Augmented Reality as an Emerging Digital Technology in Education: An Integrated Acceptance and Satisfaction Model

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Abstract. This Augmented Reality (AR) is increasingly recognized as an emerging digital technology in education due to its ability to overlay virtual information onto real-world learning environments. By integrating immersive, interactive, and mobile learning features, AR enables learners to engage actively with educational content, enhancing experiential and ubiquitous learning. However, empirical studies that comprehensively examine learners' acceptance, satisfaction, and continued usage of AR-based educational applications remain limited. This study aims to investigate the determinants of learners' satisfaction and loyalty toward educational AR applications by positioning AR as a digital educational technology. An integrated research model is proposed, drawing on the Unified Theory of Acceptance and Use of Technology (UTAUT), the Information Systems Success Model (ISSM), and Expectation Confirmation Theory (ECT). The model incorporates social influence, facilitating conditions, hedonic motivation, habit, price value, personal innovativeness, and quality dimensions to explain learners' satisfaction and loyalty toward educational AR applications. Data were collected via an online survey from 400 young adults aged 18-34 with prior AR experience and analyzed using partial least squares structural equation modeling (PLS-SEM). Findings indicate that selected technology acceptance factors and service-related quality dimensions significantly influence learners' satisfaction, which in turn drives loyalty toward AR applications. The study contributes theoretically by integrating acceptance, system quality, and post adoption perspectives into a single explanatory framework, positioning AR as a robust digital learning technology. Practically, the findings provide actionable insights for educators, instructional designers, and developers in designing effective, user-centered AR-based learning solutions.

Keywords: Augmented Reality (AR); Digital Educational Technology; Technology Acceptance (UTAUT); Information Systems Success (ISSM); Expectation–Confirmation Theory (ECT); Learner Satisfaction & Loyalty

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1 Introduction

Augmented Reality (AR) has emerged as a transformative digital technology that enhances learning experiences by overlaying virtual elements onto real-world environments in real time (Azuma, 1997; Jang & Byun, 2021). Initially developed for industries such as entertainment and healthcare, the adoption AR in educational contexts has expanded significantly due to its ability to improve learner engagement, motivation, and conceptual understanding (Chiu et al., 2023; Jang & Byun, 2021). By integrating interactive 3D visualizations, contextual simulations, and immersive content, AR enables experiential learning that extends beyond conventional instructional methods (Alalwan et al., 2022; Dwivedi et al., 2023).

Learners could actively participate through real-time feedback, spatial interaction, and contextualized content delivery in AR context, particularly beneficial in disciplines requiring visualization and applied practice, including science, engineering, and medical education (Almaiah et al., 2022). These immersive affordances align with contemporary digital learning paradigms that emphasize learner-centered engagement and interactive knowledge construction.

Young adults, typically aged between 18 and 34, represent a key demographic in the adoption of emerging educational technologies. As digitally fluent users, they demonstrate strong preferences for interactive, visually rich, and self-directed learning environments (Al-Adwan et al., 2022; Talwar et al., 2023). While AR technologies align with these preferences, digital familiarity alone does not guarantee sustained usage as the young adults are known for ever changing preferences and switching behaviors. For AR applications to achieve long-term viability, they must generate not only initial acceptance but also satisfaction and loyalty. Despite growing research on AR in education, existing studies predominantly emphasize cognitive outcomes, learning performance, or short-term engagement effects (Jang & Byun, 2021; Almaiah et al., 2022). Limited attention has been given to post-adoption behaviors such as satisfaction and loyalty, which are critical for understanding continued usage and long-term commitment (Hsu & Lin, 2023; Ooi et al., 2023). Moreover, prior research often examines technological characteristics or user-related factors independently, without integrating both perspectives into a comprehensive explanatory model.

To address this gap, the present study integrates the Unified Theory of Acceptance and Use of Technology (UTAUT) (Venkatesh et al., 2012), the Information Systems Success Model (ISSM) (DeLone & McLean, 2003), and Expectation Confirmation Theory (ECT) (Bhattacherjee, 2001) to explain learners' satisfaction and loyalty toward educational AR applications. Specifically, the study examines the effects of social influence, facilitating conditions, hedonic motivation, habit, price value, personal innovativeness, service quality, content quality, and system quality on satisfaction, which subsequently influences loyalty. The proposed framework provides a comprehensive explanation of learners' post-adoption behaviour in educational AR environments.

