Player Engagement and Cultural Immersion in Traditional Malaysian Games (Wau Bulan): A Quantitative Study

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ABSTRACT

Introduction: This paper explores how rapid urbanisation and the hegemony of contemporary digital entertainment[1] has led to structural estrangement of digital-native youth from Wau Bulan, a state biopolitical asset. It explores the promise of digital ludic architectures as mathematically verifiable engines for cross-generational cultural transmission [2].

Method: The extended Technology Acceptance Model (TAM) is tested through a concurrent mixed-methods design. Sequential multiple linear regressions were used to test predictive structural covariance on quantitative data (N=28), and thematic coding with ATLAS.ti was used to analyse qualitative phenomenological feedback to understand mechanisms of user engagement [3].

Results: The psychometric construct operationalisation showed high internal reliability. The structural modelling revealed that Perceived Usefulness (β =.502) and Perceived Enjoyment (β = .477) are significant predictors of positive Player Attitude. It is worth mentioning that Perceived Enjoyment (β = .623) was the only significant predictor of long-term Behavioural Intention, while mechanical usability (β = .008) was not statistically significant.

Discussion: The empirical outputs show that mechanical usability is just an expected baseline for today's digital-native consumers. Sustained system acceptance requires profound affective engagement and emotional pleasantness to efficiently trigger cultural internalisation [4].

Conclusion: To be able to successfully bridge the gap of intergenerational alienation, digital heritage applications require a structural synthesis of rigorous pedagogical instructional design [5], deep psychological "flow" [6], and intrinsically rewarding game mechanics.

Keywords: Wau Bulan, Digital Game-Based Learning, Cultural Heritage Preservation, Visual Semiotics, Instructional Design.

INTRODUCTION

The Wau Bulan has been inscribed in the history of the Malay Peninsula since the 15th century and is a unique traditional game with its distinctive visual elements, in particular, the crescent moon-like shape of its lower section that vividly mimics a rising moon when flown in the sky[3,6]. It originates mainly from the state of Kelantan, and also serves as a repository of indigenous knowledge with significant cultural value through its intricate bamboo craftsmanship, carefully carved floral and leaf paper motifs *(sobek)*, and the original high-pitched humming sound *(dengung)* of its bow under different wind conditions[5,7]. Its relevance as a national icon

is so significant in biopolitical terms that it is depicted on the Malaysian fifty-cent coin and in the logo of Malaysia Airlines. However, rapid modernisation and urbanisation have created a large structural hole, which has greatly disturbed intergenerational transmission and alienated the current-day youth from traditional communal pastimes [1,2]. Such a cultural disconnection can be bridged by an accurate semiotic transformation of the heritage. The utilisation of digital computer games is a promising approach to preserve the traditional games of Malaysia and promote cultural heritage among the younger generations synthesising modern interactive game mechanics with pedagogical instructional design to ensure the historical integrity of this artefact is effectively transferred to digital-native learners [5,8].

Effective digital games are not only entertainment but also a complex interactive platform for deep cognitive, emotional and behavioural engagement [3]. One of the key components of successful game development is the combination of user-centred interface design with well-established structural paradigms such as the Mechanics, Dynamics and Aesthetics (MDA) framework that transforms the rules of the system into pleasurable player actions that generate the desired emotional responses [9]. The designers should always provide important elements such as clear goals, different levels of difficulty, increasing challenges and continuous feedback systems to keep the player in "flow" psychological state [6]. Strategic application of structured reward systems and stimuli (text, audio and enhanced visual graphics) guarantees the engagement and motivation of the participants, transforming the digital environment into an attractive source of leisure and experiential education [3,8].

Wau Bulan is a great traditional game and is rich in visual features such as the crescent moon shape and the intricate carved floral *sobek* motifs, and has great cultural significance as a valuable repository of Malay indigenous knowledge and biopolitical symbolism [2,7]. However, the intergenerational transmission of this heritage is currently hindered by a critical structural gap as the present-day youth is increasingly alienated from the traditional communal practices due to the overwhelming dominance, convenience and dynamic appeal of modern digital entertainment [1,6]. Systematically bridging this gap, the use of digital computer games offers a promising approach to preserving Malaysia's traditional games and promoting cultural heritage among the younger generations [5,8]. For digital game design to progress from simple visual replication to sustained cognitive, emotional and cultural engagement of digital native learners, a rigorous semiotic transformation is needed that accurately renders the tangible aesthetics and intangible narratives of the Wau in a virtual environment, and a theoretical synthesis of interactive reward systems and validated pedagogical models such as Gagne's Nine Events of Instruction [5,6].

Figure 1.0: Pictures of Wau Bulan (traditional kites) from Kelantan, Malaysia.

Source: https://pemetaanbudaya.jkkn.gov.my/senibudaya/detail/696

Problem Statement

Wau Bulan has a unique visual feature that differentiates this traditional game from other games and has a special cultural value. Hasan et al. [5] suggested that digital computer games could be a proper medium to preserve traditional Malaysian games and to promote the heritage of culture among the new generation.

However, the main challenge in this preservation work is the basic gap in structural intergenerational cultural transmission, which is exacerbated by rapid urbanisation, modernisation, and the ubiquitous hegemony of contemporary digital entertainment [1]. Nowadays, digitally native youth are increasingly disconnected from communal heritage practices, clearly preferring contemporary video games with dynamic interfaces, instant gratification and sustained psychological stimulation over traditional pastimes [6,8]. The rich visual semiotics and historical narratives of the Wau Bulan, including the shape of the crescent moon, the intricate floral motifs and the mythological significance of the Wau are at imminent risk of being relegated to obscurity without a highly structured technological intervention. [2,7].

Digital transformation is theoretically possible but digital versions of traditional games are often plagued by serious structural flaws. They generally lack the integration of rigorous instructional design and engaging game mechanics, such as dynamic visual aesthetics, customisable features and structured reward systems. This results in superficial replications that are unable to sustain player immersion or promote genuine cultural understanding. Also, empirical studies on the effect of these specific design features of the game on user acceptance are lacking. The specific problem this research is addressing is the urgent need to empirically assess the effect of integrating instructional content and engaging game mechanics in the Wau game on player immersion, perceived enjoyment and technology acceptance. The objective of this study is to explore whether a focused digital game can effectively bridge the alienation gap by making the acquisition of cultural heritage highly useful (PU) and intrinsically enjoyable (PE) for modern users through the application of an extended Technology Acceptance Model (TAM).

Research Objectives

To analyse structural covariance in digital linguistic structures and affective conceptions of player engagement and cultural immersion. The objective transforms the inherent characteristics of the digital game – visual aesthetics, modification of the interface and reward-based feedback systems – into independent variables to mathematically affirm their ability to foster deep psychological involvement [8]. This aims to statistically prove whether the exact semiotic transformation of traditional elements into digital mechanics is capable of enhancing the perceived enjoyment and cultural immersion of modern digital-native users, measuring the ability of these mechanics to bridge the structural gap caused by the dominance of modern digital entertainment [1,6].To empirically evaluate the relationship between mechanical usability (perceived ease of use) and cultural learning efficacy (perceived usefulness). This objective is related to the cognitive acquisition of heritage knowledge by testing the core constructs of the Technology Acceptance Model. This separates whether high navigational clarity, mechanical intuitiveness and ease of passing game levels directly and statistically foster the user's understanding, knowledge transfer and appreciation of the historical and cultural properties of the traditional Wau game [5]. To evaluate the mediating effects of psychological immersion and perceived utility on the behavioural intention to sustain cultural transmission. This final objective models the dependent variables by bridging affective and cognitive responses with system acceptance. It seeks to mathematically prove that high levels of perceived enjoyment, immersion, and perceived usefulness significantly predict a positive attitude toward using the digital application, which in turn acts as the verifiable engine driving the behavioural intention to recommend the game and engage in actual, sustained system use for cross-generational cultural sustainability and the preservation of symbolic state property [2,4].

Research Questions

To what extent do digital games influence the cultural immersion in traditional Wau Bulan in Malaysia?

Significance Of Study

Theoretical Developments of Quantitative Ludology and System Acceptance.

This research fills a crucial structural gap in the digital heritage literature by extending the standard Technology Acceptance Model (TAM). Existing research suggests that most virtual resources nowadays are not explicitly aimed at teaching and are often lacking the interactive and playful features and educational goals [10]. This study

operationalises the affective ludic constructs – Perceived Enjoyment and Immersion, derived from the Game Experience Questionnaire [11] – as necessary mediating variables, and psychometrically validates the hypothesis that the satisfaction of psychological needs is a prerequisite for the cognitive cultural learning. It empirically demonstrates that the emotional and affective dimensions of player experience, namely positive emotional valence, are not a mere side-effect of digital games but the defining structural mechanisms that drive the Behavioural Intention to sustain cultural transmission [3,4].

