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Salient Factors Affecting Young Travellers' Intention to Adopt Gamified Tourism Applications: The Moderating Role of Customer Engagement

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ABSTRACT

The emergence of advanced technology has not only become part of people's lives, but its applications in the sector of tourism have indeed captured the attention of all relevant stakeholders. Nonetheless, understanding young travellers' perceptions and engagement with gamified tourism applications remains a critical yet understudied area. This paper aimed to understand these travellers' technology acceptance towards their intentions to adopt gamified tourism applications during their trips. Through a quantitative analysis of 162 valid responses using partial least squares – structural equation modeling (PLS-SEM), the study examined the pivotal roles of perceived ease of use, usefulness, social influence, safety and security, along with customer engagement as the primary drivers influencing adoption of gamified tourism applications. This study identified all examined variables as key drivers of adoption of gamified tourism applications, with the exception of safety and security. In addition, the associations between perceived ease of use, social influence, and intention to adopt gamified tourism applications were found to be moderated by

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customer engagement. The present paper puts forward some meaningful insights and suggestions to improve the said adoption in Sarawak, Borneo.

KEYWORDS
Borneo; tourism gamification; technology acceptance model; customer engagement; PLS-SEM.

1. INTRODUCTION

Tourism stands as a collection of diverse events conducted outside one's immediate environment (Streimikiene et al., 2021). It serves as a crucial driver for economic growth and acts as a source of both financial and cultural capital for nations (Bee et al., 2020). However, the tourism sector has undergone a profound transformation driven by rapid digitalisation, accelerated further by the COVID-19 pandemic. This includes Sarawak, a Bornean state in Malaysia, which witnessed a precipitous decline, with tourist visits plummeting by 74% amidst the pandemic. This decline has caused the local tourism revenue to suffer tremendous losses (Jee, 2022), urging the need for changes to conventional tourism, such as digitalization and technological integrations.

In response to these challenges, there has been a growing recognition of the transformative potential of digital technologies in revitalizing the tourism sector (Mohamad, 2023). As nations leverage their natural and cultural assets to attract visitors, the tourism industry continually evolves (Thong et al., 2023), embracing technological innovations to enhance visitor experiences while promoting sustainable practices (Thong et al., 2024). Digital tools provide features such as contactless transactions and digital navigation, which can enable the seamless resumption of tourism activities in a post-pandemic setting (Lo et al., 2024).

Among these digital innovations, gamification has emerged as a promising approach for enriching tourism experiences by integrating game-design elements into non-game contexts. Enabled by advancements in mobile technology, geolocation services, social media, and interactive interfaces, gamified tourism applications offer immersive, engaging, and personalised experiences for travellers during their trips (Yoo et al., 2017; Lamberti et al., 2020). Prior research has demonstrated that gamification can enhance tourists' enjoyment, engagement, and value co-creation, thereby influencing behavioural outcomes such as satisfaction, loyalty, and revisit intention (Abou-Shouk & Soliman, 2021).

Amidst this backdrop, the integration of gamification has emerged as a promising avenue for enhancing tourists' experiences and engagement during their travels. However, there remains a notable gap in understanding their intentions to adopt such technologies. Despite this growing body of literature, the intention to adopt gamified tourism applications remains theoretically underexplored, particularly from a technology acceptance and engagement-based perspective.

Undoubtedly, enhanced customer experience, especially when nurtured through engagement, often leads to loyalty toward specific subjects or themes (Lundaeva, 2018). Therefore, comprehending the vital role that digital technologies like gamification play in delivering tourism services and generating experiential value for travellers is essential (Opute et al., 2020). Nonetheless, the quality of technology can serve as a constraint; for example, tourism experiences enabled through VR may not achieve the same degree of authenticity as direct, tactile

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interactions in a real-world environment (Suhaidi, 2023).

The growing field of gamification within the realm of tourism has attracted considerable scholarly attention in recent years. While existing literature has extensively explored the effects of gamification on various outcomes, including user engagement and experience, there remains a notable gap in understanding the interplay between customer engagement (CE), behavioural intention, and technology acceptance within this context (Yang et al., 2018, Lim, 2023).

Consequently, there is a limited understanding of how to systematically implement gamification, coupled with a scholarly gap concerning the willingness to adopt this approach. This gap becomes particularly salient when examining young travellers, often characterised as digital natives. Rather than focusing primarily on risk avoidance, digital natives are more likely to prioritise usability, social endorsement, and experiential engagement, especially in interactive platforms such as gamified applications.

Building upon this foundation, the present study develops and tests an extended TAM framework to examine young travellers' intention to adopt gamified tourism applications. All in all, the study aims to contribute to a more comprehensive understanding of the gamification adoption process, particularly by incorporating perceived ease of use (EOU), perceived usefulness (PU), social influence (SI), safety and security, along with CE into a solitary framework. Given that tourism gamification is still in its embryonic phase, this research is structured to examine the determinants influencing the adoption of gamification and elucidating the moderating role of CE, offering valuable insights for practitioners and policymakers alike. Moreover, this study pays particular attention to younger cohorts' behavioural responses to gamified applications, following their growing relevance in digital tourism environments.

2. LITERATURE REVIEW

2.1 Tourism Gamification

In recent years, gamification has expanded into fields like information systems and social sciences. It incorporates design principles and frameworks to engage, motivate, and encourage specific behaviours (Koivisto and Hamari, 2019). In tourism, gamification has been applied in areas like location-based AR games, storytelling by destination marketing organizations (DMOs) to attract travellers, and gaming mechanisms in restaurants to drive customer rewards (Pasca et al., 2021; Pizlo & Mazurkiewicz-Pizlo, 2023). Benefits include enhancing historical site exploration and addressing sustainability (Buhalis et al., 2019), ultimately immersing customers, boosting co-creative value, and influencing purchasing decisions (Wei et al., 2023).

