

ADOPTION OF BERASTAGI VERSE IN MOBILE METAVERSE LEARNING: EXTENDING TAM WITH IMMERSION AND CULTURAL VALUE

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ABSTRACT

This study examines user acceptance of Berastagi Verse, a Roblox-based mobile metaverse learning platform that reconstructs tourism destinations in Berastagi, Indonesia, for cultural learning. The study extends the Technology Acceptance Model by adding immersive experience and cultural value as predictors of behavioral intention. A purposive sample of 180 respondents who used the platform on smartphones completed a questionnaire after interacting with the system. Data were analyzed using PLS-SEM. Perceived ease of use positively influenced perceived usefulness, and both constructs positively predicted behavioral intention. Immersive experience and cultural value also had significant direct effects on intention. The model explained 64.2% of the variance in behavioral intention, suggesting meaningful explanatory power for this context. The findings indicate that mobile metaverse learning is adopted not only for usability and usefulness, but also for the extent to which it feels immersive and culturally relevant. For educational designers, the results suggest that mobile learning platforms should combine intuitive interaction, clear pedagogical value, and culturally authentic content when seeking user adoption.

Keywords : Mobile Learning, Metaverse, Technology Acceptance Model, Cultural Values, Berastagi Verse

1. Introduction

The digital transformation of education has evolved from static e-learning platforms toward immersive, interactive, and context-sensitive learning environments (Dajang et al., 2024). Mobile learning (m-learning) has expanded access to education by enabling content delivery through portable devices, while metaverse technologies have introduced persistent virtual worlds that allow learners to interact, explore, and experience simulated environments through avatar-based presence (Hashim et al., 2023; González-Argote & González-Argote, 2022; Hamzah et al., 2025; Trivani et al., 2025; Sanjaya et al., 2026). Research in mobile learning contexts has consistently shown that perceived usefulness and ease of use are foundational drivers of adoption intention (Kalsi & Kaur, 2024) (Kumar et al., 2026), and meta-analyses confirm that performance expectancy and hedonic motivation are among the strongest cross-cultural predictors of m-learning adoption (Zhu & Huang, 2023). Together, these developments have created new possibilities for immersive mobile learning that transcends the physical and temporal constraints of conventional instruction (Kustiawan & Sugiat, 2026; Amastini et al., 2025).

Despite this momentum, three critical and interrelated gaps remain in the literature. First, the majority of empirical studies on immersive learning focus on high-immersion virtual reality (VR) environments that require dedicated hardware such as head-mounted displays (Ibili et al., 2023) (Asadi et al., 2026) (Aufenanger et al., 2025). This leaves a theoretical gap concerning how immersive experience functions in mobile-accessible metaverse platforms, where immersion is delivered through a smartphone screen without specialized equipment. Understanding whether mobile immersion can meaningfully shape adoption intention is important for designing scalable, hardware-agnostic learning systems accessible to populations in emerging economies where smartphone ownership far exceeds VR hardware availability (Shahrol et al., 2023; Alowayr, 2021).

Second, user acceptance studies in metaverse education predominantly apply the Technology Acceptance Model (TAM) using only its core constructs of perceived ease of use (PEOU) and perceived usefulness (PU), without incorporating contextual predictors that may be especially relevant in culturally situated learning systems (Al-Adwan et al., 2023; Alzahrani &

Alzahrani, 2025 ; Toraman, 2022; Purwati et al., 2025). TAM has demonstrated robustness across general digital learning contexts, its explanatory power is limited when learners engage with platforms designed around specific cultural identities and local heritage (He et al., 2024) (Mabina et al., 2025).

Third, empirical investigations rarely examine metaverse platforms designed specifically for culturally grounded educational experiences rather than general virtual interaction (Gao & He, 2025; Lai et al., 2024) Existing studies on metaverse and culture predominantly address cultural heritage preservation or arts education using VR, but the role of perceived cultural value in driving adoption intention within mobile metaverse learning remains underexplored (Al-kfairy, 2025; Gan et al., 2025).