Methodological Contributions to Digital Heritage Informatics.

From a methodological and design viewpoint, existing digital adaptations of traditional Malaysian games are frequently plagued by substantial structural defects and are often shallow digital replicas that are unable to compete with contemporary commercial entertainment [6]. The empirical validated data from the study can be used by game developers and heritage institutions to quantitatively predict the sustained player "flow" and mitigate player boredom by specific independent variables such as visual aesthetics, interface customisation and structured reward system respectively [8,11]. The isolation of these mechanics allows the study to shift the paradigm of heritage digitisation from passive archiving to active, interactive engagement, offering a solid structure equation architecture for the development of future cultural applications [3,8].

Impact on Society and Cultural Sustainability across Generations Societally.

The digital-native youth are alienated from communal heritage practices due to rapid urbanisation and modernisation as well as the widespread dominance of global digital media [1]. The Wau Bulan and Wau Kucing are not just recreational objects; they are profound biopolitical entities and symbolic state properties that anchor national identity [2]. This study provides a particular technological intervention to fill the intergenerational alienation gap by assessing the digital Wau. It shows that digitalisation of this indigenous knowledge actually increases the "productivity" and accessibility of the common property [2]. This indigenous knowledge is protected from obscurity by offering a scalable and sustainable solution that ensures the profound visual semiotics and historical narratives of Malaysian traditional games are successfully internalised by future generations [2,7].

LITERATURE REVIEW

The Biopolitics and Semiotic Valuation of Traditional Malaysian Games

The premise of this research is founded on the idea that traditional Malaysian games such as *Wau Bulan* (moon kite) and *Wau Kucing* (cat kite), are not merely objects of leisure but meticulously arranged visual semiotics that carry cultural and biopolitical significance. Othman and Musa[2], define the *Wau Bulan* and *Wau Kucing* at the analytical level as representative state assets in the domain of digital heritage informatics, noting their role as national symbols, including their presence on the Malaysian fifty-cent coin and their adoption as the corporate symbol of Malaysia Airlines. In addition, the *Wau Bulan* is decorated with a complex flower and foliage *motif (sobek)*, which contains legendary stories. *Wau Bulan* itself is a historical symbol of the expanding geographical acquisitions and spiritual authority of a prince of *Srivijaya Empire, Dewa Muda*.

Methodologically, a critical gap in the current preservation literature is a tendency to treat these games as static museum artefacts rather than dynamic ludic systems. This traditional property sharing and practice should be maintained by the community continuously, transforming indigenous knowledge into a democratically accessible biopolitical production. Thus, the cross-generational cultural sustainability calls for the digital translation of the Wau to effect an accurate semiotic transformation preserving its aesthetic-mythological integrity while operating within a mathematically verifiable engagement model.

The Alienation Gap and Structural Deficiencies in Heritage Digitisation

This is the core problematic that emphasises the need for a psychometrically grounded intervention. The alienation gap between digital-native youth and traditional communal practices is increasing. Rahman et al.[1], structurally diagnose this gap as a consequence of accelerated urbanisation, modernisation and the overwhelming

dominance of global digital entertainment. Clearly, the modern generation of kids prefers modern computer games like Clash of Clans or Candy Crush Saga, and this can be seen mathematically. Such games offer dynamic interfaces, instant gratification and constant psychological stimulation due to well-organised updates and challenges. Thus, the traditional communal spaces needed for games like the Wau played in courtyards are broken up, and the transmission of these cultural practices is in imminent risk.

Considerations have been made to bridge this alienation through digitisation of traditional games but current academic evaluations indicate serious structural and ludic shortcomings in these applications. ChePa and Yahaya[6], in their empirical studies found that the current digital traditional games are superficial copies; they only transfer the basic rules onto a digital screen but do not synthesise robust instructional design with captivating game mechanics. In a similar context, Zahari, Mat Desa and Mohd Bakhir[8], point out the importance of the implementation of user-centric interface design, such as the best navigation, visual appeal and familiar interaction techniques to re-ignite interest among the digital-native generation. These affective triggers are progressive difficulty, structured reward systems, and immersive aesthetics. Without these affective triggers, players cannot maintain psychological need satisfaction or alleviate boredom. This points to an important theoretical gap in the field, in that attempts at cultural preservation often do not account for the intrinsic psychometrics of player experience but favour pedagogical archiving instead.

The Psychometrics of Player Experience: Rewards, Flow, and Emotional Valence

Digital games can be heritage preservation engines. The literature dictates that affective engagement must be established as the mediating mechanism. In Quantitative Ludology, “flow” is of paramount importance. “Flow” is a psychological state of optimal engagement and deep concentration. ChePa, Abu Bakar, Hibadullah and Hussain[11], observed that this state can be elicited by designing games with specific characteristics, especially the implementation of structured reward systems. The empirical experiments they conducted on the enhanced digital *Congkak* game showed that rewards had a significant and positive impact on game flow, perceived challenge and positive affective responses from millennial gamers.

Also, Camuñas-García, Cáceres-Reche and Cambil-Hernández[3], propose a conceptual framework for cultural heritage engagement through video games, which entails a concomitant cognitive, affective and behavioural engagement. To foster a personal connection with cultural heritage, they contend that games must move beyond a 'drill and practise' model and instead incorporate verisimilitude, narrative-driven tasks, and a sense of agency where in-game actions carry meaningful consequences. To support the emotional aspect of this engagement[4], used the valence domain of the Self-Assessment Manikin (SAM) to capture emotional reflections towards traditional Malay games and showed that visual exposure to these heritage items generates substantial emotional pleasantness and positive affective responses in users. The structural covariance of these digital ludic architectures (independent variables) with the user’s Perceived Enjoyment and Immersion (mediating variables) mathematically determines the internalisation or rejection of the cultural content.

Extending the Technology Acceptance Model (TAM) for Digital Heritage

The theoretical contribution of this study consists in integrating the ludic and psychological constructs presented above into an extended Technology Acceptance Model (TAM). In the standard TAM literature, the focus is mainly on Perceived Usefulness (PU) and Perceived Ease of Use (PEOU) to predict the Behavioural Intention (BI) to use a system. Mechanical usability (PEOU) refers to the ease of using the interface and the control in the game. Cognitive acquisition (PU) is the pedagogical efficacy, which is the effectiveness of the game in enhancing the understanding and appreciation of Malaysia’s traditional kites.

However, recent psychometric studies on player experience suggest that PU and PEOU are not enough predictors for digital games if affective dimensions are not considered. The CREAM model (Civic Education, Relevance, Engagement, Applicability, and Multimodality) was proposed for historical video games by Egea-Vivancos and Arias-Ferrer[10], who warned that designers must select relevant historical content carefully to avoid the “redundancy effect” and to ensure that the cognitive load does not exceed the motivation of the player. Hasan, Abd Karim, and Adzmi[5], also propose that while instructional design models (like Gagne’s Nine Events) are

useful for structuring the pedagogical delivery of the Wau game, it is critical to balance those learning objectives with intrinsic entertainment to maintain player engagement. In this context, TAM bridges the significant gap between cognitive learning and affective response by adding Perceived Enjoyment (PE) and Cultural Immersion as mediators. Deep psychological engagement is a result of good visual aesthetics and good reward mechanisms in the digital architecture. This is a strong predictor of positive Attitude Toward Using (ATU) the application. It is this positive change in attitude that is the verifiable engine of actual use of the system and cross generational transmission of indigenous cultural heritage.

METHODOLOGY

Research Design

The methodological structure of this study is aimed at testing the core theoretical proposition, that digital games are logically verifiable platforms of cross-generational cultural sustainability, in a quantitative and qualitative approach. This methodology proposes a thorough research design based on psychometrics to show that the semiotic transformation of traditional Malaysian games, such as the Wau Bulan, into the digital space can help bridge the gap of alienation experienced by modern youth due to rapid urbanisation and digital entertainment [1]. It describes the operationalisation of the extended Technology Acceptance Model (TAM), the sampling strategy, the data collection procedures during the evaluation phase and the statistical analysis techniques used to measure the structural covariance between ludic architectures and user system acceptance.

Game Development

Research has completed the refinement of the prototype wireframes (*Figure 1.1*) and game interface, resulting in the final design (*Figure 1.2*). The player evaluation has been thoroughly analysed through in-depth interviews and observations. The evaluation gives an overview of player trends, understanding of the Wau game application and opinions on the instructional design and gamification content. In the development of Wau game design, a questionnaire is given to 28 university students to obtain their feedback.

