Understanding Augmented Reality App Loyalty: The Roles of System and Individual Factors and the Moderating Effect of Sustainability among Young Adult Users

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ABSTRACT

The increasing adoption of Augmented Reality (AR) applications in educational environments has highlighted the importance of understanding the factors associated with user satisfaction and loyalty among young adult users. This study investigates the influence of system and individual factors on perceived satisfaction and loyalty towards educational AR applications, with Sustainable Consumption Practices (SCP) acting as a moderating variable. This study integrates the Information Systems Success Model (ISSM), UTAUT3, and sustainability perspectives to develop a comprehensive research framework. A quantitative approach was employed, and data were collected from 400 young adult users in Malaysia. The data were analysed using Partial Least Squares Structural Equation Modelling (PLS-SEM) through SmartPLS 4.0. The findings revealed that service quality, social influence, hedonic motivation, price value, and personal innovativeness were significantly associated with perceived satisfaction towards educational AR applications. Service quality emerged as the strongest predictor of satisfaction. In addition, perceived satisfaction was significantly associated with loyalty towards educational AR applications. The findings also confirmed that Sustainable Consumption Practices significantly moderated the relationship between perceived satisfaction and loyalty. This study contributes to the existing literature by extending AR research beyond technology adoption towards post-adoption loyalty behaviour. The findings provide useful insights for educational institutions, AR developers, and digital marketers in designing sustainable and engaging AR experiences capable of enhancing long-term user loyalty.

Keywords: Augmented Reality, perceived satisfaction, loyalty, Information Systems Success Model (ISSM), UTAUT3, sustainable consumption practices, educational AR applications, PLS-SEM.

INTRODUCTION

Augmented Reality (AR) technology has rapidly transformed digital interactions by providing immersive and interactive experiences across various industries, including retail, entertainment, tourism, healthcare, and education. The increasing adoption of AR applications among young adults reflects the growing demand for innovative digital platforms that enhance user engagement, personalization, and experiential value. As mobile technologies continue to evolve, AR applications are no longer viewed merely as technological tools but as strategic platforms that influence consumer experiences, satisfaction, and long-term loyalty.

Recent advancements in digital technologies have intensified competition among application providers, making user loyalty an essential determinant of sustainability and long-term business success. In the context of AR applications, loyalty represents users' continuous intention to reuse and recommend applications based on their overall experience and perceived benefits. Loyal users are more likely to engage in repeated usage, positive word-of-mouth communication, and long-term platform commitment, all of which contribute to the competitive advantage of digital businesses. Consequently, understanding the factors associated with user satisfaction and loyalty towards AR applications has become increasingly important for researchers, developers, and businesses operating in digital environments.

Although previous studies have examined technology adoption using models such as the Unified Theory of Acceptance and Use of Technology (UTAUT) and the Information Systems Success Model (ISSM), the understanding of user loyalty towards AR applications remains fragmented. Existing studies have predominantly focused on behavioural intention, technology acceptance, usability, and adoption behaviour, while limited attention has been given to post-adoption outcomes such as satisfaction and loyalty. Furthermore, many previous studies have examined system-related factors and individual behavioural factors separately, resulting in limited understanding of how these dimensions collectively influence loyalty formation among AR application users.

Young adults represent one of the most active user groups in digital technology adoption due to their high engagement with mobile applications, immersive technologies, and digital platforms. Their familiarity with emerging technologies has accelerated the use of AR applications across multiple contexts, including entertainment, retail, social media, and education. As digital natives, young adults tend to evaluate technological experiences not only based on functionality and convenience but also on enjoyment, personalization, and sustainability-related values. Therefore, investigating the factors influencing their loyalty towards AR applications is particularly relevant in today's digitally connected environment.

In addition, sustainability-related perspectives remain underexplored in the AR application context. Growing awareness of sustainable consumption practices has significantly influenced users' digital consumption behaviour, particularly among young adults who increasingly prioritize ethical, social, and sustainable values in their technology usage decisions. However, limited empirical studies have investigated whether sustainability strengthens or weakens the relationship between satisfaction and loyalty towards AR applications. This limitation highlights the need for a more comprehensive framework integrating technological, individual, and sustainability perspectives to explain AR app loyalty.

Therefore, this study seeks to examine the roles of system and individual factors in influencing satisfaction and loyalty towards AR applications among young adult users. Specifically, this study integrates constructs derived from the Information Systems Success Model (ISSM) and the Unified Theory of Acceptance and Use of Technology (UTAUT3) to provide a more comprehensive understanding of AR app loyalty formation. In addition, sustainability is incorporated as a moderating variable to examine its moderating effect on the relationship between satisfaction and loyalty.

This study contributes to the existing literature in several ways. First, the study extends AR literature by focusing on loyalty as a post-adoption outcome rather than merely behavioural intention or initial adoption. Second, the integration of ISSM and UTAUT3 provides a more comprehensive framework for understanding both technological and individual determinants of AR app loyalty. Third, the inclusion of sustainability as a moderating variable contributes to the emerging discussion on sustainable digital consumption behaviour among young adult users. Finally, the findings offer valuable managerial insights for AR developers, digital platform providers, and businesses seeking to design more engaging, sustainable, and user-oriented AR experiences capable of enhancing long-term customer loyalty.

LITERATURE REVIEW

Augmented Reality Applications and User Loyalty

Augmented Reality (AR) technology has gained significant attention due to its ability to create immersive, interactive, and personalized digital experiences across various industries, including retail, tourism, healthcare, entertainment, and education. Recent advancements in mobile computing and immersive technologies have accelerated the widespread adoption of AR applications among young adult users, particularly within digitally connected environments (Rauschnabel et al., 2022; Dwivedi et al., 2023). AR applications enable users to interact with digital content in real-time, thereby enhancing engagement, experiential value, and overall user experience.