This study addresses these gaps by investigating user acceptance of Berastagi Verse, a metaverse-based mobile learning platform developed using Roblox Studio and accessible through the Roblox mobile application on smartphones. The platform digitally reconstructs four prominent tourism destinations in Berastagi, Indonesia — Efi Garden, Gundaling Hill, Sikulikap Waterfall, and Lau Kawar Lake — within a persistent 3D environment to facilitate experiential cultural learning. The novelty of this study lies in its dual extension of TAM: it integrates immersive experience as an experiential predictor relevant to mobile metaverse contexts, and introduces cultural value as a contextual predictor grounded in culturally situated learning theory. To the best of the authors' knowledge, no prior study has simultaneously tested these two extensions within a mobile-based, culturally contextualized metaverse platform.

The study is guided by the following research objectives: (1) To examine whether perceived ease of use predicts perceived usefulness in Berastagi Verse. (2) To examine whether perceived ease of use and perceived usefulness predict behavioral intention. (3) To examine whether immersive experience directly predicts behavioral intention. (4) To examine whether cultural value directly predicts behavioral intention.

Correspondingly, five hypotheses are proposed:

- H1: Perceived ease of use positively influences perceived usefulness.
- H2: Perceived usefulness positively influences behavioral intention.
- H3: Perceived ease of use positively influences behavioral intention.
- H4: Immersive experience positively influences behavioral intention.
- H5: Cultural value positively influences behavioral intention.

The remainder of this paper is structured as follows. Section 2 reviews the relevant literature and develops the theoretical framework. Section 3 describes the research methodology. Section 4 presents the results of the measurement and structural models. Section 5 discusses the findings in relation to prior research. Section 6 presents conclusions, implications, and directions for future research.

2. Literature Review

2.1 Technology Acceptance Model and Its Extensions in Immersive Learning

The Technology Acceptance Model, originally proposed by (Davis, 1989), posits that perceived ease of use (PEOU) and perceived usefulness (PU) are the primary determinants of behavioral intention to use a technology. Empirical applications of TAM across digital learning environments have consistently supported this structure (Alhalaybeh & Althunibat, 2023; Misirlis & Munawar, 2023; Toraman, 2022). In mobile learning contexts specifically, PU has been identified as the dominant predictor of behavioral intention across extended TAM models, with PEOU influencing intention both directly and indirectly through PU (Harnadi et al., 2024; Kalsi & Kaur, 2024; Kumar et al., 2026). A meta-analysis of 35 m-learning adoption studies confirmed that performance expectancy, attitude, and perceived enjoyment rank among the strongest cross-cultural predictors of adoption intention, and that cultural differences moderate the relationships between enjoyment and adoption intention (Zhu & Huang, 2023; Nhi & Long, 2026).

However, metaverse-based learning introduces experiential and contextual dimensions that the core TAM constructs do not fully capture. Several recent studies have proposed extensions to address this limitation. (Al-Adwan et al., 2023) surveyed 574 university students in Jordan and found that while PU remained the strongest predictor of adoption intention, variables such as

personal innovativeness and perceived enjoyment added significant explanatory power in a metaverse learning context. (Ibili et al., 2023), studying a virtual computer laboratory in a higher education setting, found that hedonic motivation and natural interaction significantly predicted both PU and behavioral intention, suggesting that the emotional and experiential quality of the metaverse interface matters for adoption beyond usability. (Damar & Koksalmis, 2025) extended TAM further in a medical education setting, adding technology readiness, imagination, and anxiety, and confirmed that PU remained the strongest predictor while immersive qualities of the platform moderated ease of use perceptions.

Studies using broader frameworks have reached complementary conclusions. Examining AI-driven metaverse adoption on 415 users via TAM combined with Hedonic Consumption Behaviour Theory, confirmed that emotional involvement, PEOU, and PU were the main predictors of adoption intention (Dhingra et al., 2026). Using a flow theory-based model (PLS-SEM + fsQCA, N=265), demonstrated that flow experience and personal innovativeness directly influenced metaverse acceptance, while interactivity and presence had significant indirect effects (Liang et al., 2024). Investigating metaverse education adoption in Vietnam, found that perceived value — encompassing emotional and social dimensions — significantly drove consumer intention, reinforcing that value perception extends well beyond functional utility (Nguyen et al., 2024). Reported that performance expectancy, social influence, effort expectancy, and facilitating conditions each contributed to student satisfaction, which in turn predicted intention to continue using metaverse platforms (Qutaishat et al., 2025).