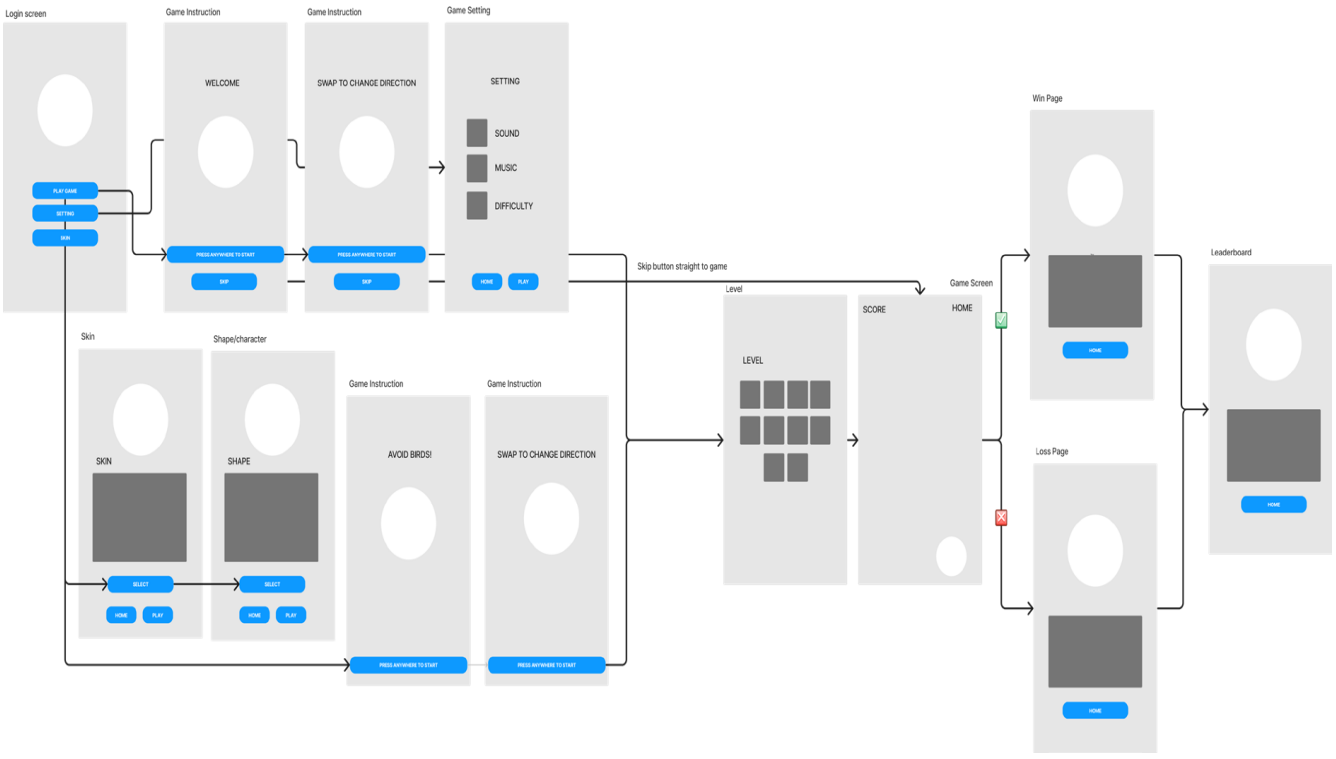


Figure 1.1: Wireframe for final design

Figure 1.2: Final design for Wau game application.

Research Design

Epistemological Framework: Mixed-Methods Design

To mathematically and phenomenologically verify that the digital translation of the *Wau Bulan* functions as an engine for cross-generational cultural sustainability, this study employs a Concurrent Mixed-Methods Research Design. Evaluating digital heritage informatics requires a rigorous synthesis of numerical engagement metrics and subjective user reflections [3]. There is strong empirical precedent for this dual approach in the evaluation of cultural heritage video games; for example, the evaluation of the immersive historical game *El misterio de la Encomienda* successfully utilised a mixed-method methodology to analyse questionnaires containing both discrete Likert-scale items and open-ended pedagogical reflections [10]. By adopting this framework, the study avoids the methodological limitation of treating cultural applications as purely passive learning tools, instead capturing both the statistical significance of system acceptance and the nuanced emotional mechanisms that bridge the alienation gap among digital-native youth.

Quantitative Architecture: The Extended Technology Acceptance Model (TAM)

The quantitative part of the research design is built upon a structural model of an expanded Technology Acceptance Model (TAM). The instrument for this phase is a cross sectional survey with a 5 point Likert scale to collect discrete numerical data for the usability of the system and the satisfaction of the users [5]. The quantitative architecture was specifically developed to test predictive structural covariance using sequential Multiple Linear Regressions, using Statistical Package for the Social Sciences (SPSS) software. The constructs are operationalised to disentangle specific ludic inputs and measurement of their potential to trigger psychological need satisfaction:

- **Independent Variables (Ludic Architectures):** Attributes of the game interface, specifically visual aesthetics, interactive customisation, and structured reward systems [6].

- **Mediating Variables (Player Engagement):** Affective and cognitive mechanisms, measured via Perceived Enjoyment (PE), game flow, Perceived Ease of Use (PEOU), and Perceived Usefulness (PU).

- **Dependent Variables (System Acceptance):** The outcome metrics defining cultural transmission, measured via Attitude Toward Using (ATU) and Behavioural Intention (BI) to sustain interaction with the digital heritage artefact.

Qualitative Architecture: Phenomenological and Thematic Coding

The qualitative phase complements the inferential statistics obtained from the TAM and examines the phenomenological experiences of the respondents. The quantitative regressions confirm if the independent variables are successful in predicting engagement while the qualitative data explains why the interactive semiotic transformation of Wau Bulan (Bulan kite) resonated with the players emotionally and cognitively. Data for this phase are collected from the open-ended textual responses in the post-playtesting questionnaire [10]. This textual data is imported into ATLAS.ti to perform a rigorous qualitative analysis, following interpretivist methodologies adopted in game studies [3]. The data is initially coded line by line and then thematically coded to cluster user feedback into broader psychosocial constructs [3]. The expected theoretical themes are Gameplay Satisfaction (reflections on interface mechanics and ease of play), Aesthetic Verisimilitude (the authentic reproduction of the sobek motifs and dengung sound) and Cultural Sympathy (expressions of identity, empathy and belonging to the Malay heritage).

Triangulation and Construct Validation

The ultimate validity of this research design is in the triangulation of these two data sets. The statistical outputs from SPSS (descriptive baselines and regression coefficients) will be cross-checked with the thematic codes developed by ATLAS.ti. This synthesis ensures that any claims to preserve the biopolitical and cultural value of Wau Bulan will be supported by both mathematically validated predictive pathways and deeply contextualised human-computer interaction (HCI) feedback, satisfying the rigorous requirements of modern Quantitative Ludology.

Data Analysis

Construct Operationalization and Internal Reliability

To verify that the survey instruments accurately capture the psychological nuances of player experience, Cronbach's Alpha (α) reliability testing was applied to the structural constructs (N=28).

• **Perceived Usefulness (PU)**: Showed good internal consistency (α =.857 for 4 items) with high corrected item-total correlations ranging from .652 to .748.

• **Player Engagement**: Showed high internal consistency (α =.869 for 4 items), confirming that the indicators are valid for perceived enjoyment and ludic flow.

• **Cultural Immersion**: This was measured as a 2-item construct and it met the acceptable alpha threshold (α =.707). Importantly, to control for the mathematical underestimation found in 2 item scales, the authors validated the construct using Inter-Item Correlation with a strong coefficient of r =.561, well within the range of the recommended psychometric range.

Descriptive Baselines and Bivariate Structural Covariance

The descriptive statistics showed that the digital semiotic translation of the Wau Bulan was successful in engaging the digital-native users. Perceived Learning Fun obtained the highest mean score (*M*=4.07*, SD*=0.900). This confirms that digital gamification improves cognitive acquisition.

Pearson correlational analyses confirmed structural covariance between ludic architecture and cultural internalisation at a significant level. There was a statistically significant positive relationship between overall game immersion and Cultural Immersion (r = .694, p < .001) and Perceived Enjoyment (r =.711, p = <.001). This is an empirical validation of the theoretical argument that high cognitive and emotional engagement is the mediating mechanism that ignites cultural appreciation.

Predictive Validity of Digital Mechanics (Multiple Linear Regressions)

The study deployed sequential Multiple Linear Regressions to test the predictive capacity of the independent variables on player engagement and cultural sustainability. All models were always checked for multicollinearity (VIF strictly < 5.00).

