quality and Information Quality will not significantly relate to User Satisfaction. This may show that users perceive System Quality and Information Quality and the accuracy of the Information as a baseline expectation and not factors that contribute to satisfaction. Therefore, System Quality and Information Quality will not significantly relate to User Satisfaction if a baseline of quality is attained.

5.3 The outcomes User Satisfaction and User Loyalty

The data confirmed that User Satisfaction directly and positively influences User Loyalty. The study confirmed that satisfied users are likely to continue the active use of educational AR applications. The users are also likely to recommend the educational applications to their friends and colleagues. This finding corresponds with the Expectation Confirmation Theory (ECT). According to ECT, if users are satisfied with the outcome from the use of the technology, they will continue to use the technology and will remain loyal to it.

5.4 Moderating Effect of Sustainable Consumption Practices

From the moderation analysis, it was observed that Sustainable Consumption Practices strengthened the association between User Satisfaction and User Loyalty. This suggests that users with highly developed sustainable consumption practices are likely to exhibit a loyalty response to their satisfaction with educational AR applications. Users with sustainable preferences value the technologies that support the sustainable consumption of educational resources and environmentally sustainable constructions of learning.

The results suggest that the integration of UTAUT3, the ISSM, and Sustainable Consumption Practices shows an understanding of user behavior regarding educational AR applications. While the motivation and service-related components of a system are likely to increase user satisfaction, sustainable consumption practices are likely to be the moderating element in the satisfaction-loyalty relationship. Therefore, sustainable consumption practices are associated with the extensive use of educational technologies.

6. PRACTICAL IMPLICATION

The results suggest that AR developers in the educational sector should focus on the following to elevate User Satisfaction. Developers should offer consistent systems, prompt, and responsive technical support, personalized learning assistance, and pleasant, fun learning experiences at little to no cost. Educational institutes can bolster the adoption of AR

by offering collaborative learning activities that promote Social Influence and Student Engagement. Moreover, the development of the Sustainable Consumption Practices by policymakers and educational institutes will promote the long-term use of educational AR.

7. THEORETICAL IMPLICATIONS

Integrating UTAUT3, the Information Systems Success Model (ISSM), and Sustainable Consumption Practices, this study aims to elaborate on User Satisfaction and User Loyalty toward educational AR applications. The results indicate that Social Influence, Hedonic Motivation, Price Value, and Service Quality User Satisfaction. Also, Sustainable Consumption Practices appear to positively relate to User Satisfaction, User Loyalty, and the creativity of educational AR sustainable research.

8. LIMITATIONS AND FUTURE RESEARCH

This study has several issues, primarily related to the research design, sample, and scope of constructs included in the study. First, this study is cross-sectional, and as such, the implications on User Satisfaction and User Loyalty over time is unknown. Some form of a longitudinal study should be applied. Second, the population consisted of young adults in Malaysia between the ages of 18 and 34. Therefore, many of the findings are not generalizable. The addition of various age populations and cultures is needed in the studies to come. Third, with the addition of constructs such as trust, perceived usefulness, learning efficacy, technology readiness, and engagement, the other studies would be more robust. Research may also evaluate various educational AR applications, various educational levels, as well as various learning environments.

9. CONCLUSION

This study concluded that Social Influence, Hedonic Motivation, Price Value, and Service Quality all have considerable impact on User Satisfaction, which in turn affects User Loyalty to educational AR applications. Among young adults in Malaysia, Sustainable Consumption Practices bolster the connection between User Satisfaction and User Loyalty. The findings suggest that successful implementation and repeated use of educational augmented reality applications rely on the quality of the technology and the satisfaction and loyalty of users, as well as service and sustainability considerations. This integrated framework helps both the theory and practice of the sustainable educational augmented reality applications for researchers, developers, educators, and policymakers.

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CONFLICT OF INTEREST STATEMENT

The authors declare no competing financial or personal interests that could have influenced the research or its findings.

CO-AUTHOR CONTRIBUTIONS

Yuana Iwan: Conceptualizing, designing the methodology, conducting the research investigations, analyzing and formally processing the data, curating the data, and visualizing the data, as well as drafting the manuscript and overseeing and conducting revisions on the manuscript.

Assoc. Prof. Ing. Grace Phang: overlooking the conceptual framework and methodology, as well as supervising the research, validating the research and manuscript with focus on the revisions and administration of the research.

DATA AVAILABILITY STATEMENT

Data will be available from the author on request. As a result of privacy and ethical considerations, the data will not be available publicly.

ETHICS APPROVAL

The ethical standards of Universiti Malaysia Sabah were adhered to in this study. This study was conducted with voluntary participation. Before the data collection, all respondents were informed and gave their consent.

SUPPLEMENTARY DATA

There are no supplements with this article.

DECLARATION OF GENERATIVE AI AND AI-ASSISTED TECHNOLOGIES IN THE WRITING PROCESS

The authors state that the use of generative AI and AI-assisted technologies were not involved in the writing, analyzing, and/or preparing of this manuscript.

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