In a mobile TAM extension context directly relevant to the present study, (Abd Razak et al., 2025) tested MetaKelas at Universiti Utara Malaysia and found that attitude fully mediated the PU-to-BI path, while PEOU had no direct effect on BI among digitally fluent students. Examined 353 students at Malaysian public universities and found that immersion and hedonic quality stimulation were significant predictors of both PU and PEOU, explaining 66% of the variance in adoption intention (Asadi et al., 2026). Studying 138 nursing students, confirmed that task suitability, perceived enjoyment, PU, PEOU, and perceived enhancement all positively and significantly predicted metaverse adoption intention (Al Saigh, 2025). Found that prior experience with virtual worlds strengthened acceptance among students using a metaverse VR class platform (Albakri et al., 2025). Taken together, these extensions provide a clear theoretical warrant for incorporating immersive experience as an additional TAM construct in the present study.

2.2 Immersive Experience in Mobile Metaverse Learning

Immersive experience refers to the psychological state in which users feel absorbed, present, and engaged within a virtual environment (González-Argote & González-Argote, 2022). In educational contexts, immersion has been theorized to enhance cognitive engagement and emotional investment through experiential learning mechanisms (Hashim et al., 2023). Studies in higher education have demonstrated that immersive VR learning environments can significantly elevate motivation, emotional engagement, and learning outcomes when designed with clear pedagogical intent and intuitive interaction (Aufenanger et al., 2025; Di Natale et al., 2024). Using PLS-SEM on an immersive VR application in engineering education, found that learning value, content value, and intrinsic motivation were the primary predictors of students' intention to use VR, further confirming that perceived educational quality — not hardware sophistication alone — drives adoption (Solmaz et al., 2024). Found that emotional immersion (M=6.81/7) and ease of use (M=6.61/7) were very highly rated by university students in virtual settings, suggesting that engagement and usability are the experiential qualities that matter most for learner acceptance (Carrión Chavarría et al., 2021).

The dominant assumption in the broader literature, however, is that meaningful immersion requires high-end VR hardware such as head-mounted displays (Asadi et al., 2026; Einloft et al., 2024; Ibili et al., 2023). The present study challenges this assumption. Berastagi Verse delivers immersion through a mobile-accessible 3D environment on a standard smartphone, without the use of head-mounted displays or haptic equipment. This is consistent with an emerging line of research demonstrating that perceived immersion — rather than hardware-driven realism — is the psychologically relevant construct for adoption behavior. Studying 2,640 secondary school

students, demonstrated that behavioral intention to use immersive VR as an instructional tool could be explained by perceived value and hedonic motivation rather than device quality, accounting for 50% of the variance in intention (Boel et al., 2023). Found that performance expectancy in a mobile metaverse browser context significantly shaped behavioral intention even without dedicated hardware (Farhi, 2024). Similarly demonstrated that metaverse-based TESOL adoption was feasible among students with limited device access, suggesting that perceived engagement rather than technical immersion capacity drives intention (Wardat & Akour, 2025).

In the context of Berastagi Verse, immersion therefore reflects the degree to which users feel engaged in exploring the 3D virtual environment rather than the technological sophistication of the rendering. This distinction is important for mobile metaverse platforms designed for emerging economies where smartphone access is far more common than VR hardware (Shahrol et al., 2023).

2.3. Cultural Value in Contextual Metaverse Learning

Cultural value refers to the degree to which learners perceive that a technology platform authentically represents meaningful cultural elements relevant to their identity and educational context (Al-kfairy, 2025; Lai et al., 2024). In culturally situated learning systems, perceived authenticity strengthens relevance and intrinsic motivation by connecting learners' cognitive engagement with familiar social and cultural references (Brown et al., 1989; Lave & Wenger, 1991). Research on cultural dimensions in technology adoption has consistently demonstrated that cultural factors are not peripheral moderators but active predictors of acceptance behavior in educational technology contexts (Gan et al., 2025; He et al., 2024; Mabina et al., 2025).