In digital platform environments, user loyalty has become a critical determinant of long-term business sustainability and competitive advantage. Loyalty generally refers to users' intention to continuously use and recommend a digital platform based on positive experiences and perceived value (Hollebeek et al., 2023). Loyal

users contribute to business growth through repeated usage, positive electronic word-of-mouth, and long-term engagement with digital platforms. Consequently, understanding the factors influencing loyalty towards AR applications has become increasingly important for businesses and application developers.

Despite the growing interest in AR technologies, previous studies have primarily focused on behavioural intention, technology acceptance, usability, and user engagement rather than post-adoption outcomes such as satisfaction and loyalty (Yuan et al., 2023; Chen & Lin, 2024). Furthermore, many studies have examined technological dimensions and individual behavioural factors separately, resulting in limited understanding of how these factors collectively shape long-term AR app loyalty. This limitation highlights the need for a more integrated framework capable of explaining loyalty formation within immersive digital environments.

Information Systems Success Model (ISSM)

The Information Systems Success Model (ISSM), developed by William H. DeLone and Ephraim R. McLean, has been widely applied to evaluate the effectiveness and success of information systems across various digital contexts. The model suggests that system quality, information quality, and service quality significantly influence user satisfaction and behavioural outcomes (DeLone & McLean, 2003). Due to its comprehensive explanatory capability, ISSM has been extensively adopted in studies related to e-commerce, mobile applications, digital platforms, and emerging technologies.

Within AR application environments, system quality refers to the technical performance, reliability, usability, accessibility, and responsiveness of the application. High system quality enhances users' interaction experiences and improves overall perceptions towards digital platforms (Al-Adwan et al., 2023). Information or content quality represents the relevance, accuracy, timeliness, and usefulness of AR-generated content, while service quality refers to the level of support, personalization, and assistance provided to users during application usage (Nisar et al., 2024).

Previous studies have demonstrated that ISSM dimensions positively influence user satisfaction, continuance intention, and loyalty in digital technology environments (Tam et al., 2023; Al-Maroof et al., 2024). In immersive technology contexts, users are more likely to remain loyal to AR applications when they perceive the system to be efficient, informative, interactive, and capable of delivering high-quality user experiences. However, existing AR studies utilizing ISSM remain relatively limited and primarily focus on adoption and usage intention rather than post-adoption loyalty behaviour.

Furthermore, most previous studies have examined either technological quality dimensions or behavioural acceptance factors independently, resulting in fragmented understanding of AR app loyalty formation. Therefore, integrating ISSM within the present study provides a valuable theoretical foundation for understanding how system-related qualities contribute to user satisfaction and loyalty towards AR applications among young adult users.

Unified Theory of Acceptance and Use of Technology (UTAUT3)

The Unified Theory of Acceptance and Use of Technology (UTAUT) is one of the most widely applied theoretical models for explaining users' acceptance and usage behaviour towards emerging technologies. Originally developed by Viswanath Venkatesh and colleagues, the model integrates several technology acceptance theories to explain behavioural intention and technology usage behaviour. Over time, the framework has evolved to accommodate broader technological and consumer contexts, leading to the development of UTAUT2 and subsequently UTAUT3, which incorporate additional individual and contextual factors relevant to modern digital environments.

UTAUT3 emphasizes the importance of individual-related determinants such as social influence, facilitating conditions, hedonic motivation, price value, habit, and personal innovativeness in influencing users' behavioural responses towards technology adoption and continued usage. Recent studies have shown that these factors significantly influence users' satisfaction, continuance intention, and loyalty within digital platform ecosystems (Venkatesh et al., 2022; Dwivedi et al., 2023).

Social influence reflects the extent to which users perceive that important others encourage or support their technology usage behaviour, while facilitating conditions refer to the availability of resources, technical infrastructure, and support required for effective technology usage. In addition, hedonic motivation has become increasingly relevant in immersive technology contexts due to the entertainment and experiential nature of AR applications. Users are more likely to engage with AR applications when they perceive the experience as enjoyable, interactive, and emotionally rewarding (Rauschnabel et al., 2022).

Price value represents users' evaluation of the benefits gained from AR applications relative to the associated costs of using the technology. Meanwhile, habit and personal innovativeness also play significant roles in influencing continued technology usage behaviour, particularly among young adults who are highly exposed to digital innovations and mobile technologies.

Although previous studies have extensively applied UTAUT-related frameworks in technology adoption research, existing studies primarily focus on behavioural intention and initial adoption stages rather than long-term loyalty outcomes (Al-Adwan et al., 2023; Yuan et al., 2023). Moreover, limited studies have integrated UTAUT3 with system-related quality dimensions to explain loyalty formation within AR application environments. Therefore, integrating UTAUT3 into the present study enables a more comprehensive understanding of how individual behavioural factors influence satisfaction and loyalty towards AR applications among young adult users.

Sustainability and AR App Loyalty

Sustainability has emerged as an increasingly important consideration in digital consumption behaviour due to growing public awareness of environmental, social, and ethical responsibilities. In contemporary digital environments, users are becoming more conscious of how technologies and digital platforms contribute to sustainable lifestyles, responsible consumption, and long-term societal well-being. As a result, sustainability-related values are increasingly influencing users' attitudes, satisfaction, and loyalty towards digital applications and services (Confente et al., 2023; Gupta et al., 2024).

Among young adults, sustainability awareness is particularly significant as this user group tends to demonstrate stronger concerns regarding ethical consumption, environmental responsibility, and sustainable technological practices. Young users are more likely to support digital platforms and applications that align with their personal values and sustainability expectations. Consequently, sustainability has become an important strategic consideration for businesses seeking to strengthen long-term customer relationships and enhance digital platform loyalty.

In the context of AR applications, sustainability may influence how users evaluate their experiences and maintain long-term engagement with digital platforms. AR technologies can support sustainability initiatives through reduced physical consumption, enhanced digital interaction, virtual experiences, and efficient information delivery. Users who perceive AR applications as supporting sustainable practices may develop stronger emotional attachment, satisfaction, and loyalty towards the applications (Dwivedi et al., 2023).