2.2 Technology Acceptance Model (TAM)

TAM is a widely used model in technology adoption research due to its versatility and robustness (Salimon et al., 2021). It has been applied in various fields, including e-learning (Sukendro et al., 2020), digital tools for educators (Scherer et al., 2019), and telemedicine (Kamal et al., 2020). Despite some criticisms, TAM remains relevant and aligns with many studies on technology adoption. The model is based on two key beliefs: PU and EOU, which significantly shape attitudes and decisions to adopt new technologies.

Furthermore, TAM considers external factors like perceived security (Jacobsson et al., 2016) and SI (Yang et al., 2018). CE has also been identified as a moderating factor in technology acceptance

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(Cheng et al., 2020). In tourism gamification, users tend to appreciate systems that are consistent, intuitive, and visually appealing, enhancing their confidence and sense of security. Recommendations from peers further influence perceptions and foster engagement, leading to stronger intentions to adopt. In summary, this study focuses on understanding the intention to adopt gamification in tourism, exploring TAM's core principles alongside external factors and the moderating role of CE.

2.3 Young Travellers and Technology

Young travellers represent one of the most prominent user segments in the adoption of digital tourism technologies, particularly mobile-based applications that integrate interactive and experiential features. The term "digital natives," originally describing millennials, refers to those skilled in using digital technologies (Rapetti & Cantoni, 2015). This group is known for adaptability, positive attitudes, and proficiency in finding tech-related information. As a result, their evaluation of digital technologies tends to differ fundamentally from that of older cohorts, shifting from risk-oriented assessments to experience-oriented considerations.

While Baby Boomers have adopted technology more slowly, their engagement has recently increased (Vogels, 2019). Millennials' quick adaptation makes them effective "reverse mentors" for teaching older generations about tech tools (Thompson, 2023), fostering broader tech adoption across age groups. "Zillennials," born between the early 1990s and 2000s, bridge millennials and Generation Z (Ward, 2023).

Younger travellers are generally more familiar with digital interfaces and interactive technologies, making them a key segment in the adoption of gamified tourism applications. Having witnessed rapid digital advancements, they were among the first to experience IT education (Warna, 2019). Consequently, traditional barriers such as safety and security concerns may become less salient, particularly in familiar mobile environments where users routinely share personal data across multiple platforms. Instead, young travellers are more inclined to focus on functional convenience, social endorsement, and experiential value, especially when technologies are embedded within leisure and entertainment contexts such as tourism gamification.

This economically significant group is a key target in various consumer markets (Kautish & Sharma, 2019), known for their problem-solving skills and tech expertise (Wei, 2023). Understanding their distinct characteristics compared to other age groups is gaining research attention (Hendirek et al., 2021). Accordingly, this study positions young travellers as a theoretically meaningful segment for examining gamified tourism application adoption. By integrating digital nativity and customer engagement perspectives within an extended TAM framework, this research seeks to clarify why certain determinants exert stronger influence than others in the context of youth-oriented, experience-centric tourism technologies.

2.4 Perceived Ease of Use (EOU) and Intention to Adopt Gamified Tourism Applications

Venkatesh et al. (2003) defined EOU as the degree to which users find new technology easy to use, including the effort needed to master it (Lee, 2009). EOU comprises three aspects: an intuitive interface, consistency, and attractiveness. Scholars (Alahi et al., 2023) note that technological complexity influences perceived EOU, particularly when it involves multiple products and services. In gamification, consistency in design, format, and language enhances EOU (Yang et al., 2019;

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Marikyan et al., 2021). Thus, EOU is a key factor influencing the adoption of gamified tourism applications in this study. This discourse forms the foundation for the subsequent hypothesis:

H1: EOU is positively related to the intention to adopt gamified tourism applications.

2.5 Perceived Usefulness (PU) and Intention to Adopt Gamified Tourism Applications

In TAM, PU explains its influence on both the intent and actual use of technologies (Davis, 1986), reflecting users' belief that a new technology offers better outcomes than previous ones. PU consistently appears as a key factor in shaping users' intentions to adopt new technologies, including gamified applications (Bitrián et al., 2023). Thus, PU is crucial for analysing users' attitudes toward gamification (Neumann, 2018; Rock et al., 2022) and exploring other factors influencing their adoption willingness. Building upon the aforementioned discourse, the ensuing hypothesis is postulated:

H2: PU is positively related to the intention to adopt gamified tourism applications.

2.6 Social Influence (SI) and Intention to Adopt Gamified Tourism Applications

SI is a key factor in influencing attitude shifts and motivating individuals in gaming (Venkatesh et al., 2003). Attitudes can be shaped by observing others and the broader social environment (Mu & Lee, 2017), with online messages often interpreted through the lens of social groups. Kamaruddin and Mokhlis (2003) emphasized SI's role in shaping brand perceptions and buying decisions in younger demographics. In gaming, both competitive and collaborative interactions reflect SI. In gamification, perceived SI can influence attitudes towards platforms, impacting brand perception and fostering engagement (Huang, 2020; Nugroho, 2024). Hence, the following hypothesis is postulated:

H3: SI is positively related to the intention to adopt gamified tourism applications.