2 Literature Review

2.1 Theoretical Foundation

The technology acceptance dimension of this study is grounded in the Unified Theory of Acceptance and Use of Technology (UTAUT2), developed by Venkatesh et al. (2012). UTAUT2 explains users' behavioural responses to technology adoption through several determinants that influence technology acceptance and continued use. In the context of educational augmented reality (AR) applications, this study extends the UTAUT perspective by incorporating social influence, facilitating conditions, hedonic motivation, habit, price value, and personal innovativeness to explain learners' evaluative responses toward AR technologies (Venkatesh et al., 2012; Faqih et al., 2021).

Habit reflects learners' tendency to use AR applications automatically based on prior experience and repeated exposure to the technology, thereby facilitating continued usage behaviour (Venkatesh et al., 2012). Price value refers to learners' cognitive evaluation of the benefits gained from AR applications relative to the effort, resources, or costs associated with their usage (Venkatesh et al., 2012). Personal innovativeness represents an individual's willingness to experiment with and adopt emerging digital technologies, influencing the likelihood of embracing innovative learning tools such as AR applications (Agarwal & Prasad, 1998; Al-Qaysi et al., 2021). Social influence reflects the extent to which important referent groups, including peers, instructors, and family members, encourage learners to use AR technologies (Venkatesh et al., 2012). Facilitating conditions refer to the availability of technological infrastructure, institutional support, and resources that enable effective utilization of AR applications (Venkatesh et al., 2012). Hedonic motivation captures the intrinsic enjoyment, fun, and immersive experience derived from interacting with AR-based learning environments, which can positively influence users' attitudes and evaluations of the technology (Venkatesh et al., 2012; Faqih et al., 2021).

Together, these factors explain learners' initial acceptance and evaluative perceptions of AR as a digital learning tool.

Complementing the acceptance perspective, this study incorporates system-related determinants derived from the Information Systems Success Model proposed by William H. DeLone and Ephraim R. McLean (2003). ISSM posits that system characteristics significantly influence user evaluations and satisfaction. In the context of educational AR applications, three quality dimensions are emphasized: content quality, system quality, and service quality.

Content quality refers to the relevance, accuracy, clarity, and pedagogical value of AR-based instructional materials. System quality reflects the technical performance of the application, including reliability, usability, responsiveness, and visual stability. Service quality captures the level of technical assistance, guidance, and support provided to users. High levels of content, system, and service quality enhance the overall learning experience and strengthen positive evaluations of the AR platform.

While UTAUT explains technology acceptance perceptions, ISSM highlights the importance of system performance attributes. To explain post-adoption evaluation, this study draws on Expectation-Confirmation Theory developed by Anol Bhattacherjee (2001). ECT posits that users form expectations prior to system use, and satisfaction arises when perceived performance meets or exceeds those expectations. In this framework, satisfaction represents learners' overall cognitive and affective assessment of their AR learning experience and serves as the central evaluative mechanism linking acceptance and quality perceptions to behavioural outcomes.

Loyalty is conceptualised as the ultimate outcome of interest. In educational AR contexts, loyalty reflects learners' intention to continue using the application, recommend it to others, and prefer it over alternative learning technologies. Loyalty represents sustained behavioural commitment and is a critical indicator of the long-term success and viability of emerging digital educational technologies.

By integrating UTAUT-based acceptance constructs, ISSM-based quality dimensions, and ECT's post-adoption evaluation logic, this study proposes an integrated acceptance-satisfaction model explaining how educational AR applications foster sustained learner loyalty. This integrated perspective contributes to digital education literature by bridging adoption-focused and system-quality research streams within a unified explanatory framework.

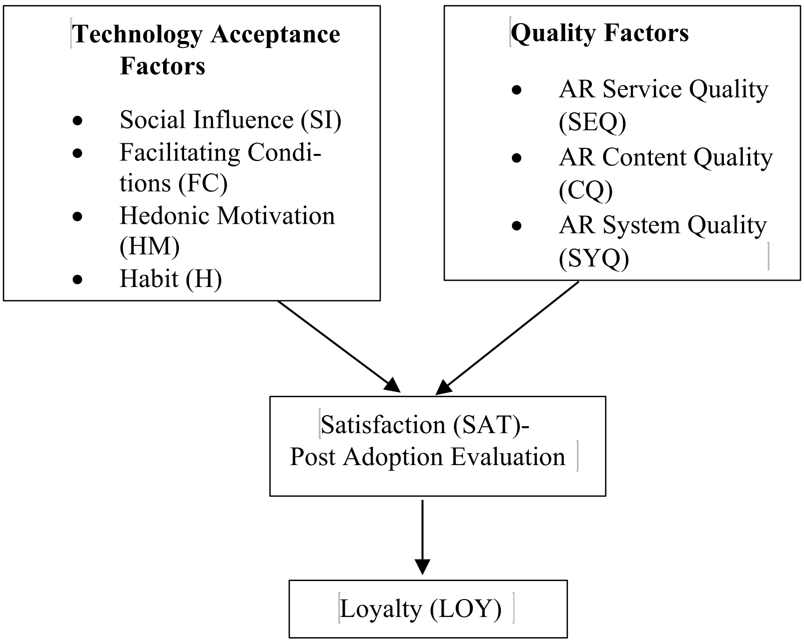

Fig. 1. Sources: Adapted from Viswanath Venkatesh et al. (2012); William H. DeLone & Ephraim R. McLean (2003); Anol Bhattacherjee (2001); Richard L. Oliver (1980); Valarie A. Zeithaml et al. (1996).