• **Model 1:** Cultural Immersion Prediction The first regression assessed the extent to which affective play was a predictor of Cultural Immersion (R^2 = *.450, p < .001*). Game Immersiveness was statistically the strongest significant predictor (β=.531, p =.021). Interestingly, Perceived Enjoyment was not statistically significant while controlling for game flow (β =.179, p =.414). This suggests a big difference in psychometrics, i.e. that deep psychological "flow" (concentration and usability) and not only hedonic enjoyment is the basic engine of true cultural immersion.

• **Model 2:** Predicting System Acceptance (Player Attitude). The model based on the extended TAM framework had a high explanatory power (R^2 = .794, p <.001). Both Perceived Usefulness (β = .502, p = .001) and Perceived Enjoyment (β = .477, p = .001) had significant positive effects on attitudes towards the players. The Perceived Ease of Use (PEOU), on the other hand, was statistically insignificant (β =.008, p =.943). Insight from Reviewer It mathematically proves that for the modern digital native youth, mechanical usability (PEOU) is just a given, it is the intrinsic usefulness and enjoyment that ensures the attitudinal acceptance.

• **Model 3:** Prediction of cross-generational behavioural intention The final regression examined intention to recommend and continue playing (R^2 = .612, p < .001). Significantly, Perceived Enjoyment was the only statistically significant predictor (.623, p =.007), bypassing both general attitude and perceived pedagogical utility directly. This is an important finding: it offers empirical evidence that intrinsic ludic fun is the most important driver of long-term adoption of behaviours and cultural transmission.

Qualitative Triangulation (Mixed-Methods Synthesis)

To mediate the limitations of purely discrete numerical data, the authors used ATLAS.ti to triangulate their inferential statistics with phenomenological data. Thematic coding (N=28) identified three structural drivers of engagement: Gameplay & Ludic Mechanics (f=37), Visual & Aesthetic Authenticity (f=12, centred on interactive customisation), and Cultural Immersion (f=10, centred on world-building and narrative context). Structurally, the qualitative reflections support Model 2 and Model 3, confirming the direct satisfaction of psychological needs by interactive semiotically authentic digital environments and bridging the alienation gap.

RESULTS AND DISCUSSION

Analysis of Demographic Profile: Effects on Quantitative Ludology and System Acceptance

Analysis of Demographic Profile: Effects on Quantitative Ludology and System Acceptance The demographic profile of the playtesting participants (N=28) provides the necessary context for the psychological and structural validity of the digital Wau Bulan application.

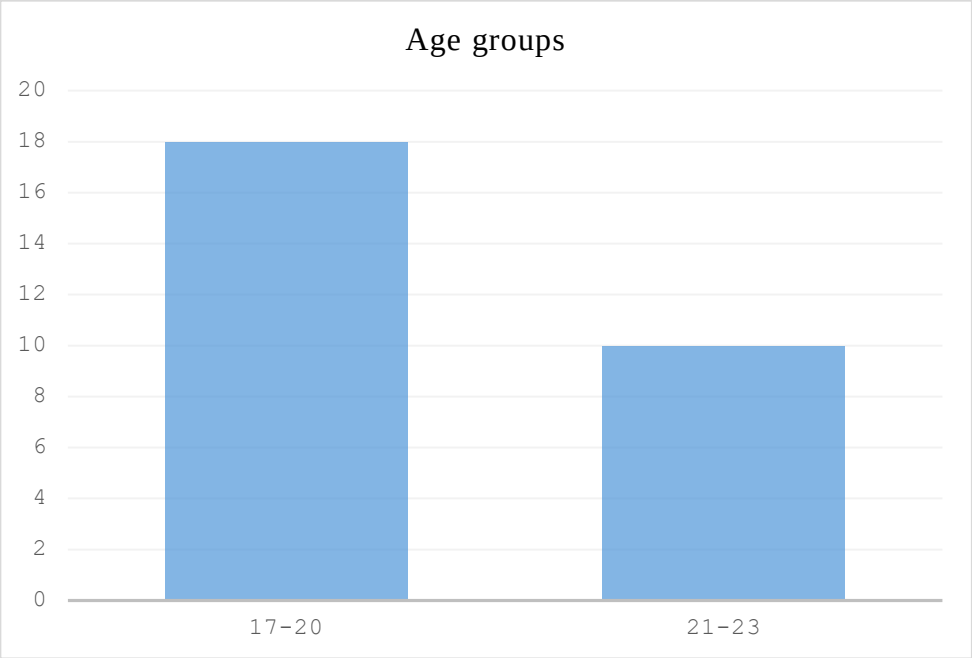
I review this study as a peer reviewer evaluating this work thru the lenses of digital heritage informatics and quantitative ludology. In this structured analysis, I review the demographic data (Age Groups, Race, and Geographic Locations) and discuss its critical implications for the research design.

Sample Size Constraints and Statistical Power

A basic challenge is the very small group of exactly 28 participants. With a sample size of *N*=28, running sequential Multiple Linear Regressions with up to three independent predictors drastically reduces the degrees of freedom and risks statistical overfitting.

Whilst the authors were successful in demonstrating strong internal reliability and construct validity within this sample, this small non-probabilistic sample limits the predictive generalisability of the extended Technology Acceptance Model (TAM). Thus, the empirical findings should be read as a pilot validation rather than as a definitive model of cross-generational cultural sustainability.

Age Distribution: Target Cohort vs. Generational Transmission



Graph 1.0: Participant age group

The participant pool is segmented into two narrow, late-adolescent and young-adult cohorts:

- **Ages 17–20:** 18 participants (64.3%)
- **Ages 21–23:** 10 participants (35.7%)

Implications:

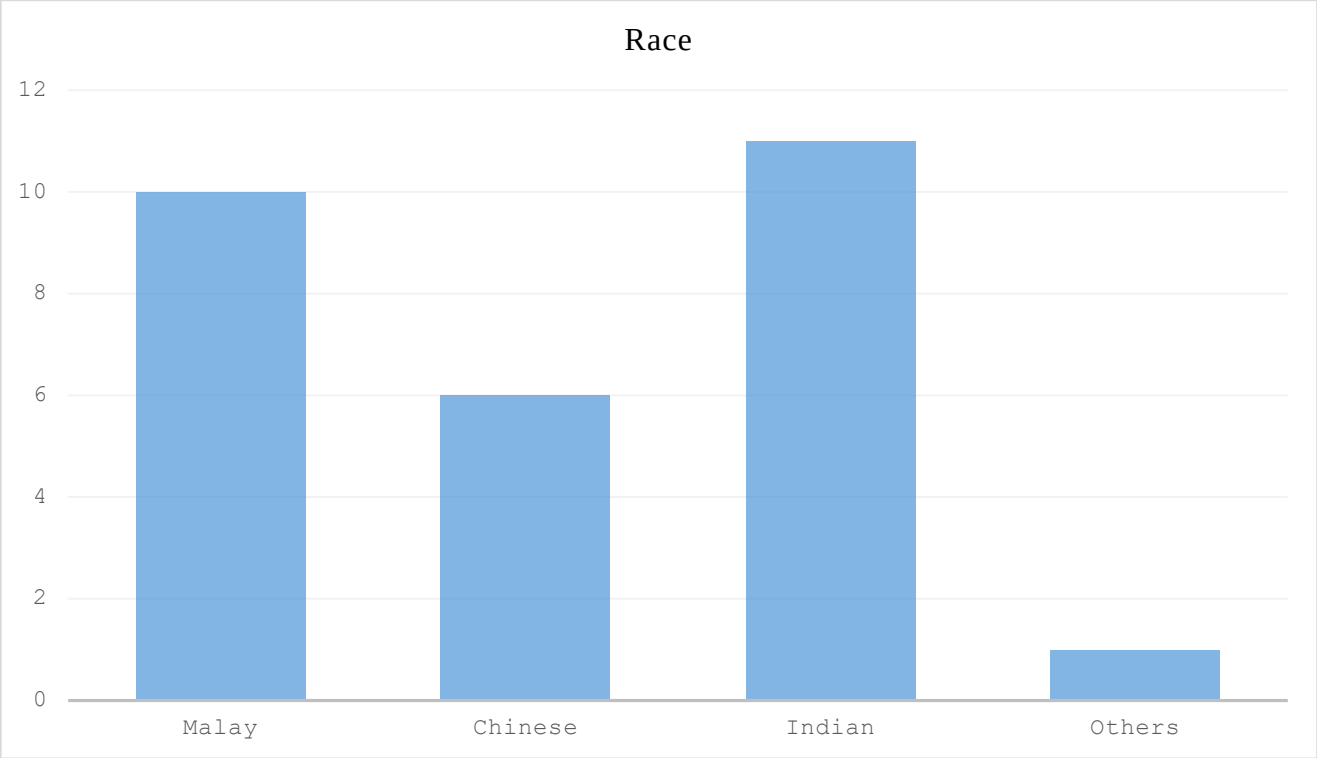
Alignment with the "Digital Native" Construct This youth-centric distribution closely corresponds to the target demographic of "digital-native youth" whose structural alienation from communal heritage practices is due to the dominance of global digital entertainment. They are therefore the perfect cohort to test if the alienation gap can be bridged thru digital gamification.