2.7 Safety and Security towards Intention to Adopt Gamified Tourism Applications

Perceived technology safety and security refer to reducing risks to users through human and technical oversight (Penmetsa et al., 2019). Effective security can reduce harmful mistakes, easing concerns about the limitations of gamified platforms (Klobas et al., 2018). Prior research consistently identifies safety and security as important determinants of technology adoption, particularly in online and mobile service environments where privacy risks and data misuse are salient concerns (Pasca et al., 2021; Lampropoulos, 2024). Nevertheless, some suggests that digitally experienced users may perceive safety risks as less influential when interacting with familiar and frequently used mobile technologies (Tobon et al., 2020). Therefore, ensuring the reliability and security of gamified applications is crucial for their adoption. Given this discourse, the following hypothesis is posited:

H4: Safety and security are positively related to the intention to adopt gamified tourism applications.

2.8 The Moderating Role of Customer Engagement (CE)

Sawhney et al. (2005) first examined CE, highlighting the shift from firm-centric to customer-centric engagement in digital environments. CE, seen as either singular or multifaceted (Zhou & Yu, 2022), fosters frequent interactions beyond transactions, including activities like "likes," feedback, and product co-creation (Brodie et al., 2011). Various definitions emerged, with CE viewed as a shared

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advancement mechanism (Sawhney et al., 2005) or a critical aspect of social networks (Zheng et al., 2015).

In gamified tourism applications, engagement reflects the extent to which users are immersed in interactive features, motivated by challenges and rewards, and socially connected through platform-based interactions. Engagement therefore plays a critical role in shaping how users process information, evaluate technological attributes, and respond to social and functional cues. From an engagement-based perspective, users with high levels of customer engagement are more likely to experience deeper immersion and enjoyment, which can amplify the perceived benefits of technology use (Cheng et al., 2020). For such users, functional attributes such as perceived ease of use and perceived usefulness may become more salient.

This study focuses on mobile apps as a platform for CE (Pagani & Malacarne, 2017), with data protection being crucial to building user confidence in gamified tourism apps (Ziefle et al., 2013). Mobile apps provide a practical medium, encouraging frequent use by engaged customers (Thakur, 2019; Nugroho, 2024). Based on the above discourse, the ensuing hypotheses are formulated:

H5: CE positively moderates the relationship between EOU and intention to adopt gamified tourism applications.

H6: CE positively moderates the relationship between PU and intention to adopt gamified tourism applications.

H7: CE positively moderates the relationship between SI and intention to adopt gamified tourism applications.

H8: CE positively moderates the relationship between safety and security towards intention to adopt gamified tourism applications.

2.9 Customer Engagement (CE) and Intention to Adopt Gamified Tourism Applications

Vivek et al. (2012) defined CE as the depth of individual involvement and attachment to offerings initiated by customers or organizations. For gamified tourism apps, CE can be gauged through actions like endorsements (de Matos & Rossi, 2008), app usage (Cvijikj & Michahelles, 2013), and sharing activities (Khan, 2017). Higher levels of CE are linked to positive intentions (Yoong & Lian, 2019; Ahmed et al., 2022), and prior research confirms CE as a key factor for businesses (Kumar & Pansari, 2015; Zada et al., 2022). Drawing from the above-mentioned discourse, the ensuing hypothesis is framed:

H9: CE is positively related to the intention to adopt gamified tourism applications.

2.10 Conceptual Framework

In accordance with the abovementioned review of literature and hypotheses formulation, Figure 1 depicts the proposed conceptual framework in this study.

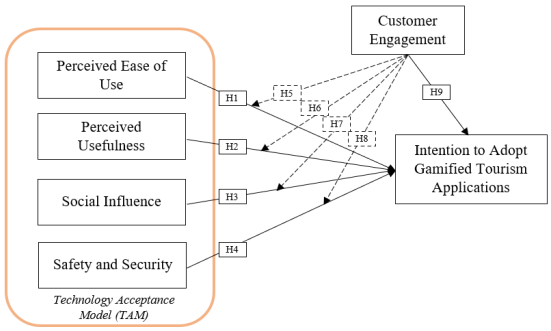

Figure 1. Conceptual framework.
Source: Authors' own drawings.

3. METHODOLOGY

3.1 Sampling and Data Collection Procedures

This study was conducted in Sarawak, a promising state in Borneo, Malaysia. The state's digitalization movement, including the adoption of gamification, has been a focus for the Sarawak

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government. As the tourism industry grows, travellers increasingly seek authentic cultural and natural experiences during their journeys (Thong, 2024). Data about travellers' willingness to adopt gamified tourism apps was also gleaned from the study site. Complementary data came from a media briefing conducted by the government of Sarawak, which revealed the state's involvement in the Global Destination Sustainability Index (GDS-Index). This participation aligns with Sarawak's Post-COVID-19 Development Strategy (PCDS) for 2030, highlighting optimal sustainable practices.

The research collected data from travellers at various gamified cultural and scenic sites, namely the Chinese History Museum, Sarawak Museum, Fort Margherita, Sarawak Cultural Village, and Kuching Waterfront. The data collection was conducted over a two-month period from January to March 2024. This study employed a non-probability sampling method for data collection, specifically convenience sampling. The participants targeted were primarily younger travellers, who are known for their active use of advanced technology in their daily lives. A substantial proportion of respondents falls within younger age brackets, which are typically more engaged with digital and gamified applications. This phenomenon is characterized by adaptability and a heightened concern for climate and ecological issues, thus the higher inclination towards digital technology application (Wu et al., 2023).

The significance of sample size in research has been highlighted in various previous studies, suggesting that it should fall within the range of 30 to 500 (Sekaran & Bougie, 2010). Utilizing an assumed effect size of 0.15, a significance level of 0.05, and 80% power involving seven predictors, the minimum sample size of 103 was determined using a priori analysis performed with G*Power 3.1.9.4 software (Faul et al., 2009).