3 Hypotheses Development

3.1 Technology Acceptance Factors and Satisfaction

3.1.1 Social Influence and Satisfaction

Previous studies suggest that social influence plays an important role in shaping users' perceptions and evaluations of technology. Recommendations and encouragement from peers, instructors, and significant others can strengthen users' confidence and acceptance of technology, leading to more positive experiences and greater satisfaction (Venkatesh et al., 2012; Al-Adwan et al., 2023). In educational AR environments, learners who receive positive support regarding AR usage are more likely to develop favourable evaluations of the technology and experience higher levels of satisfaction.

H1: Social influence positively influences satisfaction toward educational AR applications.

3.1.2 Facilitating Conditions and Satisfaction

Facilitating conditions have been identified as an important determinant of users' experiences with technology. The availability of adequate technical support, infrastructure, and learning resources can reduce usage difficulties and improve the overall learning experience (Venkatesh et al., 2012; Dwivedi et al., 2023). In educational AR environments, sufficient institutional and technological support may enable learners to interact more effectively with AR applications, thereby enhancing satisfaction.

H2: Facilitating conditions positively influence satisfaction toward educational AR applications.

3.1.3 Hedonic Motivation and Satisfaction

Hedonic motivation has been widely recognised as a significant predictor of users' evaluations of emerging technologies. Previous studies indicate that enjoyment, fun, and immersive experiences contribute positively to users' satisfaction with technology-based learning environments (Venkatesh et al., 2012; Akour et al., 2022). Given the interactive and visually engaging nature of AR applications, learners who perceive AR learning experiences as enjoyable are more likely to report higher levels of satisfaction.

H3: Hedonic motivation positively influences satisfaction toward educational AR applications.

3.1.4 Habit and Satisfaction

Habit has been found to influence users' experiences through repeated interaction and accumulated familiarity with technology. Frequent usage reduces cognitive effort and promotes smoother interactions with technological systems, resulting in more favourable evaluations and greater satisfaction (Venkatesh et al., 2012; Faqih et al., 2021). In educational AR settings, learners who regularly use AR applications may develop stronger comfort and confidence, leading to higher satisfaction.

H4: Habit positively influences satisfaction toward educational AR applications.

3.1.5 Price Value and Satisfaction

Price value reflects users' evaluation of the benefits obtained relative to the resources invested in using a technology. According to UTAUT2, users are more likely to evaluate a technology positively when the perceived benefits exceed the associated costs (Venkatesh et al., 2012). Previous studies have similarly found that perceived value contributes positively to users' satisfaction with digital technologies and learning systems (Faqih et al., 2021). In educational AR environments, learners who perceive substantial educational benefits from AR applications are expected to experience higher levels of satisfaction.

H5: Price value positively influences satisfaction toward educational AR applications.

3.1.6 Personal Innovativeness and Satisfaction

Personal innovativeness reflects an individual's willingness to experiment with and adopt emerging technologies. Innovative users are generally more receptive to technological advancements and tend to perceive new technologies more positively than less innovative users (Agarwal & Prasad, 1998). Empirical studies have shown that personal innovativeness contributes positively to users' experiences and satisfaction with emerging technologies (Al-Qaysi et al., 2021). Therefore, learners with higher levels of innovativeness are expected to report greater satisfaction with educational AR applications.

H6: Personal innovativeness positively influences satisfaction toward educational AR applications.

3.2 Quality Factors and Satisfaction

3.2.1 AR Service Quality and Satisfaction

According to the Information Systems Success Model (ISSM), service quality is an important determinant of users' evaluations of information systems (DeLone & McLean, 2003). Previous studies have shown that responsive support services, timely assistance, and effective guidance contribute positively to users' satisfaction with digital systems (Aldholay et al., 2018). In educational AR environments, quality support services may help learners overcome technical challenges and improve their overall learning experience.

H7: AR service quality positively influences satisfaction toward educational AR applications.