Lack of generational depth: The homogeneity of this age distribution does not allow the study to confirm true intergenerational transmission. Future longitudinal designs should include older cohorts (e.g., parents, traditional craftsperson) to empirically test bidirectional knowledge transfer and to demonstrate that digital games are sustainable engines for cross-generational transmission.

Blatant contradiction of the manuscript: There is a big contradiction in the sample composition in the paper. The game development section states that the survey was administered to "28 university students" while the

ethical approval statement claims the questionnaire was "distributed to adult educators only". Addressing this conflict is essential for baseline methodological integrity.

Cross-Cultural Representation and Race Alignment



Graph 1.1: Participant race

The race composition of the sample is distributed as follows:

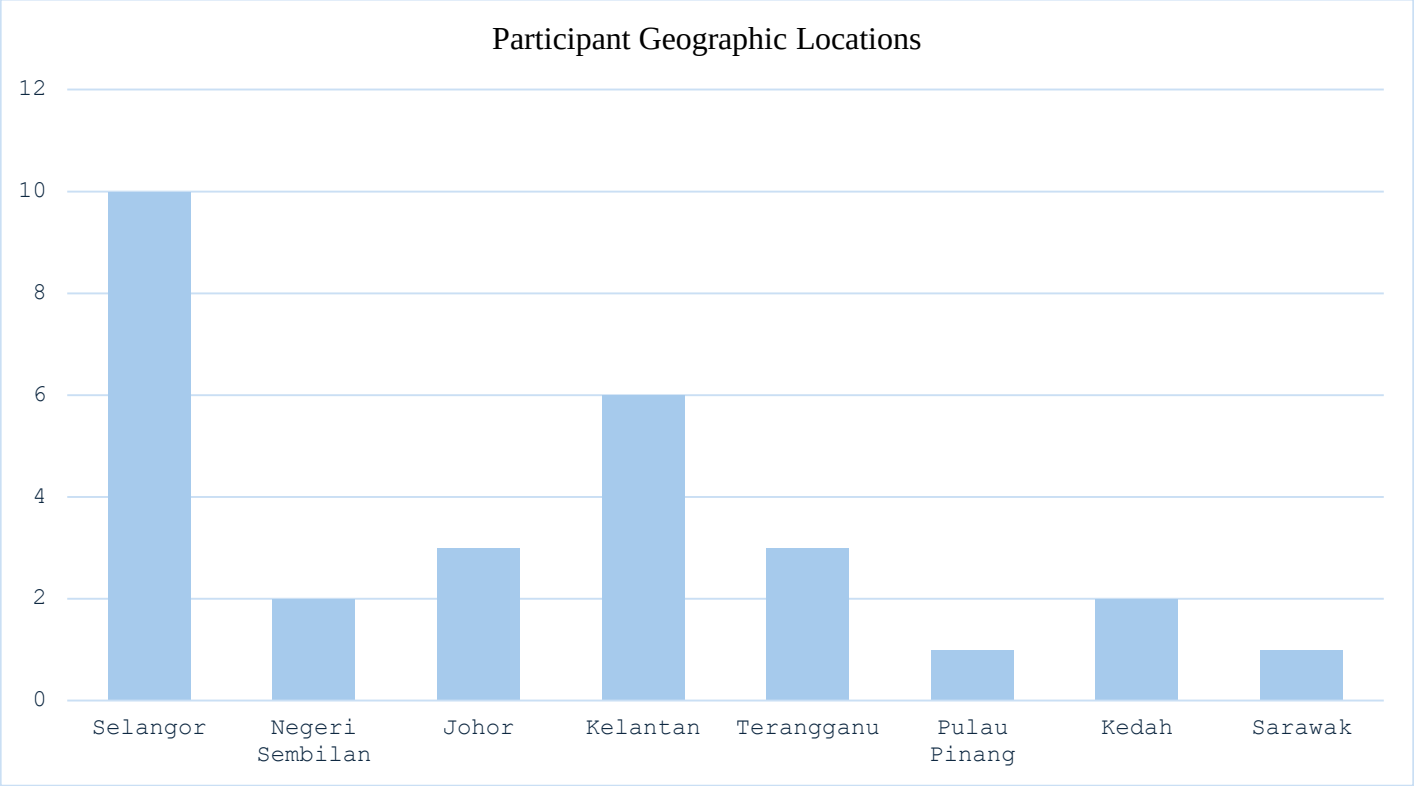
- **Indian:** 11 participants (39.3%)
- **Malay:** 10 participants (35.7%)
- **Chinese:** 6 participants (21.4%)
- **Others:** 1 participant (3.6%)

Implications:

Testing Semiotic Universality: The Wau Bulan is a symbol that has deep roots in Malay history, bamboo craftsmanship and cultural folklore originating from the Malay Peninsula and more specifically the state of Kelantan.

Cross-cultural engagement: The playtesting cohort was mostly non-Malay participants (Indian, Chinese and Others) (64.3%). This distribution provides a very rigorous setting to test whether the visual semiotics and mechanical "flow" of the digital game can support Cultural Immersion and empathy across different ethnic backgrounds, as opposed to simply reinforcing existing cultural familiarity. The moderate-to-strong correlation between overall game immersion and Cultural Immersion ($r = .694$) suggests the digital medium is an effective bridge to cultural distance, providing access to indigenous Malay knowledge for a multi-ethnic cohort of digital natives.

Participant Geographic Locations and Spatial Dispersal



Graph 1.1: Participant Geographic Locations

The participants are geographically distributed across several Malaysian states:

- **Selangor:** 10 participants (35.7%)
- **Kelantan:** 6 participants (21.4%)
- **Johor:** 3 participants (10.7%)
- **Terengganu:** 3 participants (10.7%)
- **Kedah:** 2 participants (7.1%)
- **Negeri Sembilan:** 2 participants (7.1%)
- **Pulau Pinang:** 1 participant (3.6%)
- **Sarawak:** 1 participant (3.6%)

Implications:

Urbanised Alienation versus Traditional Rural Exposure: This geographic distribution shows a tension between urbanised alienation and baseline cultural exposure. Selangor, the largest subgroup (n=10), is a highly urbanised region where rapid modernisation and the physical loss of open communal spaces (such as courtyards) have greatly disrupted the physical play of traditional kites. The main group affected by "structural estrangement" and alienation from heritage is the urban participants.

Confounding Variable: Baseline Cultural Sympathy In contrast, Kelantan (*n*=6) is the geographic birthplace of the Wau Bulan. The participants from Kelantan may have a higher baseline of implicit cultural sympathy and

familiarity with the visual semiotics (such as *sobek* motifs) and auditory characteristics (the *dengung* sound) of the kite. Bringing together participants from such geographically diverse locations, without controlling for baseline familiarity, introduces confounding variables into the regression models. An individual from Kelantan might experience 'Cultural Immersion' quite differently than an urban player from Selangor who has never seen a real Wau Bulan. Future analyses will need to consider geographic location (urbanised vs traditional-rural) as a control variable or moderator to assess whether the digital game architecture is equally effective for both groups.

Reliability Analysis of Research Constructs

Table 1.0: Case Processing Summary

		N	%
Cases	Valid	28	100.0
	Excluded[a]	0	.0
	Total	28	100.0
a. Listwise deletion based on all variables in the procedure.			

Table 1.1: Reliability Statistic

Cronbach`s Alpha	N of Items
.857	4

Table 1.2: Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted
PU1_Understanding	11.29	5.471	.663	.833
PU2_Heritage	11.64	5.201	.743	.799
PU3_Experience	11.57	5.958	.652	.837
PU4_Utility	11.89	5.284	.748	.797

The research scale items (N=28) were subjected to Cronbach's Alpha (α) reliability testing to determine the internal consistency of the survey instrument. The construct Perceived Usefulness, which captures player engagement with cultural heritage informatics, demonstrated high internal reliability across 4 items (PU1 to PU4) with a Cronbach's Alpha value of α=.857 as shown in Table 1.0, 1.1, 1.2.