3.2 Measures and Scale Development

The responses were collected through the distribution of questionnaires, comprising items adapted from past studies (Gefen & Straub, 2000; Hollebeek et al., 2014; Peña-García et al., 2020; Habib & Hamadneh, 2021). Generally, the survey was divided into two parts: the first part collected demographic data from the respondents, and the second part evaluated travellers' viewpoints on the relevance of TAM elements regarding their inclination to use gamified tourism apps.

The survey design was influenced by past scholarly contributions in the field but was adapted to fit the Malaysian setting, where the items were translated into Malay language using Google Translate, a reliable translation machine widely utilized for text mining analytics (Lee & Park, 2018). The targeted participants were young travellers visiting the said locations.

To ensure contextual appropriateness and equivalence, the questionnaire was reviewed by academic experts with experience in tourism and technology adoption research. Following that, a pilot test was conducted among a small group of representatives of the target population to assess item clarity, wording, and comprehension (Willis, 2016), where the feedback obtained was used for refinement before actual distribution. This allowed appropriate clarifications, expansions, and adjustments to the draft survey to be consistent with the study objectives.

Subsequently, actual respondents were provided with choices between physical (printed questionnaire) and virtual forms (Google Form); whichever suits them best. All participants were

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required to answer every measurement item to avoid the possibility of incomplete data.

Accordingly, 200 surveys were handed out to the target respondents in the targeted areas, garnering 175 usable responses, which translates to an 87.5% effective response rate (Nulty, 2008). During the data collection, respondents were required to provide their perceptions using a 5-point Likert scale, particularly towards the impact of TAM elements on their willingness to adopt gamified tourism applications and how their perceived CE can moderate the said associations. However, 13 responses were eliminated due to incomplete data and anomalies, thus the remaining 162 datasets were deemed valid and used for both measurement and structural assessment.

3.3 Statistical Analyses

For hypothesis testing, a quantitative research method was utilized, involving the review of data collected via self-completed surveys. As the present predictive research model incorporates multiple constructs and interaction effects, this study employed Partial Least Squares Structural Equation Modelling (PLS-SEM).

Moreover, the complexity following the moderation effects of CE, adds to the suitability of PLS-SEM (Hair et al., 2022) in this behavioural research, as it imposes fewer distributional assumptions involving self-reported survey data. This allows a more comprehensive assessment of both explanatory and predictive performance.

Initially, the collected data was processed using the Statistical Package for Social Science (SPSS) version 29.0 and SmartPLS 4.0 software. The preliminary stage of the analysis used descriptive statistics to profile the participants demographically, along with factor analysis and testing of reliability to assess the soundness of the measures. Then, the relationships between the study's constructs were assessed using PLS-SEM to test the hypotheses.

4. RESULTS

4.1 Full Collinearity Testing

Given the use of self-reported survey data collected from a single source, common method bias (CMB) was assessed to ensure that the results were not substantially affected by systematic measurement error. Following the recommendations of Kock (2022), the full collinearity variance inflation factor (VIF) approach was employed. This approach involves regressing all variables against a common factor, VIF values required to be ≤ 3.3, confirming that the data is free from bias, as documented in Table 1.

EOU	PU	SI	SEC	CE	INT
1.181	1.050	1.266	1.019	1.010	1.254

Table 1. Full collinearity testing.
Note: EOU = Perceived Ease of Use; PU = Perceived Usefulness; SI = Social Influence; SEC = Safety and Security; CE = Customer Engagement; INT = Intention to Adopt Gamified Tourism Applications.
Source: Authors' own calculations.

4.2 Respondents' Profile

Table 2 presents the respondents' demographic attributes. It is found that the majority (73.5%) of users of gamified tourism applications fell within the 18 to 45 years age bracket. Generally, individuals in this age range comprised of Gen Y, or Millennials and Gen Z, who have experienced the phases of the fourth industrial revolution (IR 4.0) and Web 3.0, making them more technologically prepared and inclined towards technological application. Additionally, their notable inclination towards innovation and optimism likely contributes to their higher willingness to embrace advanced technologies, including gamified tourism applications.

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4.3 Assessment of the Measurement Model

Rigorous measures were taken to ensure the reliability and validity of the collected data, particularly in evaluating the measurement model. The assessment commenced with a confirmatory factor analysis (CFA) to ascertain the reliability, convergent validity, and discriminant validity of the measurement scales.

Subsequent to the CFA, the constructs' internal consistency was gauged using composite reliability (CR), which employs the standardized loadings of individual variables and is regarded as a more reliable measure of internal consistency compared to Cronbach's alpha (Memon & Rahman, 2014). As advocated by Hair et al. (2011), a CR value of at least 0.70 is considered satisfactory. Convergent validity of the constructs was evaluated using the average variance extracted (AVE) value, with a minimum criterion of 0.50 (Bagozzi et al., 1991).

As illustrated in Table 3, the loadings and AVE for all items of EOU, PU, SI, safety and security, CE, and intention to adopt gamified tourism applications surpassed the minimum threshold of 0.50, while the CR of all constructs exceeded 0.70 (Chin, 2010). Although one item under the safety and security construct exhibited a marginal loading of 0.501, it was retained due to its strong theoretical relevance and consistency with prior validated scales. Following this, the construct's CR and AVE exceeded the recommended thresholds, indicating satisfactory convergent validity and internal consistency despite the lower loading of this individual indicator (Nunnally & Bernstein, 1994).