3.2.2 AR Content Quality and Satisfaction

Content quality has consistently been recognised as a key determinant of user satisfaction. Accurate, relevant, understandable, and useful content enhances users' learning experiences and improves perceived system value (DeLone & McLean, 2003; Petter et al., 2008). In educational AR applications, high-quality learning content can improve understanding and engagement, thereby increasing learner satisfaction.

H8: AR content quality positively influences satisfaction toward educational AR applications.

3.2.3 AR System Quality and Satisfaction

System quality reflects the technical performance of an information system, including reliability, usability, responsiveness, and stability. Prior research has demonstrated that systems with superior technical performance generate more positive user experiences and higher levels of satisfaction (DeLone & McLean, 2003; Petter et al., 2008). In educational AR settings, stable and user-friendly systems may enhance learners' experiences and contribute to greater satisfaction.

H9: AR system quality positively influences satisfaction toward educational AR applications.

3.3 Satisfaction and Loyalty

Expectation–Confirmation Theory (ECT) suggests that satisfaction is a key determinant of users' post-adoption behaviours and continued engagement with a technology (Bhattacherjee, 2001). Previous studies have consistently reported that satisfied users are more likely to continue using a system, recommend it to others, and develop stronger loyalty toward the technology (Oliver, 1999; Bhattacherjee, 2001). In educational AR environments, learners who are satisfied with their AR learning experiences are expected to demonstrate stronger loyalty toward educational AR applications.

H10: Satisfaction positively influences loyalty toward educational AR applications.

4 Research Methodology

This study examined young adults' satisfaction and loyalty toward educational augmented reality (AR) applications using a quantitative research methodology. Data were collected through a self-administered online survey employing purposive sampling. The target population comprised young adults in Malaysia aged between 18 and 34 who had prior experience using augmented reality applications for educational purposes.

Between May and August 2024, the survey link was distributed through university associations, academic networks, and educational forums. To ensure that respondents had prior exposure to educational AR platforms, a screening question was included asking whether they had previously used AR-based applications such as Quiver, 3DBear, or Assemblr Edu. A total of 450 questionnaires were distributed, and 400 usable responses were obtained, yielding a valid response rate of approximately 88.9%.

A G*Power analysis was conducted using an effect size of 0.15 and a statistical power of 0.95 to determine the minimum required sample size for Partial Least Squares Structural Equation Modelling (PLS-SEM). The analysis indicated that a minimum of 184 responses was required. The final sample of 400 exceeded this threshold and was therefore considered statistically adequate and methodologically appropriate for structural model analysis. Larger sample sizes are generally recommended in PLS-SEM as they improve estimation accuracy, predictive capability, and model stability.

Validated measurement items were adapted from established scales reported in prior studies to ensure content validity and reliability. Social influence, facilitating conditions, hedonic motivation, habit, and price value were adapted from the Unified Theory of Acceptance and Use of Technology 2 (UTAUT2) measurement scale developed by Venkatesh et al. (2012). Personal innovativeness items were adapted from Agarwal and Prasad (1998), which has been widely applied in technology adoption research.

The quality-related constructs were adapted from the Information Systems Success Model (ISSM). Specifically, AR content quality, AR system quality, and AR service quality were adapted from the measurement scales proposed by DeLone and McLean (2003) and subsequently validated in information systems research by Petter et al. (2008) and Aldholay et al. (2018).

Satisfaction was measured using items adapted from Bhattacherjee (2001), which assess users' overall evaluation of their post-adoption experience with a technology. Loyalty was measured using items adapted from prior studies on customer loyalty and continuance behaviour, particularly Oliver (1999) and Zeithaml et al. (1996), which capture users' intention to continue usage, recommend the application to others, and maintain commitment toward the service.

Minor wording modifications were made to ensure the suitability of all measurement items within the context of educational augmented reality (AR) applications while preserving the original meaning of the validated scales.

All constructs were measured using a five-point Likert scale ranging from 1 = strongly disagree to 5 = strongly agree. To ensure linguistic accuracy and conceptual equivalence in the Bahasa Melayu version of the instrument, an iterative and collaborative translation technique was employed. The original English questionnaire was translated into Bahasa Melayu by a team comprising experts in English language studies and Bahasa Melayu language specialists. The translated version was subsequently reviewed collaboratively by the translators and research team to evaluate semantic equivalence, conceptual consistency, and contextual appropriateness. Several rounds of discussion and refinement were conducted to resolve discrepancies and improve the clarity of questionnaire items. This iterative process ensured that the translated instrument retained the intended meaning of the original items while remaining culturally appropriate and relevant to the educational augmented reality (AR) context.