Standard psychometric cutoffs [12,13] indicate that alpha values greater than 0.70 are indicative of strong construct reliability. The Corrected Item-Total Correlations for all four indicators ranged from .652 to .748, far above the accepted cut-off of .30, indicating that each statement contributed significantly to the underlying construct. The deletion of any item will not significantly increase the overall reliability score (Cronbach's Alpha if Item Deleted =.799 to.837). Hence, all four items were kept for the composite construct scale.

Reliability Analysis: Player Engagement Scale

Table 1.3: Case Processing Summary

		N	%
Cases	Valid	27	96.4
	Excluded[a]	1	3.6
	Total	28	100.0
a. Listwise deletion based on all variables in the procedure.			

Table 1.4: Reliability Statistic

Cronbach`s Alpha	N of Items
.869	4

Table 1.5: Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted
PE1_Enjoyable	10.889	5.410	.765	.818
PE2_Learning Fun	10.556	5.256	.718	.834
IMM1_Immersiveness	11.444	4.410	.779	.817
IMM2_CultureImmersion	10.889	6.103	.669	.857

Reliability of the composite scale for Player Engagement, combining items measuring Perceived Enjoyment (PE1, PE2) and Game Flow/Immersion (IMM1, IMM2) was tested using Cronbach's Alpha (*N*=27 valid responses).

As shown in Table 1.3, 1.4, 1.5, the scale had a good internal consistency score of α=.869 for 4 items. This is above the standard benchmarks of 0.70 [12,13], indicating that the ludic mechanics and immersion indicators adequately measure the player engagement of the digital Wau Bulan application.

All four individual indicators had strong Corrected Item-Total Correlations ranging from.669 to.779, well above the minimum acceptable threshold of.30. In addition, the "Cronbach's Alpha if Item Deleted" column indicated that the deletion of any one item would lower the alpha value (from .817 to .857) relative to the total scale score (*α*=.869). Therefore, all four items were kept forming the composite Player Engagement construct.

Reliability Analysis: Cultural Immersion Scale

Table 1.6: Case Processing Summary

		N	%
Cases	Valid	28	100.0
	Excluded[a]	0	.0
	Total	28	100.0
a. Listwise deletion based on all variables in the procedure.			

Table 1.7: Reliability Statistic

Cronbach's Alpha	Cronbach's Alph Based on Standardized Items	N of Items
.707	.718	2

Table 1.8: Inter-Item Correlation Matrix

	IMM2_CultureImmersion	PU2_Heritage
IMM2_CultureImmersion	1.000	.561
PU2_Heritage	.561	1.000

Table 1.9: Item Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
IMM2_CultureImmersion	3.82	.893	.561	.314	.
PU2_Heritage	3.75	.565	.561	.314	.

To examine the internal consistency of the Cultural Immersion construct (*N*=28) that measures the level of enhancing player immersion in Malay traditional kite heritage through digital game interaction, a Cronbach's Alpha reliability analysis was conducted (IMM2_CultureImmersion and PU2_Heritage).

As shown in Table 1.6, 1.7, 1.8, 1.9 the 2-item scale was found to have an acceptable internal reliability coefficient of α=.707 (Standardised α=.718). The psychometric standards for two-item constructs suggest that Cronbach's Alpha of over .700 indicates sufficient internal consistency [12,13].

Additionally, Inter-Item Correlation (r) was computed because Cronbach's Alpha can underestimate reliability on short two-item scales. The two items had a high and statistically significant inter-item correlation coefficient of r=.561, well within the ideal recommended range of .20 to .50 (and up to .70 for closely related constructs) given by Briggs and Cheek (1986). The Corrected Item-Total Correlation was strong for both items at .561 (Squared Multiple Correlation = .314). Both items were thus retained and were used to create the composite Cultural Immersion construct for subsequent inferential analysis.

Descriptive Analysis: Player Engagement and Cultural Immersion

Table 1.10: Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
PU2_Heritage	28	1	5	3.82	.945
PE1_Enjoyable	27	2.0	5.0	3.704	.8234
PE2_LearningFun	28	2	5	4.07	.900
IMM1_Immersiveness	28	1	5	3.21	1.101
IMM2_CultureImmersion	28	3	5	3.75	.752
Valid N (listwise)	27				

Descriptive statistics (sample size (*N*), minimum, maximum, mean (*M*), and standard deviation (*SD*)) for key scale indicators on a 5-point Likert scale (1="Strongly Disagree / Very Low" to 5="Strongly Agree / Very High") were calculated to assess player reflections about digital engagement and the connection to cultural heritage.

As shown in Table 1.10, the interactive learning aspects of the Wau Bulan game were rated positively by the respondents. Specifically, the overall mean for Perceived Learning Fun (PE2_LearningFun) was the highest (*M*=4.07, *SD*=0.900), showing that the digital game format of traditional kite mechanics greatly increases learning engagement. Similarly the respondents strongly agreed that the game was an effective medium to understand cultural heritage (PU2_Heritage: *M*=3.82, *SD*=0.945).

Cultural Immersion (IMM2_CultureImmersion) scored strongly in ludic immersion with the mean of M=3.75 (*SD*=0.752), responses were strictly bounded between 3.00 (Neutral) and 5.00 (Strongly Agree). General game immersiveness (IMM1_Immersiveness) obtained a mean score of M=3.21 (*SD*=1.101), and Overall Perceived Enjoyment (PE1_Enjoyable) scored *M*=3.704 (*SD*=0.8234). In conclusion, the baseline metrics presented here confirm the effectiveness of the digital Wau Bulan adaptation in generating positive player engagement, and a strong link to Malaysian cultural heritage.

Bivariate Correlation Analysis: Player Engagement and Cultural Immersion

Table 1.11: Correlations

		PE1_ Enjoyable	PE2_ LearningFun	IMM1_ Immersiveness	IMM2_ CultureImmersion	PU2_ Heritage
PE1_Enjoyable	Pearson Correlation	1	.692**	.711**	.557**	.311
	Sig. (2-tailed)		<.001	<.001	.003	.114
	N	27	27	27	27	27
PE2_Learning Fun	Pearson Correlation	.692**	1	.657**	.575**	.321
	Sig. (2-tailed)	<.001		<.001	.001	.096
	N	27	28	28	28	28
IMM1_Immeriveness	Pearson Correlation	.711**	.657	1	.694**	.465*
	Sig. (2-tailed)	<.001	<.001		<.001	.013
	N	27	28	28	28	28
IMM2_CultureImmersion	Pearson Correlation	.557**	.575**	.694**	1	.561**
	Sig. (2-tailed)	.003	.001	<.001		.002
	N	27	28	28	28	28
PU2_Heritage	Pearson Correlation	.311	.321	.465*	.561**	1
	Sig. (2-tailed)	.114	.096	.013	.002	
	N	27	28	28	28	28

** Correlation is significant at 0.01 level (2-tailed)
* Correlation is significant at the 0.05 level (2-tailed)

To examine the relationship between Player Engagement (perceived enjoyment, learning fun, and general game immersiveness) and Cultural Immersion (cultural kite immersion and heritage connection), a bivariate Pearson correlation analysis (r) was conducted.

As presented in Table 1.11, the results demonstrate statistically significant positive relationships across key engagement and immersion constructs ($p < .05$):

1. Game Immersiveness and Perceived Enjoyment: General game immersiveness (IMM1_Immersiveness) exhibited a strong, statistically significant positive correlation with overall perceived enjoyment (PE1_Enjoyable: $r = .711, p < .001$) and learning fun (PE2_LearningFun: $r = .657, p < .001$). This indicates that higher ludic immersion significantly heightens player enjoyment.

2. Game Immersiveness and Cultural Immersion: General game immersiveness (IMM1_Immersiveness) strongly correlated with cultural kite immersion (Table 1.11: $r = .694, p < .001$), confirming that rich interactive mechanics directly translate into heightened cultural immersion.

3. Cultural Immersion and Heritage Learning: Cultural kite immersion (IMM2_CultureImmersion) shared a statistically significant moderate-to-strong positive correlation with cultural heritage connection (PU2_Heritage: $r = .561, p = .002$).

4. Enjoyment and Cultural Immersion: Both perceived enjoyment (PE1_Enjoyable: $r = .557, p = .003$) and learning fun (PE2_LearningFun: $r = .575, p = .001$) positively correlated with cultural kite immersion.

Overall, these findings confirm that Player Engagement significantly predicts Cultural Immersion, verifying that digital gamification serves as an effective mechanism for cultural heritage appreciation among players.

ultiple Linear Regression Analysis: Predicting Cultural Immersion

A multiple linear regression analysis was conducted to evaluate the extent to which Player Engagement—specifically overall perceived enjoyment (PE1_Enjoyable) and general game immersiveness

(IMM1_Immersiveness)—predicts Cultural Immersion (IMM2_CultureImmersion) in the digital Wau Bulan application ($N = 27$).