Demographic Variable	Category	Frequency (n)	Percentage (%)
Gender	Male	92	56.8
	Female	70	43.2
Age	Between 18 and 25 years old	18	11.1
	Between 26 and 35 years old	44	27.2
	Between 36 and 45 years old	57	35.2
	Between 46 and 55 years old	39	24.1
	55 years old and above	4	2.5
Education Level	High school or below	83	51.2
	Diploma	46	28.4
	Degree or professional qualifications	25	15.4
	Postgraduate	8	4.9
Monthly Income	Less than RM 1,000	18	11.1
	Between RM 1,001 and RM 3,000	43	26.5
	Between RM 3,001 and RM 5,000	37	22.8
	Between RM 5,001 and RM 7,000	33	20.4
	Between RM 7,001 and RM 9,000	23	14.2
	RM 9,001 and above	8	4.9

Table 2. Demographic profiles of respondents.
Source: Authors' own calculations.

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Constructs	Item(s)	Loadings	CR	AVE
Perceived Ease of Use				
Gamified tourism application is easy-to-use.	EOU_01	0.845	0.904	0.759
Gamified tourism application is flexible to interact with.	EOU_02	0.874		
It is easy to interact with gamified tourism application.	EOU_03	0.894		
Perceived Usefulness				
Gamified tourism application enables me to search for a destination easily.	PU_01	0.827	0.893	0.735
Gamified tourism application makes it easier to understand tourist spots.	PU_02	0.860		
Gamified tourism application enhances my effectiveness in understanding tourist spots.	PU_03	0.885		
Social Influence				
People who are important to me, believe I should use gamified tourism application.	SI_01	0.862	0.894	0.739
People who influence me, think I should use gamified tourism application.	SI_02	0.862		
People whose opinions are valuable for me, would rather I use gamified tourism application.	SI_03	0.854		
Safety and Security				
I feel safe using gamified tourism application.	SEC_01	0.501	0.768	0.541
I feel my personal information is protected while using gamified tourism application.	SEC_02	0.831		
I feel my personal details given during usage of gamified tourism application are safe.	SEC_03	0.851		
Customer Engagement				
It is interesting to use gamified tourism application.	CE_01	0.699	0.843	0.648
Gamified tourism application is appealing to me.	CE_02	0.708		
The contents within gamified tourism application mean a lot to me.	CE_03	0.977		
Intention to Adopt Gamified Tourism Applications				
I would use gamified tourism application.	INT_01	0.898	0.898	0.746
I would like to obtain information from gamified tourism application.	INT_02	0.895		
I am very likely to use gamified tourism application.	INT_03	0.795		

Table 3. Summary of construct reliability and validity.
Source: Authors' own calculations.

As displayed in Table 4, the assessment of discriminant validity involved a comparison between the square root of each construct's AVE value and its inter-correlations with other constructs within the research model using Heterotrait-Monotrait Ratio of Correlations (HTMT) criterion (Henseler et al., 2015). As a result, the measurement model was found to be satisfactory, providing substantiation of reliability, convergent validity, and discriminant validity (Cohen, 1988).

4.4 Assessment of the Structural Model

Table 5 and Figure 2 display the outcomes derived from hypothesis testing. Generally, the foundational guideline for executing one-tailed hypothesis testing suggests that the computed t-values should reach a minimum threshold of 1.645 ($p < 0.05$) or 2.33 ($p < 0.01$). In terms of the current statistical findings from the entire sample, four out of five direct relationship hypotheses garnered support, with the significance of perceived EOU (H1) and PU (H2) being established at the 0.01 level of significance. Similarly, SI (H3) and CE (H9) displayed direct positive links with the intention to

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adopt gamified tourism applications, with significance identified at the 0.05 level.

Drawing from the statistical results, two out of four hypotheses evidenced supported moderating relationships, namely H5 and H7, reflect the intention to adopt gamified tourism applications among young travellers in Sarawak. These moderating relationships achieved significant levels of 0.05 and 0.01 respectively. Furthermore, the coefficient of determination (R^2) for the intention to adopt gamified tourism applications was 0.526. This indicates that the proposed model explains 52.6% of the variance in adoption intention, demonstrating moderate explanatory power (Cohen, 1988). The results therefore suggest that the proposed model provides a meaningful explanation of young travellers' intention to adopt in the context of gamified tourism applications.

Subsequently, the predictive capability was assessed using the PLSpredict method, which employs a holdout sample and a 10-fold procedure to generate individual-level predictions at the item or construct level (Shmueli et al., 2019). In comparison with the linear regression (LM_RMSE) model, a robust predictive power is indicated by a preponderance of item (PLS-LM) disparities being lower. As Table 6 shows, the larger proportion of prediction errors (PLS_RMSE) was lower than in the LM_RMSE model, signifying a moderate predictive power. Despite this, its predictive power is meaningful given the complexity and experiential nature of tourism technology adoption, where it can be deduced by a wide range of situational, emotional, and contextual factors.

Constructs	EOU	PU	SI	SEC	CE	INT
EOU						
PU	0.745					
SI	0.583	0.453				
SEC	0.187	0.139	0.238			
CE	0.086	0.152	0.128	0.133		
INT	0.790	0.697	0.536	0.222	0.051	

Table 4. Discriminant validity of constructs (HTMT criterion).
Source: Authors' own calculations.