Data were analysed using Partial Least Squares Structural Equation Modelling (PLS-SEM) with SmartPLS software. The analysis followed a two-step approach consisting of measurement model assessment and structural model evaluation. The measurement model assessment examined internal consistency reliability, convergent validity, and discriminant validity using Cronbach's Alpha, Composite Reliability (CR), Average Variance Extracted (AVE), and the Heterotrait–Monotrait Ratio (HTMT). Subsequently, the structural model assessment was conducted to evaluate the proposed hypotheses through bootstrapping procedures.

5 Results and Findings

Most respondents were young adults aged between 18 and 34 years (92%), consistent with the targeted population of digitally literate learners. Slightly more than half of the respondents were female (54%), and 65% held at least an undergraduate degree. Most participants were university students or early-career professionals, reflecting typical users of emerging educational technologies.

All respondents had prior experience using AR-based educational applications such as Quiver, Assemblr Edu, and similar platforms. This demographic profile is consistent with the intended research focus, as young, educated individuals represent primary adopters of AR technologies in higher education and skill-based learning environments.

The measurement model was assessed in terms of indicator reliability, internal consistency reliability, and convergent validity using PLS-SEM procedures. All outer loadings exceeded the recommended threshold of 0.70, confirming satisfactory indicator reliability.

Internal consistency reliability was evaluated using Cronbach's Alpha and Composite Reliability (CR). As shown in Table 1, all constructs achieved values above the recommended threshold of 0.70, indicating acceptable reliability.

Convergent validity was examined using the Average Variance Extracted (AVE). All AVE values exceeded the minimum requirement of 0.50, demonstrating adequate convergent validity.

Overall, the measurement model met the established criteria for reliability and validity, supporting the robustness of the constructs used in the proposed integrated acceptance and satisfaction framework.

Table 1: Internal Consistency Reliability and Convergent Validity

Construct	Composite Reliability	Cronbach's Alpha	AVE
Service Quality	0.870	0.875	0.723
Content Quality	0.886	0.892	0.746
System Quality	0.824	0.831	0.741
Social Influence	0.780	0.790	0.819
Facilitating Conditions	0.865	0.871	0.713
Hedonic Motivation	0.933	0.935	0.882

Habit	0.895	0.901	0.827
Price Value	0.845	0.876	0.765
Personal Innovativeness	0.869	0.923	0.790
Perceived Satisfaction	0.882	0.887	0.680
Loyalty	0.927	0.928	0.819

AVE= Average Variance Extracted, CR = Composite Reliability, CA = Cronbach's Alpha

Discriminant Validity (HTMT)

Discriminant validity was assessed using the Heterotrait–Monotrait ratio (HTMT), as recommended by Henseler et al. (2015). HTMT values below 0.90 indicate adequate discriminant validity among constructs.

As presented in Table 2, all HTMT values were below the conservative threshold of 0.90, confirming that each construct is empirically distinct from the others. These findings suggest that multicollinearity and construct overlap are not major concerns in the proposed model.

Therefore, the measurement model demonstrates satisfactory discriminant validity and supports the structural model assessment.

Table 2: Heterotrait–Monotrait Ratio (HTMT)

Construct	SQ	CQ	SYQ	SI	FC	HM	HB	PV	PI	SAT	LOY
(SQ)	—										
(CQ)	0.845	—									
(SYQ)	0.884	0.895	—								
(SI)	0.725	0.834	0.835	—							
(FC)	0.811	0.795	0.766	0.837	—						
(HM)	0.707	0.683	0.716	0.595	0.768	—					
(HB)	0.474	0.603	0.569	0.711	0.628	0.389	—				
(PV)	0.674	0.687	0.694	0.763	0.752	0.573	0.629	—			
(PI)	0.679	0.639	0.658	0.630	0.748	0.653	0.612	0.720	—		
(SAT)	0.883	0.754	0.748	0.716	0.718	0.683	0.499	0.681	0.582	—	
(LOY)	0.651	0.748	0.733	0.730	0.682	0.555	0.755	0.637	0.712	0.585	—

Discriminant validity was assessed using the Heterotrait–Monotrait (HTMT) ratio. As shown in Table 2, all HTMT values were below the recommended threshold of 0.90, indicating satisfactory discriminant validity among the constructs. The highest HTMT value observed was below the conservative cutoff of 0.90, confirming that the constructs are empirically distinct from one another.

These results demonstrate that the measurement model satisfies the criteria for internal consistency reliability, convergent validity, and discriminant validity. The structural model evaluation is presented in the subsequent section.

Hypotheses Testing

The structural model was evaluated using Partial Least Squares Structural Equation Modelling (PLS-SEM) with bootstrapping procedures. Prior to hypothesis testing, collinearity was assessed using the Variance Inflation Factor (VIF). All VIF values were below the recommended threshold of 5.0, indicating that multicollinearity was not a concern in the structural model.