Examining 90 Chinese college students, found that cultural trust significantly predicted m-learning adoption intention at a level comparable to PU and PEOU, indicating that cultural alignment functions as an independent acceptance driver rather than a background variable (He et al., 2024). Integrating UTAUT with Hofstede's cultural dimensions for 153 Malaysian students, found that long-term orientation — a cultural construct reflecting respect for tradition and heritage — predicted mobile technology adoption intention (Gan et al., 2025). Using a mixed-methods approach across 250 university students in developing countries, demonstrated that collectivist cultural backgrounds led to higher engagement with collaborative educational technologies, while high power-distance contexts shaped how learners deferred to institutional recommendations in technology adoption decisions (Mabina et al., 2025; Idkhan & Idris, 2021). Taken together, these findings establish that cultural factors operate as meaningful adoption drivers in mobile learning contexts, independent of core TAM constructs.

Several studies further support cultural value as an adoption predictor specifically in metaverse and immersive learning contexts. Established a cyber-physical metaverse learning environment for indigenous cultural education and found that cultural engagement significantly increased learning motivation and multicultural identity (Lai et al., 2024). Investigated metaverse-based digital storytelling platforms and found that emotional engagement and perceived intangible cultural value significantly drove adoption intention (Al-kfairy, 2025). Demonstrated that a metaverse environment built around cultural landmarks was the most effective medium for cultural learning in an EFL context (Hwang & Lee, 2024). Used a quasi-experimental design to show that metaverse-based multicultural learning significantly improved students' social attitudes and critical thinking compared to traditional instruction (Mutchima et al., 2025).

These findings collectively justify incorporating cultural value as a fifth predictor in the extended TAM model, alongside the four constructs inherited from the classical TAM structure and the immersive experience extension.

2.4 Conceptual Framework

Drawing on the above literature, this study proposes an extended TAM model in which PEOU influences PU (H1), PU influences behavioral intention (H2), PEOU influences behavioral intention (H3), immersive experience directly influences behavioral intention (H4), and cultural value directly influences behavioral intention (H5). The model integrates classical TAM

relationships with experiential and contextual extensions appropriate for culturally situated mobile metaverse learning environments.

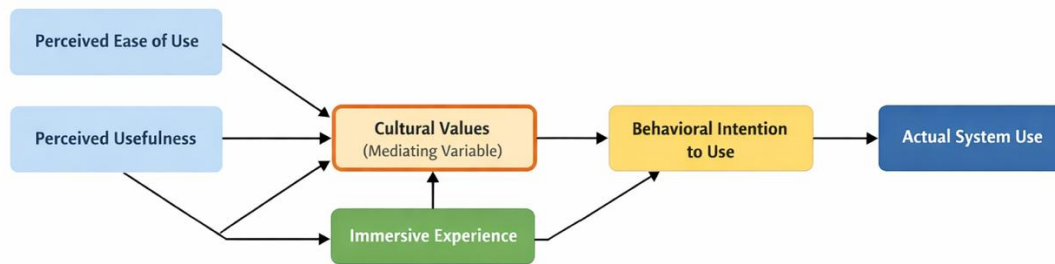


Fig 1. Technology Acceptance Model (TAM) for Mobile Metaverse Learning

3. Research Methods

3.1 Research Design

This study adopted a quantitative explanatory research design. Partial Least Squares Structural Equation Modeling (PLS-SEM) was selected as the analytical approach because it is well-suited for: (a) theory extension contexts in which new predictors are added to an established model, (b) complex latent variable structures with multiple constructs and paths, (c) moderate sample sizes, and (d) a predictive orientation that prioritizes explanatory power over strict model fit. These characteristics align with the purpose of this study, which tests an extended TAM model in a novel mobile metaverse learning context. PLS-SEM is preferred over covariance-based SEM (CB-SEM) in this case because the study's primary aim is theory development and prediction rather than model confirmation (Hair et al., 2019).

3.2 Platform Description: Berastagi Verse

Berastagi Verse was developed using Roblox Studio as the development environment, deployed on an Intel Core i7 workstation with 16 GB RAM and 250 GB SSD storage. The platform digitally reconstructs four prominent tourism destinations in Berastagi, North Sumatra, Indonesia: Efi Garden, Gundaling Hill, Sikulikap Waterfall, and Lau Kawar Lake. Each destination is rendered as a fully navigable 3D environment containing embedded cultural information panels, interactive objects, and spatial audio elements. Learners explore each site using avatar-based locomotion within the persistent virtual world. The platform is accessible through the Roblox mobile application on both Android and iOS, ensuring access via standard smartphones without dedicated VR hardware — a design choice that distinguishes Berastagi Verse from hardware-intensive VR systems studied in prior literature.