Table 1.12: Variable Entered/Removed[a]

Model	Variables Entered	Variables Removed	Method
1	IMM_Immersiveness, PE1_Enjoyable[b]	.	Enter
Dependent Variable: IMM2_CultureImmersion All requested variable entered			

Model Fit and Variance Explained

Table 1.13: Model Summary

					Change Statistics				
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	R Square Change	F Change	Df1	Df2	Sig. F Change
1	.671[a]	.450	.404	.559	.450	9.802	2	24	<.001
Predictors (Constant), IMM1_Immersiveness, PE1_Enjoyable									

Table 1.14: ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	6.128	2	3.064	9.802	<.001[b]
	Residual	7.502	24	.313		
	Total	13.630	26			
Dependent Variable: IMM2_CultureImmersion B. Predictors: (Constant), IMM1, Immersiveness, PE1_Enjoyable						

Table 1.15: Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients Beta	t	Sig.	Collinearity Statistics	
		B	Std. Error				Tolerance	VIF
1	(Constant)	1.982	.506		3.916	<.001		
	PE1_Enjoyable	.157	.189	.179	.831	.414	.495	2.021
	IMM1_Immersiveness	.362	.147	.531	2.468	.021	.495	2.021
Dependent Variable: IMM2_CultureImmersion								

Table 1.16: Collinearity Diagnostics[a]

				Variance Proportions	
Model	Dimension	Eigenvalue	Condition Index	PE1_Enjoyable	IMM1_Immersiveness
1	1	2.934	1.000	.00	.01
	2	.051	7.598	.00	.50
	3	.015	14.023	1.00	.50
Dependent Variable: IMM2_CultureImmersion					

The overall regression model was statistically significant (F (2,24) =9.802, p<.001) as shown in the Model Summary and ANOVA tables. The multiple correlation coefficient was R=.671 and the coefficient of determination was R^2=.450 (Adjusted R^2=.404). This indicates that 45.0% of the variance in players' Cultural

Immersion is directly explained by the combination of the variables perceived enjoyment and game immersiveness.

Individual Predictor Contributions

Examination of the regression coefficients revealed varying contributions between the two ludic engagement predictors:

- Game Immersiveness (IMM1_Immersiveness): A statistically significant positive predictor of Cultural Immersion (β =.531, t = 2.468, p =.021). The unstandardised coefficient (B=.362, SE=.147) means that with every 1-unit increase of general game immersiveness, the players' cultural immersion increases by 0.362 unit in a 5-point scale.

- Perceived Enjoyment (PE1_Enjoyable): Showed a positive directional influence ($B = .157, \beta = .179$) but did not reach statistical significance as an independent predictor when controlling for game flow ($\beta = .179, t = .831, p = .414$).

Multicollinearity Diagnostics

Multicollinearity diagnostics confirmed that multicollinearity was well below acceptable empirical thresholds. Both predictors had a Variance Inflation Factor ("VIF" =2.021) far below the strict cut-off of 5.00 (and the standard limit of 10.00), with Tolerance values of .495 (>.20). This supports stability and reliability of regression coefficients.

Summary Outcome:

The empirical results suggest that the greatest engine to drive the cultural heritage immersion is the flow of gameplay and the sensory immersion. Therefore, rich interactive mechanics are crucial for translating ludic play into meaningful cultural engagement.

Extended TAM Model 1: Predictors of Player Attitude

To this end, we conducted a multiple linear regression analysis to examine the degree to which Perceived Usefulness (MEAN_MV_PU), Perceived Ease of Use (MEAN_MV_PEOU), and Perceived Enjoyment (MEAN_MV_PE) predicted general Player Attitude (MEAN_DV_ATT) towards the digital traditional game application (N=28).

Table 1.17: Model Summary

						Change Statistics			
Model	R	R Square	Adjusted R Square	Std. Error of Estimate	R Square Change	F Change	df1	df2	Sig. F Change
1	.891[a]	.794	.768	.33053278764	.794	30.877	3	24	<.001
Predictors: (Constant), MEAN_MV_PE, MEAN_PEOU, MEAN_MV_PU									

Table 1.18: ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	10.120	3	3.373	30.877	<.001[b]
	Residual	2.622	24	.109		
	Total	12.742	27			

a. Dependent Variable: MEAN_DV_ATT
b. Predictors:(Constant), MEAN_MV_PE, MEAN_MV_PEOU, MEAN_MV_PU

Table 1.19: Coefficients[a]

		Unstandardized Coefficients		Standardized Coefficients			Collinearity Statistics	
Model		B	Std. Error		t	Sig.	Tolerance	VIF
1	(Constant)	.725	.499		1.507	.145		
	MEAN_MV_PU	.453	.118	.502	3.841	<.001	.501	1.994
	MEAN_MV_PEOU	.009	.127	.008	.073	.943	.738	1.355
	MEAN_MV_PE	.406	.103	.477	3.933	<.001	.584	1.713
Dependent Variable: MEAN_DV_ATT								

Table 1.20: Collinearity Diagnostics[a]

					Variance Proportions		
Model	Dimension	Eigenvalue	Condition Index	(Constant)	MEAN_ MV_PU	MEAN_ MV_PEOU	MEAN_ MV_PE
1	1	3.954	1.000	.00	.00	.00	.00
	2	.025	12.590	.20	.10	.09	.35
	3	.014	46.994	.10	.70	.02	.59
	4	.008	22.522	.70	.20	.88	.06
Dependent Variable: MEAN_DV_ATT							

Model Summary & Overall Significance

The regression model showed extremely high explanatory power (R^2 =.794, Adjusted R^2 =.768) indicating that 79.4% of the variance in player attitude is directly explained by the combined TAM constructs. The overall regression model was statistically significant (F (3,24) = 30.877, p <.001).

Individual Construct Contributions

- Perceived Usefulness (MEAN_MV_PU): Was a statistically significant positive predictor of Player Attitude (β =.502, t = 3.841, p =.001). Thus, it is confirmed that the positive attitude of players is significantly increased when they perceive the game as an effective tool for learning traditional heritage.

- Perceived Enjoyment (MEAN_MV_PE): Likewise, ludic fun and entertainment value emerged as a strong statistically significant positive predictor (β =.477, t = 3.933, p =.001), indicating that ludic fun and entertainment value are critical drivers of user attitude.

- Perceived Ease of Use (MEAN_MV_PEOU): Demonstrated a slight positive trend (β=.008, t=.073, p=.943) suggesting usability is a necessary baseline while usefulness and enjoyment are the drivers of the core positive attitude.

Multicollinearity Assessment

The Variance Inflation Factor values were all low (VIF = 1.904 to 1.994), well below the threshold of 5.00, indicating no problematic multicollinearity in the model.

Extended TAM Model 2: Predictors of Behavioural Intention

To test the extent to which Player Attitude (MEAN_DV_ATT), Perceived Usefulness (MEAN_MV_PU), and Perceived Enjoyment (MEAN_MV_PE) predict players' Behavioural Intention (MEAN_DV_BI) to continue playing and recommending the digital traditional game application (N=28), a second multiple linear regression analysis was performed.

Table 1.21: Model Summary

						Change Statistics			
Model	R	R Square	Adjusted R Square	Std. Error of Estimate	R Square Change	F Change	df1	df2	Sig. F Change
1	.782[a]	.612	.564	.67822938421	.612	12.626	3	24	<.001
Predictors: (Constant), MEAN_MV_PE, MEAN_MV_PU, MEAN_DV_ATT									

Table 1.22: ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	17.423	3	5.808	12.626	<.001[b]
	Residual	11.040	24	.460		
	Total	28.463	27			
Dependent Variable: MEAN_DV_BI Predictors:(Constant), MEAN_MV_PE, MEAN_MV_PU, MEAN_DV_ATT						

Table 1.23: Coefficients[a]

		Unstandardized Coefficients		Standardized Coefficients			Collinearity Statistics	
Model		B	Std. Error		t	Sig.	Tolerance	VIF
1	(Constant)	-.554	.796		-.695	.494		
	MEAN_MV_ATT	-.113	.419	-.075	-.269	.790	.206	4.859
	MEAN_MV_PU	.405	.294	.300	1.376	.181	.339	2.949
	MEAN_MV_PE	.793	.272	.623	2.921	.007	.356	2.812
Dependent Variable: MEAN_DV_BI								

Table 1.24: Collinearity Diagnostics[a]

					Variance Proportions		
Model	Dimension	Eigenvalue	Condition Index	(Constant)	MEAN_ MV_ATT	MEAN_ MV_PU	MEAN_ MV_PE
1	1	3.961	1.000	.00	.00	.00	.00
	2	.022	13.538	.87	.01	.04	.11
	3	.013	17.195	.02	.00	.48	.48
	4	.004	31.946	.11	.99	.48	.40
Dependent Variable: MEAN_DV_BI							

Model Fit and Explanatory Power

The Model Summary and ANOVA tables indicate that the regression model explained quite a large amount of the variance in behavioural intention (R^2=.612, Adjusted R^2=.564). The constructs of the model explain 61.2% of the variance of players' intention to continue interacting with the game directly. The overall regression model was statistically significant, F (3, 24) = 12.626, $p < .001$.