Despite the increasing importance of sustainability in digital business research, limited studies have examined sustainability as a moderating factor in AR loyalty research. Previous research has mainly focused on technology acceptance and usability, experiential value and relatively little on sustainability-related influences on post-adoption behaviour. Furthermore, the moderating role of sustainability in strengthening the relationship between satisfaction and loyalty remains underexplored within immersive technology environments.

Therefore, the present study incorporates sustainability as a moderating variable to examine whether sustainability-related values strengthen the relationship between satisfaction and loyalty towards AR applications among young adult users. The inclusion of sustainability provides a broader understanding of digital consumer behaviour and contributes to the growing discussion on sustainable technology adoption and long-term digital loyalty.

Satisfaction and Loyalty Towards AR Applications

User satisfaction is widely recognized as one of the most important determinants of loyalty in digital technology and consumer behaviour research. Satisfaction generally refers to users' overall evaluation of their experiences after interacting with a product, service, or digital platform. In technology-related contexts, satisfaction is formed when users perceive that the application successfully meets or exceeds their expectations in terms of functionality, usefulness, enjoyment, and overall experience (Oliver, 2014).

In AR application environments, satisfaction plays a critical role in shaping users' post-adoption behaviour due to the immersive and experiential nature of the technology. Users who experience high-quality interactions, engaging content, smooth system performance, and enjoyable experiences are more likely to develop positive evaluations towards AR applications. Previous studies have demonstrated that satisfied users are more likely to continue using digital applications, recommend them to others, and develop long-term loyalty behaviours (Hollebeek et al., 2023; Tam et al., 2023).

Loyalty in digital platform environments refers to users' intention to continuously use and support a particular application over time. Loyal users often exhibit repeated usage behaviour, positive electronic word-of-mouth, emotional attachment, and resistance to switching to alternative platforms. In increasingly competitive digital markets, loyalty has become a key indicator of long-term business sustainability and platform success.

Several studies have reported that satisfaction is positively associated with loyalty across various digital technology contexts, including mobile applications, e-commerce platforms, social media applications, and immersive technologies (Al-Maroof et al., 2024; Chen & Lin, 2024). Within AR contexts, users who perceive greater satisfaction from immersive experiences are more likely to remain loyal towards AR applications. However, existing AR studies focusing specifically on the satisfaction–loyalty relationship remain relatively limited, particularly among young adult users.

Furthermore, previous studies have rarely considered how sustainability-related values may strengthen or influence the relationship between satisfaction and loyalty within AR environments. As sustainability awareness continues to increase among digitally active consumers, understanding the role of sustainability in loyalty formation becomes increasingly relevant. Therefore, the present study proposes that satisfaction is significantly associated with loyalty towards AR applications and that sustainability moderates this relationship among young adult users.

Hypothesis Development

Content Quality and Satisfaction

Content quality refers to the relevance, accuracy, usefulness, timeliness, and attractiveness of information or digital content provided within AR applications. In immersive technology environments, users rely heavily on high-quality digital content to support meaningful and engaging experiences. Previous studies have shown that content quality is significantly associated with user satisfaction and continued technology usage behaviour (Nisar et al., 2024; Yuan et al., 2023).

AR applications that provide interactive, informative, and visually appealing content are more likely to enhance users' overall experiences and satisfaction levels. Conversely, poor-quality or irrelevant content may reduce users' interest and negatively affect their perceptions of the application.

H1: Content quality is positively associated with satisfaction towards AR applications among young adult users.

System Quality and Satisfaction

System quality refers to the overall technical performance of a digital application, including reliability, usability, accessibility, responsiveness, and ease of navigation. In AR application environments, high system quality

enables users to experience smoother interactions, faster response times, and more efficient system functionality. Previous studies have consistently reported that system quality is positively associated with user satisfaction in digital platforms and immersive technology environments (Al-Adwan et al., 2023; Tam et al., 2023).

Users are more likely to feel satisfied when AR applications operate efficiently and provide seamless interactive experiences. Poor technical performance, system errors, or slow responsiveness may negatively affect user experiences and reduce satisfaction levels. Therefore, high-quality system performance is essential in enhancing positive user perceptions towards AR applications.

H2: System quality is positively associated with satisfaction towards AR applications among young adult users.

Service Quality and Satisfaction

Service quality refers to the support, assistance, personalization, and responsiveness provided by digital platform providers to users. In AR environments, service quality may include technical support, personalized recommendations, customer assistance, and continuous updates that enhance users' experiences. Previous studies have found that service quality positively contributes to user satisfaction and loyalty in digital platforms (Al-Maroof et al., 2024).

Users who receive reliable support and personalized services are more likely to perceive AR applications positively and remain satisfied with their experiences. Effective service quality enhances trust and strengthens users' emotional attachment towards digital applications.

H3: Service quality is positively associated with satisfaction towards AR applications among young adult users.

Social Influence and Satisfaction

Social influence refers to the extent to which individuals perceive those important others, such as friends, family members, or peers, encourage the use of a particular technology. In digital platform environments, social influence plays a significant role in shaping users' attitudes, perceptions, and behavioural outcomes, especially among young adults who are highly connected through social networks and online communities.

Previous studies have shown that positive recommendations and peer influence are significantly related to users' perceptions and satisfaction towards emerging technologies (Rauschnabel et al., 2022). In AR contexts, users may develop stronger satisfaction when they perceive social approval and positive feedback regarding the use of AR applications.

H4: Social influence is positively associated with satisfaction towards AR applications among young adult users.

Facilitating Conditions and Satisfaction

Facilitating conditions refer to the extent to which users believe that adequate technical infrastructure, resources, and support are available to assist them in using a technology effectively. In AR application environments, facilitating conditions may include device compatibility, internet accessibility, technical guidance, and customer support services. Previous studies have reported that facilitating conditions positively influence users' satisfaction and continued usage behaviour towards digital technologies (Venkatesh et al., 2022; Al-Maroof et al., 2024).