3.3 Participants and Sampling Procedure

A total of 180 participants were recruited through purposive sampling. Recruitment was conducted through two channels: (1) direct invitation to undergraduate students enrolled in digital technology-related courses at Universitas Pembangunan Panca Budi who had participated in guided technology exploration sessions involving Berastagi Verse, and (2) voluntary participation by individuals in the local community who were introduced to the platform during a digital cultural literacy event. The inclusion criterion required that all participants had interacted with Berastagi Verse via the Roblox mobile application for a minimum of 15 minutes prior to completing the questionnaire. This minimum interaction duration was established to ensure that participants had sufficient exposure to form perceptions of immersive experience, cultural value, usefulness, and ease of use before responding to survey items. Participants who reported interaction durations below this threshold were excluded from the final sample.

Participants ranged in age from 18 to 34 years. The majority were undergraduate students (78.3%), with the remainder being recent graduates or working professionals. All participants used personal Android or iOS smartphones to access the platform. Informed consent was obtained from all participants prior to their involvement. The study was conducted in accordance with

institutional ethical guidelines, and no sensitive personal data were collected. Participants were assured of the anonymity and confidentiality of their responses.

Table 1 - Respondent Profile (N = 180)

Characteristic	Category	Frequency	Percentage (%)
Gender	Male	82	45,6
	Female	98	54,4
Age	<18	12	6,7
	18–22	104	57,8
	23–27	48	26,7
	>27	16	8,8
Experience Using Metaverse	Yes	146	81,1
	No	34	18,9

3.4 Measurement Instrument

All constructs were operationalized using validated multi-item scales adapted to the mobile metaverse learning context. Perceived ease of use (PEOU) and perceived usefulness (PU) items were adapted from Davis (1989) and subsequently revised versions used in mobile learning contexts (Al-Adwan et al., 2023). Behavioral intention (BI) items were adapted from (Venkatesh et al., 2003). Immersive experience (IE) items were adapted from immersion scales validated in educational VR contexts (Asadi et al., 2026; Ibili et al., 2023), modified to reflect mobile 3D engagement rather than hardware-dependent presence. Cultural value (CV) items were newly developed drawing on the cultural authenticity and perceived value dimensions used in (Al-kfairy, 2025; Lai et al., 2024), adapted to reflect learners' perceptions of the local Berastagi cultural content represented in the platform.

All items used a five-point Likert scale anchored from 1 (strongly disagree) to 5 (strongly agree). The instrument was initially drafted in English and translated into Indonesian by two bilingual researchers with expertise in educational technology. Back-translation was subsequently conducted to verify semantic equivalence. A pilot test involving 30 participants (not included in the main study) was conducted to check item clarity and initial reliability. Items with corrected item-total correlations below 0.50 were reviewed and revised before the main data collection.

3.5 Validity, and Reliability Assessment

Measurement model quality was assessed using: (1) outer loadings as indicators of item reliability, (2) composite reliability (CR) as a measure of internal consistency, (3) average variance extracted (AVE) as a measure of convergent validity, and (4) the Heterotrait-Monotrait ratio (HTMT) as a criterion for discriminant validity. Threshold criteria followed (Hair et al., 2019): outer loadings ≥ 0.70 , CR ≥ 0.70 , AVE ≥ 0.50 , and HTMT < 0.85 .

Common method bias was assessed using Harman's single-factor test as a preliminary check. To complement this, full collinearity variance inflation factor (VIF) values were also examined; VIF values below 3.3 for all constructs indicate the absence of problematic collinearity and provide additional evidence against common method bias (Kock, 2015).

4. Results and Discussions

4.1. Result

The four tourism destinations in Berastagi Verse were each designed as a fully navigable 3D environment with embedded cultural narratives, interactive information panels, and spatial visual cues supporting both geographic exploration and cultural learning. These visualizations provide learners with an experiential encounter with local cultural heritage that conventional text-based or video-based instruction cannot replicate.

The tourism destinations visualized in the metaverse represent several prominent attractions in Berastagi, including:

- * Efi Garden
- * Gundaling Hill
- * Sikulikap Waterfall
- * Lau Kawar Lake

Each destination was designed as a three-dimensional virtual environment that allows users to explore the landscape, access cultural and historical information, and experience tourism in an immersive way through mobile devices. This visualization not only presents geographical aspects but also integrates interactive elements that support cultural learning and digital tourism promotion.