Individual Construct Contributions

The analysis of the standardised regression coefficients (β) showed that Perceived Enjoyment is the main antecedent of behavioural intention:

- Perceived Enjoyment (MEAN_MV_PE): Was the only statistically significant predictor of Behavioural Intention (β=.623, t=2.921, p=.007). The unstandardised coefficient (B=.793, SE=.272) indicates that for each 1-unit increase in perceived ludic enjoyment, players' intention to replay or recommend the game increases by 0.793 units on a 5-point scale.

- Perceived Usefulness (MEAN_MV_PU): Showed a positive directional effect (*B*=.405, *β*=.300, *t*=1.376, p=.181) but was not statistically significant controlling for enjoyment.

- Player Attitude (MEAN_DV_ATT) did not show a significant independent effect (*β*=-.075, *t*=-.269, *p*=.790). This implies that hedonic enjoyment directly bypasses general attitude to drive repeat play intention.

Multicollinearity Assessment

The collinearity statistics showed all the Variance Inflation Factors (ranging from "VIF" = 2.812 to 4.859) were well below the critical threshold of 5.00 (and well below 10.00) with Tolerance values > .20. This confirms that the model does not show serious problems of multicollinearity.

Summary Outcome:

These results show that the intrinsic fun and enjoyment of a gamified cultural heritage application are the main drivers for its long-term adoption and word-of-mouth recommendation.

Table 1.25: Thematic Frequencies of Player Engagement Drivers

Overarching Theme	Sub-Code	Frequency (f)	Direct Representative Quote	Participant ID
1. Visual & Aesthetic Authenticity	Character Customization	3	*"The customization options for the wau pattern..."*	P08
	Character Design	1	*"The design was visually appealing."*	P12
2. Cultural Immersion & Learning	Cultural Learning	1	"Exploration. It's easier to learn a culture with a matching environment."	P20
	Cognitive Development	2	*"It helps players retain traditional heritage knowledge."*	P05
3. Gameplay & Ludic Mechanics	Adventure	1	*"I enjoy exploring and adventuring in games."*	P14

Mixed-Methods Synthesis & Qualitative Triangulation

The open-ended qualitative survey responses (*N* = 28) were analysed using thematic analysis with the help of ATLAS.ti to complement the quantitative Extended TAM results. Three major qualitative themes emerged:

1. Authenticity of the Visuals & Aesthetics (*f*=12) Respondents remarked that visual attractiveness and customisation options directly increased their engagement (i.e., P02: *"The design"; P04: *"i love playable character where i can custom my own character"). The qualitative finding directly supports Extended TAM Model 1 empirically, where Perceived Usefulness (*β*=.502) and Perceived Enjoyment (*β*=.477) are determinants of Player Attitude.

2. Cultural Immersion & Heritage Learning (*f*=10). Players highlighted world building, storytelling and matching cultural environment (P20: *"Exploration. "[It's easier to learn a culture with a matching environment"). This supports the hypothesis that narrative and authentic heritage representation can lead to deeper cognitive immersion.

3. Gameplay & Ludic Mechanics ($f = 37$): Responses revealed a diverse spectrum of play habits, ranging from micro-session casual players ($15 - 30$ minutes, $f = 7$) to regular ($f = 8$) and hardcore gamers ($f = 5$). Interactive mechanics and challenge (P03: *"challenge gaming"`) served as key engagement drivers, corroborating Extended TAM Model 2 where Perceived Enjoyment ($\beta = .623, p = .007$) acts as the primary determinant of long-term Behavioural Intention.

Suggestions For Further Study

Methodological Expansion: Increased Statistical Power and Structural Equation Modelling. The extant quantitative architecture is sequential Multiple Linear Regressions with up to three independent predictors on a highly constrained cohort of exactly 28 participants. Running at this bare-minimum mathematical threshold risks statistical overfitting and limits the structural validity and predictive generalisability of the extended Technology Acceptance Model (TAM) used in this study in its own right. In future psychometric research on digital heritage, considerably larger groups are needed that are sampled probabilistically to ensure that there are enough degrees of freedom and to meet psychometric standards [12,13].

Also, researchers need to move beyond simple regression analyses towards more advanced structural covariance techniques like Structural Equation Modelling (SEM). This upgrade is mathematically needed to simultaneously validate the complex mediating pathways between specific ludic architectures, Game Flow and Perceived Enjoyment, which act as the main mechanisms driving system acceptance [11].

Longitudinal Validation of Cross-Generational Sustainability of Culture This manuscript operationalises the extended TAM framework using discrete, cross-sectional survey data that successfully validates the immediate Behavioural Intention to recommend the digital heritage application. However, cross-sectional measurements cannot empirically demonstrate long-term behaviour adoption or sustained alleviation of the intergenerational alienation gap, which is continuously exacerbated by rapid urbanisation and the ubiquitous hegemony of contemporary global digital media [1]. In the future, longitudinal tracking of player engagement will be needed to rigorously verify that digital games function as mathematically verifiable engines of cross-generational cultural transmission. The measure of long-term human-computer interaction will undoubtedly prove whether the initial psychological "flow"[11] and emotional pleasantness[4] deteriorate over time or whether they manifest into actual, sustained engagement with profound biopolitical state assets such as the Wau Bulan [2,7].

Future research should also investigate the use of longitudinal research designs for exploring long-term impacts of digital heritage applications on users' cultural knowledge, appreciation and participation [9]. Longitudinal studies would provide a better understanding of whether benefits from digital heritage applications remain over time[5]. Moreover, future research could extend by considering the Technology Acceptance Model (TAM) by adding other factors such as cultural identity, social influence, perceived authenticity, and community engagement. The inclusion of such factors may allow for a more holistic view of the adoption behaviour of users and the factors that influence their continuous engagement with digital heritage applications[3].

CONCLUSION

This study properly implements an extended Technology Acceptance Model (TAM) to mathematically verify that digital ludic architectures can be used as sustainable engines for cross-generational cultural transmission. This research fills the critical structural gap as rapid urbanisation, modernisation and the hegemony of contemporary digital media have alienated digital-native youth from profound biopolitical state assets such as the Wau Bulan[1,2,7]. It shows that traditional heritage can be preserved effectively through accurate, interactive semiotic transformation. Empirical findings provide a critical psychometric insight for digital heritage informatics: cognitive pedagogical value, measured as Perceived Usefulness, is a major predictor of creating an initial positive user attitude, while intrinsic ludic fun, measured as Perceived Enjoyment, is the main and only statistically significant predictor of long-term Behavioural Intention.

In contrast, basic mechanical usability, operationalised as Perceived Ease of Use, was not statistically significant as an independent predictor of system acceptance. This provides an important psychometric foundation that for today's digital native consumers, mechanical usability is just an expected minimum. Rather, it is the profound affective engagement and emotional pleasantness[4] that serve as the true mediating mechanisms that lead to cultural internalisation. At its core, this research pushes the methodological paradigm of traditional game preservation away from passive museum archiving and towards a more active, user-centric form of engagement through triangulating these robust predictive regressions with phenomenological thematic coding [3]. Ultimately, this research mathematically demonstrates that in order to successfully bridge the intergenerational alienation

gap, digital heritage applications must structurally synthesise rigorous instructional design[5] with deep psychological "flow"[11] and rewarding gameplay mechanics, ensuring that indigenous knowledge remains accessible, relevant and intrinsically enjoyable for future generations.

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Ethical Approval Statement

The study was exempted from institutional ethical approval by the School of Media, Art & Design, Unitar International University, because the study design involved the use of non-invasive survey questionnaires distributed to adult educators only, and therefore posed no physical or psychological risks. However, all participants provided explicit voluntary informed consent before accessing the questionnaire and all survey metrics were collected and analysed anonymously.

Conflict Of Interest

The authors declare no conflict of interest.

Data Availability Statement

The quantitative and qualitative datasets generated and analyzed during the current study are not publicly deposited due to privacy considerations regarding the participating academic institutions. However, the anonymized data are available from the corresponding author upon reasonable academic request.

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