H	Relationships	Std Beta	Std Error	f^2	t-values	p-values	Decision
	Direct Relationships						
H1	EOU → INT	0.434	0.100	0.207	4.345	0.000	Supported
H2	PU → INT	0.269	0.085	0.089	3.171	0.001	Supported
H3	SI → INT	0.130	0.074	0.026	1.769	0.038	Supported
H4	SEC → INT	0.035	0.070	0.002	0.504	0.307	Not Supported
	Moderating Relationships						
H5	CE*EOU → INT	0.319	0.175	0.004	1.822	0.035	Supported
H6	CE*PU → INT	0.004	0.187	0.000	0.019	0.492	Not Supported
H7	CE*SI → INT	0.221	0.082	0.021	2.695	0.004	Supported
H8	CE*SEC → INT	0.038	0.074	0.003	0.515	0.303	Not Supported
	Engagement and Intention to Adopt						
H9	CE → INT	0.186	0.096	0.033	1.937	0.027	Supported

Table 5. Summary of path coefficients and hypotheses testing.
Note: Asterisks (*) indicate moderation.
Source: Authors' own calculations.

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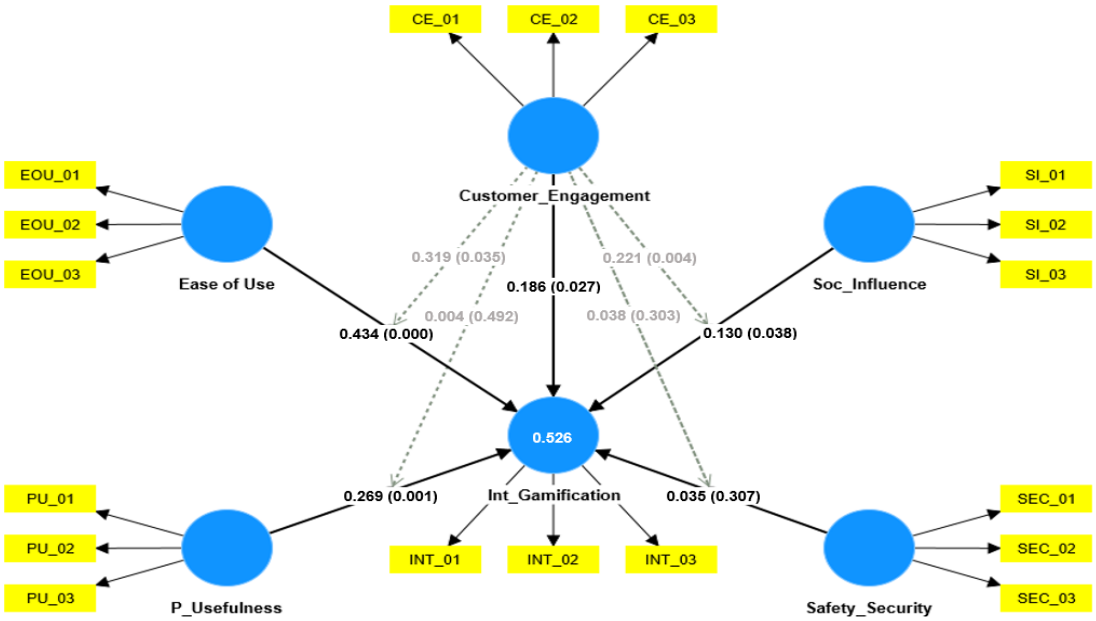

Figure 2. Research model with path coefficients and p-values.
Source: Authors' own calculations.

Item	PLS_RMSE	LM_RMSE	PLS-LM	Q^2_predict
Sample (n = 162)				
INT_01	0.692	0.720	-0.028	0.358
INT_02	0.740	0.777	-0.037	0.331
INT_03	0.883	0.840	0.043	0.256

Table 6. Results of PLSpredict.
Source: Authors' own calculations.

5. DISCUSSION

While the sample includes respondents from a wider age range, the findings are interpreted with particular attention to younger cohorts, given their higher engagement with digital environments. This study set out to examine their intention to adopt gamified tourism applications by extending the TAM with social influence, perceived safety and security, and customer engagement as a moderating variable. Overall, the findings provide partial support for the proposed framework and offer several theoretically meaningful insights into technology adoption within experiential tourism contexts. This research reinforces the theoretical boundaries of technology acceptance by demonstrating how interactive game-design elements transform conventional adoption pathways. By integrating customer engagement into TAM, the study extends existing knowledge, revealing that the predictive power of functional usability is intrinsically tied to a user's active immersion. Specifically, this study advances the TAM literature by empirically establishing customer engagement as an important boundary condition that dictates how effectively these conventional usability factors can be transformed into actual adoption intentions. This outcome aligns with prior research emphasizing the crucial role of EOU in simplifying technological complexities, thereby increasing the likelihood of adoption (Huang et al., 2020), thus validating H1.

Similarly, in line with previous studies (Neumann, 2018; Rock et al., 2022), the current statistical results underscore the importance of PU in

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enhancing the likelihood of positive intentions among travellers, confirming H2. PU is recognized as a pivotal predictor of users' positive perceptions and subsequent adoption intentions (Bitrián et al., 2023), especially in the context of adopting gamification. This suggests that even within gamified and experience-oriented applications, young travellers continue to value functional efficiency and instrumental benefits. Ease of navigation and perceived utility remain fundamental prerequisites that shape adoption decisions, reinforcing TAM's relevance in tourism technology research.

Moreover, the results further reveal the meaningful impact of SI on travellers' intention to embrace gamified tourism applications, thereby supporting H3. This finding aligns with prior research highlighting the socially embedded nature of digital consumption among digital natives, where recommendations, shared experiences, and online visibility shape behavioural intentions (Mu & Lee, 2017; Nugroho, 2024). It highlights the importance of user-centric design and the role of social networks in influencing individuals' perceptions and behaviours, underscoring the importance of peer endorsement and social validation among young travellers.