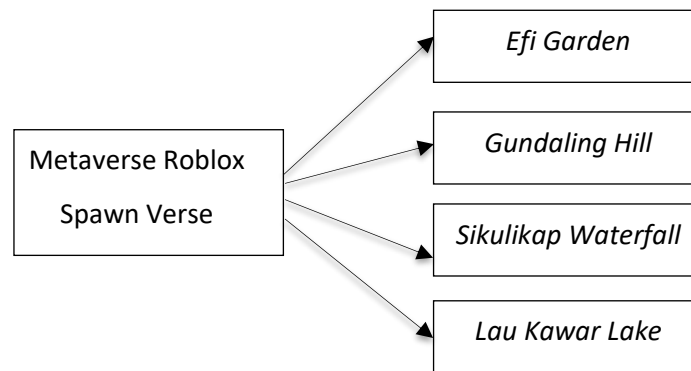


Fig. 2. Berastagi Verse Access

The following presents the development results of several tourist destinations in Berastagi that have been visualized within the Roblox metaverse:



Fig. 3. Spawn Location of Beras Tagi Verse

Figure 3 illustrates the Spawn Location, which serves as the initial entry point for user avatars upon accessing the *Beras Tagi Verse*. This area functions as a primary virtual gateway, designed specifically to provide initial orientation and welcome users before they explore the metaverse ecosystem further. This design aims to immediately establish a sense of presence and introduce the cultural and geographical characteristics of Berastagi within the three-dimensional virtual space.



Fig 4. Overall Landscape of the Beras Tagi Roblox Metaverse

Figure 4 provides a comprehensive overview of the virtual environment constructed within the Roblox engine. This macro-level perspective highlights the structural coherence of the metaverse, demonstrating how the environment is optimized to create an immersive, contiguous world that facilitates seamless user traversal and interaction across the simulated region.

a. Measurement Model

All factor loadings exceeded 0.70. Composite reliability values ranged from 0.88 to 0.92. AVE values exceeded 0.50. HTMT ratios were below 0.85, confirming discriminant validity. No significant common method bias was detected.

Table 2 – Measurement Model

Construct	Indicator	Loading	Cronbach's Alpha	CR	AVE
PEOU	PEOU1	0,78	0,84	0,89	0,67
	PEOU2	0,82			
	PEOU3	0,85			
	PEOU4	0,79			
PU	PU1	0,8	0,86	0,9	0,69
	PU2	0,83			
	PU3	0,87			
	PU4	0,81			
CV	CV1	0,76	0,83	0,88	0,64
	CV2	0,82			
	CV3	0,84			
	CV4	0,78			
IE	IE1	0,85	0,85	0,9	0,7
	IE2	0,88			
	IE3	0,83			
	IE4	0,79			
BI	BI1	0,87	0,88	0,92	0,74
	BI2	0,89			
	BI3	0,85			
	BI4	0,82			

b. Structural Model

The structural model was estimated using PLS-SEM with 5,000 bootstrap resamples, following the recommendation of (Hair et al., 2019) for stable path coefficient estimation and confidence interval construction. The standardized root mean square residual (SRMR) was 0.064, below the 0.08 threshold recommended for PLS models, indicating acceptable model fit.

The model explains 64.2% of the variance in behavioral intention ($R^2 = 0.642$), indicating substantial explanatory power. This R^2 value exceeds the 0.50 benchmark used in technology acceptance research to indicate a model with high predictive relevance.

All five hypothesized paths were statistically significant at $p < 0.05$. The path coefficients, t-statistics, and 95% bias-corrected confidence intervals from bootstrapping are presented in Table 3.