Users are more likely to experience satisfaction when they have sufficient resources and support to interact with AR applications without technical difficulties. The availability of reliable infrastructure and assistance enhances users' confidence and overall digital experiences.

H5: Facilitating conditions are positively associated with satisfaction towards AR applications among young adult users.

Hedonic Motivation and Satisfaction

Hedonic motivation refers to the enjoyment, pleasure, and entertainment users derive from using a particular technology. In immersive technology environments, hedonic motivation plays a particularly important role because AR applications are designed to provide interactive, engaging, and enjoyable experiences. Previous studies have consistently demonstrated that enjoyment-related experiences significantly influence users' satisfaction and loyalty towards digital applications (Rauschnabel et al., 2022; Dwivedi et al., 2023).

Users who perceive AR applications as enjoyable and entertaining are more likely to develop positive emotional responses and greater satisfaction. The immersive and experiential characteristics of AR technologies further strengthen the influence of hedonic motivation on users' behavioural outcomes.

H6: Hedonic motivation is positively associated with satisfaction towards AR applications among young adult users.

Habit and Satisfaction

Habit refers to the extent to which users perform behaviours automatically due to prior experiences and repeated usage. In digital technology environments, users who are familiar with and accustomed to using a particular application are more likely to continue engaging with the platform and experience greater satisfaction (Venkatesh et al., 2022).

Young adults who frequently use AR applications may develop habitual usage patterns that positively influence their comfort, confidence, and satisfaction towards the application. Habitual users generally experience fewer difficulties and are more likely to perceive AR applications positively.

H7: Habit is positively associated with satisfaction towards AR applications among young adult users.

Price Value and Satisfaction

Price value refers to users' cognitive evaluation of the benefits received from a technology relative to the associated costs of using the application. Users are more likely to feel satisfied when they perceive that the benefits and experiences gained from AR applications exceed the monetary or non-monetary costs incurred during usage.

Previous studies have shown that price value is significantly associated with users' satisfaction and behavioural responses towards digital technologies and mobile applications (Venkatesh et al., 2012; Dwivedi et al., 2023). In educational AR environments, users may evaluate the usefulness, enjoyment, and accessibility of AR applications against the costs associated with internet usage, subscriptions, or digital resources.

H8: Price value is positively associated with satisfaction towards AR applications among young adult users.

Personal Innovativeness and Satisfaction

Personal innovativeness refers to an individual's willingness to try and adopt new technologies or innovative digital solutions. Individuals with high levels of innovativeness are generally more open to experimenting with emerging technologies and are more likely to perceive new digital experiences positively. In the context of AR applications, personal innovativeness plays an important role in influencing users' perceptions, engagement, and satisfaction towards immersive technologies.

Previous studies have reported that innovative users tend to demonstrate more favourable attitudes and stronger satisfaction towards emerging digital applications due to their curiosity and openness to technological experimentation (Yuan et al., 2023; Gupta et al., 2024). Young adults with higher personal innovativeness are more likely to appreciate the interactive and immersive features offered by AR applications, leading to enhanced satisfaction.

H9: Personal innovativeness is positively associated with satisfaction towards AR applications among young adult users.

Satisfaction and Loyalty

Previous studies have consistently demonstrated that satisfied users are more likely to continue using digital applications, recommend them to others, and develop long-term loyalty towards immersive technologies (Hollebeek et al., 2023; Chen & Lin, 2024). Within educational AR environments, users who experience positive and engaging interactions are more likely to maintain continuous usage and loyalty towards AR applications.

Therefore, satisfaction is expected to play a central role in influencing loyalty behaviour among young adult AR application users.

H10: Satisfaction is positively associated with loyalty towards AR applications among young adult users.

The Moderating Effect of Sustainability

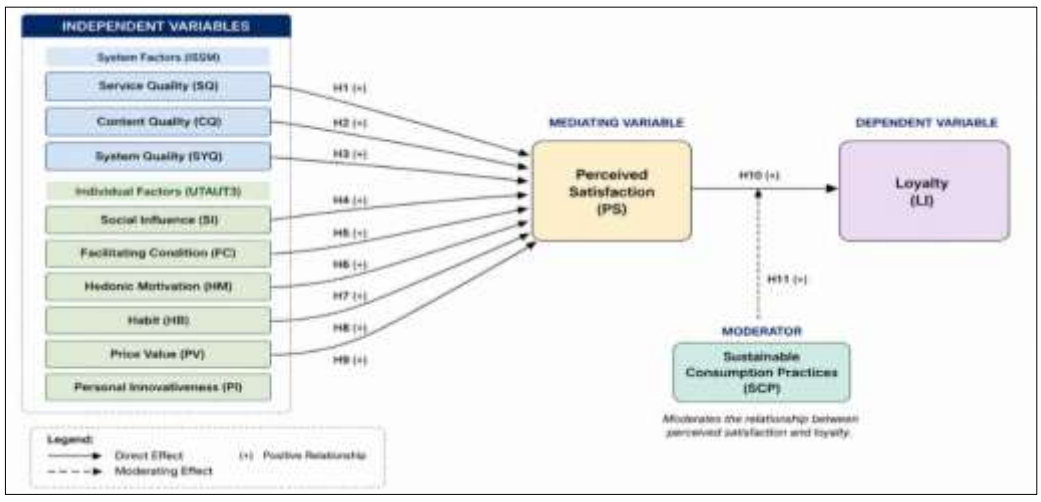
Sustainability has become an increasingly influential factor in shaping users' digital consumption behaviour and long-term platform engagement. Users who value sustainability are more likely to develop stronger emotional attachment and loyalty towards digital platforms that align with their ethical, environmental, and social values. Among young adults, sustainability awareness is significantly associated with consumption preferences and behavioural decisions within digital environments.

Previous studies suggest that sustainability-related values strengthen positive behavioural outcomes, including customer loyalty and continued engagement with digital platforms (Confente et al., 2023; Gupta et al., 2024). In the context of AR applications, users who perceive sustainable value in digital experiences may demonstrate stronger loyalty when they are satisfied with the application.