Nevertheless, perceived safety and security showed otherwise. The inconsistency between present and past findings (Pasca et al., 2021; Lampropoulos, 2024) indicates that H4 was not supported, suggesting that the habitual trust developed through frequent technology use may regularize data-sharing practices among young travellers, rendering safety concerns less prominent during their adoption decisions (Tobon et al., 2020). Furthermore, the great emphasis on interactivity and enjoyment in gamification may further divert attention away from risk-related evaluations.

On the other hand, the investigation of the moderating role of CE on the linkages between EOU, SI, and intentions to adopt signifies another key contribution of the study. Specifically, a substantial level of CE significantly contributes to individuals' inclination to adopt gamified tourism applications (Ahmed et al., 2022), thus confirming H9. Moreover, a high level of CE further amplifies the positive influences of the determinants of intention to adopt. The extent of travellers' perceived CE was found to significantly and positively moderate the relationships between their perceived EOU, SI, and intentions to adopt gamified tourism applications, substantiating H5 and H7. Gamified tourism applications offer users a convenient and user-friendly platform for various functions. Consequently, highly engaged users are more likely to intend to frequently interact with these applications, resulting in increased BIs (Thakur, 2019). Figures 3 and 4 visually depict the moderation effect of CE, further enhancing the comprehensibility and clarity of these findings. This shows that highly engaged users are more immersed in the gamified experience, motivated to explore platform features, and open to social cues, strengthening the influence of functional efficiency and peer endorsement on intention to adopt.

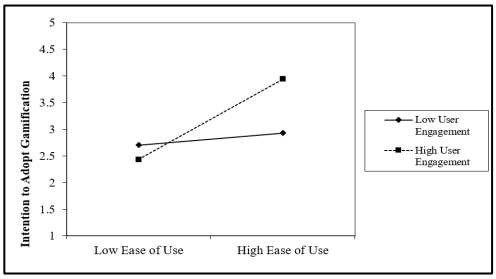

Figure 3. Graph for moderating effect of H5.
Source: Authors' own calculations.

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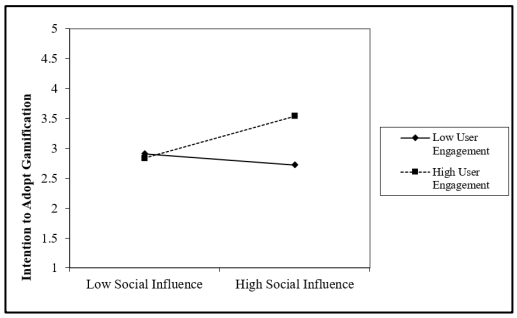

Figure 4. Graph for moderating effect of H7.
Source: Authors' own calculations.

However, the outcomes pertaining to the remaining hypothesis concerning direct relationships revealed that travellers' perception of safety and security did not exhibit a significant correlation with their intention to adopt, thus H4 was not substantiated. This finding contradicts prior research where end-consumers expressed substantial concern about the safety aspect of the used gamified tourism applications (Pasca et al., 2021). This discrepancy underscores the need for further investigation into the evolving perceptions and attitudes of consumers (Marina et al., 2025), particularly in the context of technological advancements and changing societal norms. Additionally, this inconsistency can be rationalized by considering that the respondents predominantly comprised young travellers, often recognized as pioneers of digital technology. They exist in an environment characterized by rapid technological advancements, resulting in a reduced sensitivity towards the security of contemporary technology, especially gamified tourism applications. In the current age of modernization, these applications have indeed become increasingly commonplace within the realm of tourism and hospitality (Yoo et al., 2017; Tobon et al., 2020).

Finally, the statistical results revealed that CE did not significantly moderate the effect of PU on the intention to adopt gamified tourism applications, nor did it moderate the effect of safety and security on adoption intention. Consequently, hypotheses H6 and H8 were not supported. Interestingly, these findings deviate from prior investigations that underscored the role of CE in reinforcing these relationships (Ziefle et al., 2013; Thakur, 2019). Nonetheless, this inconsistency could stem from the fact that perceived usefulness remains a potent determinant of usage intention, even when CE is not present. This finding suggests that the relevance of safety considerations may be offset among highly engaged individuals, following their high familiarity and immersion.

The present era of the web, often referred to as Web 3.0, which is primarily designed to establish an unalterable record of online activities and marked by its decentralized governance and blockchain technology, may have influenced the relationships under investigation. This technology contributes to creating worry-free authentication among participants, subsequently minimizing concerns about security when their safety is generally assured. The evolving nature of consumer behaviour in the digital age may also contribute to the unexpected outcomes. With increasing exposure to digital technologies and interactive experiences, consumers may prioritize factors such as PU and EOU over the level of engagement with gamified platforms. This continuous shift in global consumer preferences underscores the dynamic nature of technology acceptance processes and the need for adaptive research frameworks.

6. CONCLUSION AND IMPLICATIONS

Overall, the significance of TAM constructs, including perceived EOU, PU, SI, safety and security, has been examined in this study. Generally, users of gamified tourism applications hold these factors in high regard as key influencers of their intention to adopt such applications. As a result,

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EOU, PU, SI, and CE were found to be closely linked to the intention to adopt gamified tourism applications. Notably, perceived EOU emerged as the most influential factor affecting this intention. From the obtained statistical results, several insights can be gleaned and extended to stakeholders like government bodies, policy developers, and businesses.

Additionally, the research unveiled a notable moderating role of CE, particularly in intensifying the connections between EOU, SI, and the intention to adopt gamified tourism applications. In essence, these relationships become more pronounced when young travellers exert a higher level of CE. Within the moderated relationships highlighted, CE's most substantial impact was observed in moderating the link between EOU and the intention to adopt gamified applications. Here, CE functions as a mechanism through which youthful users evaluate the interactive aspects of innovations they encounter. Consequently, those who are more engaged are more likely to develop a heightened intention to adopt gamified tourism applications. As a recommendation, both public and private stakeholders should enhance their brand interfaces and communication strategies to amplify the level of CE perceived by end-users, ultimately leading to more favourable behavioural intentions. The subsequent sections delineate theoretical and practical implications, along with pathways for potential future research endeavours.