Table 3 – Structural Model

Hypothesis	Path	β	t-value	p-value	f ²	Decision
H1	PEOU → PU	0,62	10,45	0	0,52	Supported
H2	PEOU → BI	0,21	2,85	0,004	0,06	Supported
H3	PU → BI	0,32	4,1	0	0,18	Supported
H4	CV → BI	0,25	3,75	0	0,14	Supported
H5	IE → BI	0,29	4,28	0	0,16	Supported

4.2. Discussion

a. Perceived Usefulness as the Dominant Predictor

Perceived usefulness emerged as the strongest predictor of behavioral intention in this study ($\beta = 0.38$, $p < 0.001$), a finding that aligns consistently with TAM-based metaverse and mobile learning research. In a study of 574 Jordanian university students, found that PU was the primary driver of metaverse adoption intention even when experiential variables were included (Al-Adwan et al., 2023). Confirmed PU as the dominant predictor in a medical metaverse context (Damar & Koksalmis, 2025), and replicated this finding on a broader AI-enhanced metaverse platform (N=415) (Dhingra et al., 2026). In mobile learning contexts more broadly, meta-analytic evidence consistently places performance expectancy and perceived usefulness at the top of the predictor hierarchy across diverse cultural settings (Zhu & Huang, 2023). The consistency of this finding strengthens its generalizability and suggests that learners evaluate mobile metaverse systems primarily through a functional-utilitarian lens: the platform must demonstrably support learning goals to be adopted.

This has a direct implication for Berastagi Verse and similar platforms. Immersive environments must not merely entertain or visually engage users; they must embed measurable educational content that learners can identify as relevant to their objectives. The cultural information panels, historical narratives, and interactive site elements in Berastagi Verse serve precisely this function. Corroborated this argument, finding that learning value and content value were the primary predictors of VR adoption intention in engineering education — a context where the quality of embedded content, not immersion per se, drove intention (Solmaz et al., 2024). Platforms that rely solely on novelty or visual richness without pedagogical scaffolding are unlikely to sustain adoption intention over time (Hashim et al., 2023; Moray, 2023).

b. Perceived Ease of Use and the Role of Mobile Usability

Perceived ease of use significantly influenced both PU ($\beta = 0.44$, $p < 0.001$) and BI ($\beta = 0.18$, $p < 0.05$), reaffirming the foundational TAM structure while demonstrating that PEOU retains a direct path to behavioral intention in a mobile metaverse context. This is notable because some studies in high-immersion VR environments have found the PEOU-to-BI path non-significant among experienced or digitally fluent users (Abd Razak et al., 2025; Misirlis & Munawar, 2023). The significance of this path in Berastagi Verse likely reflects the novelty of the platform and the unique challenges posed by navigating 3D avatar environments on a smartphone touchscreen interface, consistent with findings by (Kalsi & Kaur, 2024; Kumar et al.,

2026), who both found PEOU as a significant predictor of adoption intention and attitude in mobile learning contexts.

For mobile metaverse designers, this underscores that even among young, digitally literate users, the usability of mobile interaction mechanics — touch-based navigation, camera control, interface responsiveness — directly shapes both usefulness perceptions and adoption intention. Similarly found hedonic motivation and effort expectancy as the key usability-adjacent predictors of m-learning adoption among preschool teachers in China, indicating that the effort dimension of interaction design matters across diverse learner demographics (Chen et al., 2024). Optimization of mobile UI specifically for 3D avatar-based navigation, rather than adapting desktop-centric interfaces to smaller screens, is therefore a priority for this class of platforms (Alowayr, 2021).

c. Immersive Experience in a Mobile-Only Environment

Immersive experience significantly predicted behavioral intention ($\beta = 0.22$, $p < 0.01$), a finding of particular theoretical weight given that immersion here was achieved without dedicated VR hardware. The dominant assumption in prior literature is that meaningful immersion requires head-mounted displays or haptic feedback systems (Asadi et al., 2026; Einloft et al., 2024; Ibil et al., 2023). The Berastagi Verse findings challenge this empirically: perceived immersion — operationalized as the degree to which users felt absorbed exploring the 3D mobile environment — is achievable on a standard smartphone and sufficient to influence adoption intention.

This finding is consistent with (Farhi, 2024), who found performance expectancy in a mobile metaverse browser context shaped behavioral intention without dedicated hardware. Confirmed metaverse-based TESOL adoption among learners with limited device access (Wardat & Akour, 2025). Using flow theory, demonstrated that the experiential quality of presence and interactivity in a metaverse environment — not the hardware used to deliver it — constituted the active mechanisms shaping acceptance (Liang et al., 2024). In a large-scale study of 2,640 secondary students, further confirmed that behavioral intention to use immersive VR was predicted by perceived value and hedonic motivation rather than prior hardware exposure (Boel et al., 2023).