Therefore, sustainability is expected to strengthen the positive relationship between satisfaction and loyalty towards AR applications.

H11: Sustainability positively moderates the relationship between satisfaction and loyalty towards AR applications among young adult users.

Figure 1. Research Model



Sources: Viswanath Venkatesh et al. (2012); William H. DeLone & Ephraim R. McLean (2003); Anol Bhattacherjee (2001); Richard L. Oliver (1980); Valarie Zeithaml et al. (1996); M. Joseph Sirgy (1985); Ken Peattie & Sue Peattie (2009).

METHODOLOGY

Research Design

This study employed a quantitative research approach to examine the relationships between system factors,

individual factors, satisfaction, sustainability, and loyalty towards AR applications among young adult users. A cross-sectional survey design was adopted because it allows researchers to collect data from many respondents within a specific period and is widely used in technology adoption and consumer behaviour studies.

The quantitative approach was considered appropriate for this study because it enables statistical analysis of relationships among variables and provides empirical evidence for hypothesis testing. Furthermore, the study aimed to examine causal relationships between multiple constructs within an integrated theoretical framework consisting of ISSM, UTAUT3, and sustainability perspectives.

Population and Sampling

The target population of this study consisted of young adult users aged between 18 and 34 years who had prior experience using Augmented Reality (AR) applications. Young adults were selected because they represent one of the most active groups in adopting immersive technologies and digital applications.

A non-probability purposive sampling technique was employed to select respondents who met the study criteria. Specifically, respondents were required to have prior experience using AR applications in contexts such as entertainment, retail, education, tourism, gaming, or social media. Data were collected through online survey distribution using digital platforms and social networking channels.

The minimum sample size requirement was determined based on Partial Least Squares Structural Equation Modelling (PLS-SEM) recommendations. Previous studies have suggested that PLS-SEM is suitable for complex research models involving multiple constructs and relationships (Hair et al., 2022). Therefore, the sample size was considered sufficient for conducting structural model analysis and hypothesis testing.

Participants were asked to evaluate educational Augmented Reality (AR) applications that they had previously used within the last six months. The respondents evaluated their experiences based on the educational AR application they used most frequently. Examples of educational AR applications included AR anatomy visualization applications, interactive science learning tools, AR language learning applications, virtual laboratory simulations, and mobile AR educational games. This approach ensured that respondents provided evaluations based on actual AR learning experiences rather than general perceptions of AR technology.

Research Instrument

The survey instrument was developed based on previously validated measurement scales adapted from prior studies related to the Information Systems Success Model (ISSM), UTAUT3, satisfaction, sustainability, and loyalty. Minor modifications were made to ensure suitability within the educational AR application context.

The questionnaire consisted of several sections. The first section collected respondents' demographic information, including age, gender, educational background, and AR application usage experience. The subsequent sections measured the study constructs, including content quality, system quality, service quality, social influence, facilitating conditions, hedonic motivation, habit, price value, personal innovativeness, perceived satisfaction, sustainable consumption practices, and loyalty.

All measurement items were assessed using a five-point Likert scale ranging from 1 ("strongly disagree") to 5 ("strongly agree"). The Likert scale was selected due to its suitability in measuring users' perceptions, attitudes, and behavioural responses in social science research.

Data Collection Procedure

Data collection was conducted through online survey distribution using platforms such as Google Forms and social media channels. Online data collection was considered appropriate because the target respondents were digitally active young adults with frequent internet and mobile application usage.

Prior to the actual data collection, a pilot test was conducted to ensure the clarity, reliability, and validity of the questionnaire items. Feedback obtained from pilot respondents was used to improve wording clarity and overall

questionnaire structure.

Respondents were informed about the purpose of the study, and participation was entirely voluntary. Confidentiality and anonymity of responses were assured to encourage honest and unbiased participation throughout the survey process.

Data Analysis Technique

The collected data were analysed using Partial Least Squares Structural Equation Modelling (PLS-SEM) through SmartPLS software. PLS-SEM was selected because it is suitable for examining complex predictive models involving multiple constructs, moderating effects, and latent variables.

The analysis process involved two stages: assessment of the measurement model and assessment of the structural model. The measurement model evaluation included reliability, convergent validity, and discriminant validity assessments using factor loadings, Composite Reliability (CR), Average Variance Extracted (AVE), and Cronbach's Alpha values. Subsequently, the structural model assessment examined path coefficients, coefficient of determination (R^2), effect size (f^2), predictive relevance (Q^2), and hypothesis testing using bootstrapping procedures.

Several control variables, including age, gender, AR usage frequency, and prior experience with AR applications, were incorporated into the structural model to isolate the effects of the focal constructs on perceived satisfaction and loyalty towards educational AR applications.

Furthermore, moderation analysis was conducted to examine the moderating effect of sustainability on the relationship between satisfaction and loyalty towards AR applications among young adult users.

To assess the potential issue of common method bias (CMB), Harman's single-factor test was conducted. The results indicated that the first factor accounted for less than 50% of the total variance, suggesting that common method bias was not a serious concern in this study. In addition, full collinearity assessment was performed, and all Variance Inflation Factor (VIF) values were below the recommended threshold of 3.3, further confirming the absence of significant common method bias.

FINDINGS

Respondents' Profile

A total of 400 respondents participated in this study. The majority of the respondents were female (n = 281, 70.3%), while 29.8% were male (n = 119). The respondents' mean age was 26.28 years (SD = 4.84), indicating that most participants were young adults aged between 18 and 34 years.

In terms of educational background, most respondents possessed a bachelor's degree (n = 186, 46.5%), followed by Diploma holders (n = 169, 42.3%). Regarding occupation, 27.8% worked in the private sector, 27.5% were employed in the government sector, while others were self-employed or engaged in other occupations. In addition, most respondents earned less than RM1,000 monthly (44.3%) and were single (75.4%).