While existing research has explored the adoption of gamified applications, there is a dearth of studies that have specifically investigated the variables of interest: EOU, PU, SI, safety and security, and the intention to adopt gamified tourism applications, with the inclusion of CE as a moderating factor (Yang et al., 2018; Lim, 2023). This research aims to address this gap by contributing novel insights to the existing literature on gamified tourism application adoption, particularly in the context of Borneo. While TAM has been extensively applied to understand the intention to adopt technologies, this study enriches and extends the literature by incorporating the moderating role of CE. This integration offers empirical evidence within distinct contextual factors and advances the understanding of technology adoption processes in the domain of gamified tourism. The identification of significant factors driving the acceptance of technology, including EOU, PU, SI, safety and security, further elucidates the associations between these variables and the intention to adopt gamified tourism applications, specifically from the perspective of young travellers in Sarawak. Additionally, the cross-validation techniques employed in this study, drawing upon the research of previous scholars, generated reliable and valid outcomes, thereby affirming their consistencies. As a result, it has the potential to serve as a valuable reference for future studies conducted in similar contexts.

Moreover, this study offers valuable practical insights for key stakeholders in the industry, primarily government agencies and policymakers. It underscores the importance of considering perceptible elements, particularly when targeting younger users in the adoption of smart technology. Variables such as perceived EOU, PU, SI, and safety and security emerged as significant influences on these users, as indicated by the statistical findings. Additionally, the role of CE as a vital moderating factor among young individuals highlights its importance in the development of gamified tourism applications. This insight can guide developers in creating innovations that prioritize interactivity and communication.

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The significance of adoption intention as a driver for actual usage highlights the importance of proactive strategies to enhance user engagement and promote adoption behaviours. Industry stakeholders can leverage insights from this study to design targeted interventions aimed at increasing intention to adopt and facilitating the seamless integration of gamified tourism applications into travellers' experiences worldwide. For instance, gamified tourism applications could include reward systems according to users' achievements, providing them with interesting incentives (i.e., monetary and non-monetary), thereby their intentions can be encouraged. Furthermore, to create unique experiences for users, the key industry players such as the governments, agencies, and practitioners could leverage on existing gamified platforms and integrate solutions with customized features that are tailored to meet individual needs.

In addition to its relevance to stakeholders in Sarawak, Borneo, this study offers valuable practical insights with broader applicability on an international scale. While the empirical investigation was conducted in a specific geographical context, the identified factors and insights hold relevance for tourism industries worldwide. This is because digital natives exhibit largely homogenous digital consumption and engagement patterns regardless of their origin, the mechanisms of gamification adoption observed here may offer transferable insights for other global tourism destinations. Despite this, they should be adapted with caution to account for varying sociocultural contexts. Furthermore, tourism industry stakeholders across different regions can benefit from these insights provided by the actionable guidance for enhancing user experience and promoting technology adoption in the tourism sector. As digital natives increasingly shape consumer preferences and expectations worldwide, it is advisable for industry stakeholders to prioritize the user-friendliness and accessibility of these applications, which resonates with global trends in technology and consumer behaviour, thereby fostering greater intention to adopt.

Beyond the tourism sector, the results of this study have implications for various industries where gamified applications could be applied or extended. For instance, sectors such as education, healthcare, and retail could leverage gamification to enhance user engagement, promote behaviour change, and drive customer loyalty. By identifying the key determinants of technology acceptance within the context of gamified applications, this research provides a valuable framework for guiding future innovation and application development across diverse industries.

7. LIMITATIONS AND DIRECTIONS FOR FUTURE STUDIES

This study is not without its limitations. Firstly, the sampling process was confined to Sarawak, focusing specifically on cultural sites where gamification was actively implemented. This geographic limitation may restrict the generalizability of the findings and their applicability to other contexts.

Additionally, due to the study being conducted within a singular geographic area, variations in sociocultural, economic, and environmental factors across different regions might influence the outcomes differently. Consequently, the outcomes of this research might not be universally applicable to other regions, including both other parts of Malaysia and other countries that have embraced smart technology. As a result, caution should be exercised when extrapolating the study findings to other geographical areas, both within Malaysia and internationally. A more comprehensive exploration

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of the determinants of perceived EOU, PU, SI, and user behaviours (intentions to adopt) within the context of smart technology is recommended, encompassing diverse settings.

Furthermore, this study solely investigated the moderating effect of CE through PLS-SEM, thus additional moderators such as trust and technology readiness, may also be integrated into the present model. Furthermore, the data collection conducted was cross-sectional, where the responses were gathered at a singular point in time. This methodology limitation affected the ability to establish causality. As the data did not stem from a consistent group of participants over an extended duration, the study was limited to inferring and discussing general relationships between variables and potential moderating impacts. Therefore, future research should undertake longitudinal studies to track the evolution of technology adoption patterns over time and assess the long-term impacts of gamified tourism applications on user engagement and behaviour.

Lastly, although the study focuses on 'young travellers', the inclusion of a broader age range may influence the generalizability of the findings specifically to younger cohorts. To overcome the limitations of a traveller-centric sample, it is advisable to incorporate a broader spectrum of perspectives. Future studies could involve input from stakeholders on the supply side, to ensure more comprehensive and inclusive results. Ultimately, this could yield meaningful outcomes that are consistent or dissimilar with the present study.

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