The results of the structural path analysis revealed that six out of ten hypotheses were supported. Service quality (H1: $\beta = 0.560$, $p < 0.001$), social influence (H4: $\beta = 0.104$, $p = 0.023$), hedonic motivation (H6: $\beta = 0.192$, $p < 0.001$), price value (H8: $\beta = 0.162$, $p < 0.001$), and personal innovativeness (H9: $\beta = 0.072$, $p = 0.049$) were found to have significant positive effects on perceived satisfaction.

Furthermore, perceived satisfaction significantly influenced loyalty toward educational AR applications (H10: $\beta = 0.534$, $p < 0.001$), confirming its central role in driving continued usage and commitment.

However, content quality (H2), system quality (H3), facilitating conditions (H5), and habit (H7) did not demonstrate statistically significant effects on perceived satisfaction.

Overall, the findings indicate that experiential, social, and value-driven factors play a more substantial role in shaping learner satisfaction compared to purely technical system attributes.

Table 3: Results of Hypothesis Testing

Hypothesis	Path	Std. Beta	Std. Error	t-Value	p-Value	Result
H1	Service Quality → Satisfaction	0.560	0.055	10.167	0.000	Supported
H2	Content Quality → Satisfaction	0.069	0.057	1.226	0.110	Not Supported
H3	System Quality → Satisfaction	-0.066	0.051	1.291	0.098	Not Supported
H4	Social Influence → Satisfaction	0.104	0.052	1.997	0.023	Supported
H5	Facilitating Conditions → Satisfaction	-0.062	0.058	1.078	0.140	Not Supported
H6	Hedonic Motivation → Satisfaction	0.192	0.046	4.136	0.000	Supported
H7	Habit → Satisfaction	0.058	0.038	1.535	0.062	Not Supported
H8	Price Value → Satisfaction	0.162	0.040	4.055	0.000	Supported
H9	Personal Innovativeness → Satisfaction	0.072	0.044	1.652	0.049	Supported
H10	Satisfaction → Loyalty	0.534	0.038	13.956	0.000	Supported

The results indicate that six out of ten hypotheses were supported. Service quality emerged as the strongest predictor of satisfaction ($\beta = 0.560$, $p < 0.001$), followed by hedonic motivation ($\beta = 0.192$, $p < 0.001$), price value ($\beta = 0.162$, $p < 0.001$), social influence ($\beta = 0.104$, $p = 0.023$), and personal innovativeness ($\beta = 0.072$, $p = 0.049$).

Conversely, content quality, system quality, facilitating conditions, and habit did not demonstrate statistically significant effects on satisfaction.

Furthermore, satisfaction significantly influenced loyalty ($\beta = 0.534$, $p < 0.001$), confirming its central mediating role in driving continued engagement with educational AR applications.

The model explains 66.8% of the variance in perceived satisfaction ($R^2 = 0.668$), indicating substantial explanatory power. In addition, 28.6% of the variance in loyalty was explained by satisfaction ($R^2 = 0.286$), suggesting moderate predictive capability for post-adoption behavior.

Mediation Analysis

Although mediation analysis was not explicitly tested in this conference model, the structural results highlight the central role of perceived satisfaction in explaining loyalty toward educational AR applications. The significant path from satisfaction to loyalty ($\beta = 0.534$, $p < 0.001$) indicates that satisfaction functions as the primary mechanism translating acceptance and system-quality factors into continued usage behavior.

Specifically, service quality, social influence, hedonic motivation, price value, and personal innovativeness were found to significantly influence satisfaction. In turn, satisfaction strongly predicted loyalty. This pattern suggests that learner satisfaction operates as a key explanatory variable within the integrated acceptance and system-quality framework.

These findings reinforce the post-adoption perspective of Expectation Confirmation Theory (ECT), where positive experiential and evaluative responses toward the system enhance continued engagement and loyalty intentions.

Although indirect effects were not separately estimated in this model, the significant structural relationships indicate that perceived satisfaction serves as a central explanatory mechanism linking acceptance and quality dimensions to loyalty.

The strong effect of satisfaction on loyalty ($\beta = 0.534$, $p < 0.001$) demonstrates that post-adoption evaluation plays a critical role in determining continued engagement with educational AR applications. Acceptance-related factors (e.g., hedonic motivation, social influence) and value-related perceptions (e.g., service quality, price value, personal innovativeness) significantly enhance satisfaction, which subsequently drives loyalty.

This finding aligns with the post-adoption logic of Expectation Confirmation Theory (ECT), where users' evaluative responses determine continued system usage and commitment.