The demographic findings suggest that young adults represent active users of educational AR applications and are highly engaged with immersive digital technologies

Measurement Model Assessment

The measurement model was assessed by evaluating indicator reliability, internal consistency reliability, convergent validity, and discriminant validity using SmartPLS

Indicator Reliability

Indicator reliability was evaluated through outer loadings. According to Hair et al. (2016), factor loadings should exceed 0.60. The results demonstrated that all retained items achieved satisfactory loading values above the recommended threshold. However, two items, namely SI1 and SYQ4, were removed to improve the measurement model.

Table 1: Outer Loadings

Construct	Items	Outer Loading
Service Quality	SQ1–SQ4	0.791–0.914
Content Quality	CQ1–CQ4	0.834–0.899
System Quality	SYQ1–SYQ3	0.806–0.918
Social Influence	SI2–SI3	0.891–0.918
Facilitating Condition	FC1–FC4	0.769–0.875
Hedonic Motivation	HM1–HM3	0.933–0.946
Habit	HB1–HB3	0.897–0.931
Price Value	PV1–PV3	0.770–0.928
Personal Innovativeness	PI1–PI3	0.804–0.936
Perceived Satisfaction	PS1–PS5	0.800–0.879
Loyalty	LI1–LI4	0.879–0.919

Internal Consistency Reliability

Internal consistency reliability was assessed using Composite Reliability (CR) and Cronbach's Alpha. The results indicated that all constructs exceeded the recommended threshold value of 0.70, confirming satisfactory internal consistency reliability.

Table 2: Composite Reliability and Cronbach's Alpha

Construct	Composite Reliability	Cronbach's Alpha
Service Quality	0.870	0.875
Content Quality	0.886	0.892
System Quality	0.824	0.831
Social Influence	0.780	0.790
Facilitating Condition	0.865	0.871
Hedonic Motivation	0.933	0.935
Habit	0.895	0.901

Price Value	0.845	0.876
Personal Innovativeness	0.869	0.923
Perceived Satisfaction	0.882	0.887
Loyalty	0.927	0.928

Convergent Validity

Convergent validity was assessed using the Average Variance Extracted (AVE). All constructs achieved AVE values above the recommended threshold value of 0.50, confirming adequate convergent validity.

Table 3 : Average Variance Extracted (AVE)

Construct	AVE
Service Quality	0.723
Content Quality	0.746
System Quality	0.741
Social Influence	0.819
Facilitating Condition	0.713
Hedonic Motivation	0.882
Habit	0.827
Price Value	0.765
Personal Innovativeness	0.790
Perceived Satisfaction	0.680
Loyalty	0.819

Discriminant Validity

Discriminant validity was assessed using the Fornell-Larcker criterion, cross-loadings, and the Heterotrait–Monotrait Ratio (HTMT). The Fornell-Larcker results showed that the square root of the AVE values for each construct exceeded the correlations with other constructs, confirming satisfactory discriminant validity.

In addition, all indicators demonstrated higher loadings on their respective constructs compared to other constructs, further supporting discriminant validity.

The HTMT values were also below the threshold value of 0.90, indicating that all constructs were empirically distinct from one another.

Table 4: Heterotrait–Monotrait Ratio (HTMT)

Construct	Highest HTMT Value

All Constructs	< 0.90

Structural Model Assessment

Collinearity Assessment

Collinearity issues were assessed using the Variance Inflation Factor (VIF). All VIF values were below the recommended threshold value of 5.0, indicating that multicollinearity was not a concern in this study.

Coefficient of Determination (R^2)

The coefficient of determination (R^2) was used to assess the explanatory power of the structural model. The R^2 value for perceived satisfaction was 0.668, indicating a moderate explanatory level. This suggests that 66.8% of the variance in perceived satisfaction was explained by service quality, content quality, system quality, social influence, facilitating condition, hedonic motivation, habit, price value, and personal innovativeness.

Meanwhile, the R^2 value for loyalty was 0.286, indicating a weak explanatory level. This result indicates that 28.6% of the variance in loyalty was explained by perceived satisfaction. Although the R^2 value for loyalty was relatively low, previous studies have suggested that behavioural outcomes such as loyalty are often influenced by multiple psychological, experiential, and contextual factors beyond satisfaction alone (Hair et al., 2022). Therefore, the obtained R^2 value remains acceptable within the context of exploratory behavioural research involving immersive technologies and digital consumer behaviour.

Table 5: Coefficient of Determination (R^2)

Endogenous Construct	R^2	Relationship
Perceived Satisfaction	0.668	Moderate
Loyalty	0.286	Weak

Hypothesis Testing

The bootstrapping procedure was employed to evaluate the significance of the proposed hypotheses. The findings revealed that six out of ten direct hypotheses were supported. Service quality demonstrated the strongest positive effect on perceived satisfaction ($\beta = 0.560$, $t = 10.167$, $p < 0.001$), followed by hedonic motivation ($\beta = 0.192$, $t = 4.136$, $p < 0.001$), price value ($\beta = 0.162$, $t = 4.055$, $p < 0.001$), and social influence ($\beta = 0.104$, $t = 1.997$, $p = 0.023$).

Personal innovativeness also significantly influenced perceived satisfaction, although the relationship was negative and weak ($\beta = -0.072$, $t = 1.652$, $p = 0.049$). In addition, perceived satisfaction significantly influenced loyalty towards educational AR applications ($\beta = 0.534$, $t = 13.956$, $p < 0.001$).

However, content quality, system quality, facilitating condition, and habit did not significantly influence perceived satisfaction.

Table 6: Hypothesis Testing Results

Hypothesis	Relationship	Beta	t-Value	p-Value	Result
H1	Content Quality → Perceived Satisfaction	0.069	1.226	0.110	Not Supported
H2	System Quality → Perceived Satisfaction	-0.066	1.291	0.098	Not Supported

H3	Service Quality → Perceived Satisfaction	0.560	10.167	0.000	Supported
H4	Social Influence → Perceived Satisfaction	0.104	1.997	0.023	Supported
H5	Facilitating Condition → Perceived Satisfaction	-0.062	1.078	0.140	Not Supported
H6	Hedonic Motivation → Perceived Satisfaction	0.192	4.136	0.000	Supported
H7	Habit → Perceived Satisfaction	0.058	1.535	0.062	Not Supported
H8	Price Value → Perceived Satisfaction	0.162	4.055	0.000	Supported
H9	Personal Innovativeness → Perceived Satisfaction	-0.072	1.652	0.049	Supported
H10	Perceived Satisfaction → Loyalty	0.534	13.956	0.000	Supported

Moderation Analysis

Moderation analysis was conducted to examine the moderating effect of Sustainable Consumption Practices (SCP) on the relationship between perceived satisfaction and loyalty towards educational AR applications.

The findings revealed that SCP significantly moderates the relationship between perceived satisfaction and loyalty ($\beta = 0.070$, $t = 4.216$, $p < 0.001$). This result indicates that users with stronger sustainable consumption practices demonstrate a stronger relationship between satisfaction and loyalty towards educational AR applications.

Table 7: Moderation Analysis Results

Hypothesis	Relationship	Beta	t-Value	p-Value	Result
H11	SCP × Perceived Satisfaction → Loyalty	0.070	4.216	0.000	Supported

Hypothesis Testing

The findings revealed that service quality, social influence, hedonic motivation, price value, and personal innovativeness were significantly associated with perceived satisfaction towards educational AR applications.

Among all predictors, service quality emerged as the strongest determinant of perceived satisfaction, indicating the importance of reliable systems, responsiveness, and high-quality digital services in enhancing users' experiences with educational AR applications. Hedonic motivation and price value also significantly contributed to users' satisfaction, suggesting that enjoyable experiences and perceived value play important roles in influencing positive evaluations towards AR applications.

However, content quality, system quality, facilitating condition, and habit did not significantly influence perceived satisfaction. These findings suggest that not all technological and behavioural factors contribute equally to users' satisfaction within educational AR environments.

Furthermore, the findings confirmed the significant moderating effect of Sustainable Consumption Practices (SCP) on the relationship between perceived satisfaction and loyalty. Users with stronger sustainability awareness demonstrated stronger loyalty towards educational AR applications when they experienced higher levels of satisfaction.

Overall, the findings support the integration of ISSM, UTAUT3, and sustainability perspectives in explaining

user satisfaction and loyalty towards educational AR applications among young adult users.

DISCUSSION

The present study examined the influence of system and individual factors on perceived satisfaction and loyalty towards educational AR applications among young adult users, with Sustainable Consumption Practices (SCP) acting as a moderating variable. Overall, the findings provide partial support for the integrated framework based on the Information Systems Success Model (ISSM), UTAUT3, and sustainability perspectives in explaining user loyalty towards educational AR applications.

The findings revealed that service quality was significantly associated with perceived satisfaction and emerged as the strongest predictor among all independent variables. This finding indicates that users place considerable importance on reliable systems, responsiveness, support services, and overall digital service experiences when evaluating educational AR applications. High-quality service experiences enhance users' perceptions and contribute positively to satisfaction levels. This result is consistent with previous studies emphasizing the importance of service quality in influencing satisfaction and post-adoption behaviour within digital technology environments.

In addition, social influence is significantly related to perceived satisfaction towards educational AR applications. This finding indicates that recommendations, peer influence, and social encouragement play important roles in shaping users' perceptions and satisfaction levels, particularly among young adult users who are highly connected through digital communities and social networks.

The findings further demonstrated that hedonic motivation positively influenced perceived satisfaction. This finding highlights the importance of enjoyment, entertainment, and immersive experiences within educational AR environments. Users are more likely to feel satisfied when AR applications provide engaging, enjoyable, and interactive experiences. Similarly, price value was significantly associated with perceived satisfaction, indicating that users evaluate AR applications based on the balance between perceived benefits and the costs associated with using the applications.

Interestingly, personal innovativeness demonstrated a significant but negative relationship with perceived satisfaction. This finding may suggest that highly innovative users possess higher expectations towards educational AR applications, causing them to evaluate existing AR technologies more critically. As a result, innovative users may become less satisfied when AR applications fail to meet their advanced technological expectations.

However, content quality, system quality, facilitating condition, and habit did not significantly influence perceived satisfaction. These findings indicate that technical and behavioural factors may not always directly contribute to users' satisfaction within educational AR environments. One possible explanation is that young adult users may prioritize experiential and emotional aspects, such as enjoyment and service experiences, over technical characteristics when evaluating AR applications.

In addition, perceived satisfaction was significantly associated with loyalty towards educational AR applications. Satisfied users are more likely to continue using AR applications, recommend them to others, and develop long-term commitment towards the platforms. This finding supports previous digital consumer behaviour studies suggesting that satisfaction is a critical determinant of loyalty and continued usage behaviour.

Importantly, the findings also confirmed the moderating role of Sustainable Consumption Practices (SCP) in the relationship between perceived satisfaction and loyalty. Users with stronger sustainability awareness demonstrated stronger loyalty towards educational AR applications when they experienced higher levels of satisfaction. This finding highlights the increasing importance of sustainability-related values in influencing digital consumption behaviour among young adult users.

The study contributes to the existing literature in several ways. First, the study extends educational AR research by focusing on loyalty as a post-adoption outcome rather than merely technology acceptance or behavioural

intention. Second, the integration of ISSM, UTAUT3, and sustainability perspectives provides a broader understanding of user satisfaction and loyalty formation within educational AR environments. Finally, the inclusion of SCP as a moderating variable contributes to the growing literature on sustainable digital consumer behaviour and immersive technology adoption.

Theoretical Implications

This study contributes to the existing literature on augmented reality (AR) applications, digital consumer behaviour, and technology adoption in several important ways. First, the study extends existing AR literature by focusing on loyalty as a post-adoption outcome rather than merely examining behavioural intention or initial technology acceptance. While many previous studies have concentrated on users' intention to adopt AR technologies, limited studies have explored the factors influencing long-term loyalty towards educational AR applications.