Structural Model Evaluation

The structural model results indicate that satisfaction plays a central role in predicting loyalty toward educational AR applications. The significant path from satisfaction to loyalty ($\beta = 0.534$, $p < 0.001$) confirms that post-adoption evaluation is a key determinant of continued engagement.

The findings suggest that experiential, social, and value-driven factors contribute to learner satisfaction, which subsequently translates into loyalty behavior. These results support the integrated acceptance and system-quality framework proposed in this study.

6 Discussion

Augmented Reality (AR) applications are increasingly being adopted in educational settings due to their ability to support interactive and immersive learning experiences. The findings of this study provide important insights into the factors that influence learners' satisfaction and loyalty toward educational AR applications among young adults in Malaysia.

The results indicate that service quality is the strongest predictor of satisfaction. This finding suggests that learners place considerable importance on reliable system support, responsiveness, and smooth platform performance when using AR applications for educational purposes. In digital learning environments, technical assistance and stable system performance contribute significantly to positive user experiences. This finding is consistent with previous studies highlighting the importance of service-related dimensions in technology-supported learning systems (Rahi et al., 2022; Nguyen & Ha, 2023).

Hedonic motivation was also found to significantly influence satisfaction. This indicates that learners are more satisfied when AR applications provide enjoyable, engaging, and immersive learning experiences. Since AR technologies combine interactive visual elements with real-time engagement, learners may perceive the learning process as more interesting and motivating compared to traditional digital learning platforms. This finding supports prior educational technology studies emphasizing the role of intrinsic enjoyment in shaping positive learning experiences (Jang & Byun, 2021; Al-Adwan et al., 2022).

Similarly, price value demonstrated a significant positive effect on satisfaction. Learners appear to evaluate AR applications based on the perceived benefits gained relative to the effort, time, or potential cost associated with usage. When learners perceive that AR technologies provide meaningful educational value and enhance learning effectiveness, their level of satisfaction increases. This finding aligns with previous research showing that perceived value plays an important role in post-adoption evaluation within digital learning systems (Mishra et al., 2022).

Social influence was also found to significantly affect satisfaction. Recommendations and encouragement from peers, instructors, and educational institutions may positively shape learners' perceptions toward AR applications. Even among digitally experienced young adults, external influence and academic support remain important factors in technology evaluation and acceptance. This finding is consistent with previous studies highlighting the continued relevance of social and institutional influence in educational technology adoption (Chiu et al., 2023).

In addition, personal innovativeness significantly influenced satisfaction. Learners who are more open to experimenting with new technologies may develop stronger positive perceptions toward AR-supported learning environments. Innovative individuals are generally more willing to explore immersive digital technologies and adapt to new forms of interactive learning. This result supports earlier findings suggesting that technology-oriented individuals tend to demonstrate more favorable evaluations toward emerging educational technologies (Talwar et al., 2023).

Interestingly, content quality, system quality, facilitating conditions, and habit did not demonstrate significant effects on satisfaction. One possible explanation is that young adult learners may perceive adequate system functionality and content quality as basic expectations rather than factors that strongly enhance satisfaction. In digitally mature environments, users may focus more on experiential value and engagement rather than purely technical attributes. This finding suggests that emotional engagement and perceived value may play a more influential role than basic functional characteristics in shaping satisfaction toward AR applications.

Most importantly, satisfaction significantly influenced loyalty toward educational AR applications. Learners who reported higher levels of satisfaction were more likely to continue using AR applications and demonstrate stronger commitment toward AR-supported learning environments. This finding supports the post-adoption perspective of Expectation Confirmation Theory, which explains that positive evaluations of technology experiences contribute to continued usage intention and long-term behavioral commitment.

Overall, the findings suggest that learner loyalty toward educational AR applications is primarily influenced by positive learning experiences, perceived value, and supportive service quality rather than purely technical system characteristics. The study therefore highlights the importance of designing AR learning environments that are engaging, reliable, and capable of delivering meaningful educational experiences for long-term learner retention.

7 Theoretical and Practical Implications

This study contributes to the literature on digital educational technologies by integrating technology acceptance factors and system-quality dimensions within a post-adoption framework for educational AR applications. By combining constructs derived from UTAUT, the Information Systems Success Model (ISSM), and Expectation Confirmation Theory (ECT), the study provides a more comprehensive explanation of how learners evaluate and remain committed to AR-supported learning environments.

From a theoretical perspective, the findings highlight the importance of service quality in shaping learner satisfaction. The results suggest that reliable support, smooth system performance, and responsive assistance play a central role in influencing positive evaluations toward educational AR applications. This finding extends previous ISSM-based studies by demonstrating that service-related dimensions remain important in immersive digital learning environments.