Second, this study contributes theoretically by integrating the Information Systems Success Model (ISSM), UTAUT3, and sustainability perspectives into a single comprehensive framework. The integration of system-related and individual-related factors offers a broader understanding of how technological and behavioural determinants collectively influence perceived satisfaction and loyalty within educational AR environments.

Third, the findings provide empirical evidence regarding the importance of service quality, hedonic motivation, social influence, price value, and personal innovativeness in influencing perceived satisfaction towards educational AR applications. The findings highlight that experiential, and emotional factors may play more important roles than technical characteristics in shaping satisfaction among young adult users.

Furthermore, this study contributes to the growing literature on sustainable digital consumer behaviour by examining the moderating effect of Sustainable Consumption Practices (SCP) on the relationship between perceived satisfaction and loyalty. The significant moderating effect suggests that sustainability-related values strengthen users' loyalty towards educational AR applications, thereby extending current discussions on sustainability within immersive technology and digital platform research.

Overall, the study enriches the theoretical understanding of user satisfaction and loyalty formation in educational AR environments and provides a foundation for future research involving immersive technologies, sustainability, and digital consumer behaviour.

Practical Implications

This study provides several practical implications for educational institutions, AR application developers, digital marketers, and businesses operating within digital learning environments. The findings revealed that service quality demonstrated the strongest association with perceived satisfaction towards educational AR applications. Therefore, organizations should prioritize improving responsiveness, reliability, technical support, and overall service experiences to enhance users' satisfaction and long-term engagement with AR applications.

The significant influence of hedonic motivation indicates that enjoyable and immersive experiences are important in shaping users' satisfaction. AR developers should focus on designing interactive, engaging, and visually appealing application features capable of enhancing users' enjoyment and emotional attachment towards educational AR platforms. Incorporating gamification, interactive simulations, and personalized learning experiences may further strengthen users' engagement and satisfaction levels.

In addition, social influence significantly is related to perceived satisfaction, suggesting that peer recommendations, social interactions, and community engagement play important roles in encouraging positive perceptions towards educational AR applications. Educational institutions and digital marketers may therefore leverage social media campaigns, peer-sharing activities, and collaborative learning communities to increase user engagement and application adoption.

The findings also demonstrated that price value positively influenced perceived satisfaction. This suggests that users evaluate educational AR applications based on the balance between perceived benefits and associated

costs. Consequently, businesses and educational providers should ensure that AR applications deliver meaningful educational value, accessibility, and cost-effective digital experiences to strengthen users' satisfaction and loyalty.

Furthermore, the moderating effect of Sustainable Consumption Practices (SCP) highlights the growing importance of sustainability-related values in influencing users' loyalty behaviour. Organizations should integrate sustainability-oriented initiatives and responsible digital practices into their AR application strategies to strengthen long-term loyalty among sustainability-conscious young adult users.

Overall, the findings emphasize the importance of combining high-quality service experiences, enjoyable digital interactions, social engagement, affordability, and sustainability values in enhancing user satisfaction and loyalty towards educational AR applications.

LIMITATIONS AND FUTURE RESEARCH

Despite the valuable contributions of this study, several limitations should be acknowledged. First, this study employed a cross-sectional research design, which limits the ability to examine changes in users' perceptions and behaviours over time. Future studies may consider using longitudinal approaches to investigate the long-term development of satisfaction and loyalty towards educational AR applications.

Second, the study focused specifically on young adult users in Malaysia. Although young adults represent active users of immersive digital technologies, the findings may not be fully generalizable to other age groups, cultural settings, or geographical contexts. Future research is encouraged to examine AR app loyalty across different countries, demographic groups, and educational environments to improve the generalizability of the findings.

Third, the study examined selected system-related and individual-related factors derived from ISSM and UTAUT3. Other potential determinants, such as trust, perceived usefulness, emotional attachment, user engagement, technological anxiety, affective commitment, and switching costs, were not included in the present model. Future studies may incorporate these additional psychological and behavioural variables to provide a broader understanding and improve the explanatory power of loyalty formation towards educational AR applications.

In addition, this study focused primarily on educational AR applications. Future research may extend the investigation to other AR application contexts, such as retail, tourism, healthcare, entertainment, and e-commerce environments, to compare users' behavioural responses across industries.

Finally, although Sustainable Consumption Practices (SCP) demonstrated a significant moderating effect, future studies may further explore other sustainability-related dimensions, including environmental awareness, ethical consumption, and green technology perceptions, to better understand the role of sustainability in digital consumer behaviour and immersive technology adoption.

CONCLUSION

This study examined the influence of system-related and individual-related factors on perceived satisfaction and loyalty towards educational Augmented Reality (AR) applications among young adult users, with Sustainable Consumption Practices (SCP) acting as a moderating variable. By integrating the Information Systems Success Model (ISSM), UTAUT3, and sustainability perspectives, the study provides a comprehensive understanding of user satisfaction and loyalty formation within educational AR environments.

The findings revealed that service quality, social influence, hedonic motivation, price value, and personal innovativeness significantly influenced perceived satisfaction towards educational AR applications. Among these factors, service quality emerged as the strongest predictor of satisfaction, highlighting the importance of reliable services, responsiveness, and high-quality digital experiences in enhancing users' perceptions towards AR applications. In addition, perceived satisfaction significantly influenced loyalty, indicating that satisfied users are more likely to continue using and supporting educational AR applications.

Furthermore, the study confirmed the significant moderating role of Sustainable Consumption Practices (SCP) in strengthening the relationship between perceived satisfaction and loyalty. This finding suggests that sustainability-related values play an increasingly important role in shaping users' long-term commitment towards educational AR applications among young adult users.

Overall, this study contributes to the growing literature on educational AR applications, digital consumer behaviour, and sustainable technology adoption. The findings provide valuable theoretical and practical insights for researchers, educational institutions, AR developers, and businesses seeking to enhance user satisfaction and long-term loyalty within immersive digital learning environments.

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