The findings also confirm the significance of hedonic motivation and price value in influencing satisfaction. Learners appear to value AR applications not only for their functional benefits but also for the enjoyment and meaningful learning experiences they provide. This supports recent educational technology research emphasizing that immersive learning technologies should deliver engaging and rewarding user experiences in addition to technical functionality.

In addition, social influence was found to significantly affect satisfaction, indicating that encouragement from peers, instructors, and educational institutions continues to shape learners' perceptions toward educational technologies. This finding suggests that institutional support and positive peer influence remain relevant even among digitally experienced young adults. Interestingly, content quality, system quality, facilitating conditions, and habit did not significantly influence satisfaction. One possible explanation is that young adult learners may perceive adequate system functionality and content quality as standard expectations rather than factors that enhance satisfaction. This finding suggests that experiential and value-related dimensions may play a stronger role than technical features in influencing learners' evaluations of AR applications.

Most importantly, satisfaction significantly influenced loyalty toward educational AR applications. This finding reinforces the post-adoption perspective of Expectation Confirmation Theory, which explains that positive user evaluations contribute to continued usage intention and long-term commitment. The study therefore demonstrates that learner loyalty is strongly influenced by satisfaction derived from positive AR learning experiences.

From a practical perspective, the findings provide important implications for educators, instructional designers, educational institutions, and AR developers. Since service quality emerged as the strongest predictor of satisfaction, developers and institutions should prioritize reliable technical support, stable system performance, and responsive assistance. AR applications should also incorporate engaging and interactive features that enhance enjoyment and learning motivation. For instance, interactive 3D models, virtual laboratory simulations, augmented instructional animations, gamified learning activities, and real-time feedback mechanisms can create more immersive learning experiences. Such features encourage active participation, improve learner engagement, and increase the perceived enjoyment of the learning process, thereby contributing to higher satisfaction and continued usage intentions.

Furthermore, institutions should encourage instructor support and peer engagement through structured classroom activities, collaborative AR-based learning tasks, and instructor-led demonstrations that showcase the effective use of AR applications. Such initiatives may strengthen learners' confidence and foster more positive perceptions of AR-supported learning environments.

Developers and educational providers should also communicate the value of AR applications by emphasizing the specific benefits identified in this study. In particular, the educational value of AR should be demonstrated through its ability to improve conceptual understanding, facilitate visualization of complex topics through interactive 3D content, enhance learner engagement, and provide more immersive learning experiences. These benefits can be communicated through orientation sessions, training workshops, classroom demonstrations, instructional videos, and user testimonials that illustrate how AR applications contribute to learning effectiveness. By clearly highlighting these practical and educational benefits, learners are more likely to perceive AR applications as valuable, which may enhance satisfaction and promote long-term loyalty toward AR-supported learning environments.

Overall, the findings suggest that successful educational AR applications should focus not only on technical functionality but also on delivering meaningful, enjoyable, and supportive learning experiences that encourage long-term learner loyalty.

8 Directions For Future Research

Despite its contributions, this study has several limitations that provide opportunities for future research.

First, this study focused on young adults aged between 18 and 34 in Malaysia. Although this group represents digitally literate users with prior exposure to AR technologies, the findings may not be generalizable to other age groups or cultural settings. Future research could examine different demographic groups, such as secondary school students, older adult learners, or users from different countries, to determine whether the factors influencing satisfaction and loyalty vary across populations and educational contexts.

Second, this study employed a cross-sectional research design that captured respondents' perceptions at a single point in time. Learners' evaluations of AR applications may change with continued usage, technological improvements, or evolving learning needs. Future studies could adopt longitudinal approaches to examine how satisfaction and loyalty develop over time. Experimental research designs may also provide deeper insights into how specific AR features influence learners' experiences and behavioral outcomes.

Third, although this study integrated technology acceptance and system-quality factors, future research could include additional psychological or contextual variables to strengthen the explanatory power of the model. Variables such as trust in educational technology, learning self-efficacy, perceived learning effectiveness, student engagement, or technology readiness may provide a more comprehensive understanding of learner evaluations toward AR applications.

Future studies may also examine indirect or moderating relationships within AR learning environments. For example, researchers could explore whether engagement, emotional attachment, or perceived learning outcomes mediate the relationship between satisfaction and loyalty. Contextual moderators such as learning environment, academic discipline, or institutional technological support may also influence how learners evaluate AR applications.

Finally, future research could investigate AR adoption in different educational settings, including formal classrooms, informal learning environments, professional training, or skills-based education. Expanding research across different contexts may provide broader insights into the long-term sustainability and effectiveness of AR-supported learning technologies.

Overall, future research should continue exploring how technological, psychological, and contextual factors interact to shape learners' satisfaction, continued usage, and loyalty toward educational AR applications.

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