However, an important competing explanation warrants acknowledgment: the novelty effect. Users encountering a metaverse platform for the first time may report high immersion partly because the experience is unfamiliar and stimulating. Longitudinal research is needed to determine whether immersion effects persist after initial novelty diminishes — a concern consistent with (Hwang & Lee, 2024), who noted that immersion in metaverse cultural learning can decrease over time. Found that prior experience with virtual worlds strengthened acceptance, suggesting that familiarity and continued exposure, rather than novelty alone, sustain immersion-driven intention (Albakri et al., 2025).

d. Cultural Value as a Contextual Predictor

Cultural value produced the second-largest direct effect on behavioral intention ($\beta = 0.29$, $p < 0.001$). This is among the most theoretically significant contributions of the study, providing empirical evidence that the cultural contextualization of a metaverse platform directly shapes adoption intention — not merely as background but as an independent predictor with practical significance.

This result converges with He et al. (2024), who found cultural trust to be a predictor of m-learning adoption intention at a level comparable to PU and PEOU among Chinese college students. Similarly found that long-term cultural orientation predicted mobile technology adoption in Malaysian higher education (Gan et al., 2025), and demonstrated that collectivist cultural identity drove higher engagement with educational technologies in developing-country contexts (Mabina et al., 2025). In metaverse-specific research, the finding aligns with (Lai et al., 2024), who demonstrated that culturally grounded metaverse content increased learning motivation in indigenous education, and with (Al-kfairy, 2025), who showed perceived intangible cultural value drove adoption of metaverse storytelling platforms. It also aligns with the situated

learning tradition, positing that learners engage more deeply with content embedded in meaningful social and cultural contexts (Brown et al., 1989; Lave & Wenger, 1991).

For Berastagi Verse specifically, the cultural value effect reflects learners' perception that the platform authentically represents local heritage — the natural and cultural landscapes of Berastagi familiar from their own regional identity. This suggests that mobile metaverse platforms can derive a distinct adoption advantage over generic systems by grounding their content in local cultural narratives, an argument supported by (Zhu & Huang, 2023) meta-analytic finding that cultural differences moderate the relationship between enjoyment and adoption intention in m-learning contexts.

e. How Berastagi Verse Differs from Conventional Gamified Learning Systems

Berastagi Verse is not a gamified learning system in the conventional sense. Where gamification adds game mechanics (points, badges, leaderboards) to existing instructional content (Mohideen & Ilyas, 2025; Sappaile et al., 2025), Berastagi Verse constructs a persistent virtual world in which the environment itself is the primary vehicle for cultural learning. The act of spatial exploration and avatar-mediated discovery of cultural sites constitutes the learning experience — not reward accumulation. Research on gamification has shown that while such mechanics effectively increase engagement in the short term, they risk creating dependency on extrinsic rewards that may undermine intrinsic motivation if not carefully designed around meaningful learning outcomes (Mohideen & Ilyas, 2025; Sappaile et al., 2025; Kalua et al., 2026). Berastagi Verse avoids this risk by design: the motivational architecture derives from cultural relevance and spatial exploration rather than reward structures.

This experiential structure aligns more closely with situated learning theory and (Kolb, 1984) experiential learning cycle than with behavioral reward-based gamification frameworks. Practically, this suggests that the adoption advantages of Berastagi Verse derive from the quality of the cultural environment — the fidelity of virtual reconstructions, the depth of embedded cultural information, and the degree to which the spatial experience recreates the character of visiting these sites. Developers seeking to replicate this model should invest in environmental design and cultural content depth rather than gamification layers.

5. Conclusion and Implications

5.1. Conclusion

This study demonstrates that the metaverse can serve as an effective, culturally rich learning environment without the barrier of expensive virtual reality hardware. Through the evaluation of the Berastagi Verse mobile platform, our extended Technology Acceptance Model reveals that perceived usefulness—strongly supported by perceived ease of use—is the primary driver of user adoption among smartphone users. Beyond validating the TAM framework within a mobile-accessible metaverse environment (Harnadi et al., 2024; Qutaishat et al., 2025; Toraman, 2022), this research fundamentally challenges the dominant assumption that deep immersion requires dedicated VR equipment (Einloft et al., 2024; Ibili et al., 2023). Instead, it empirically proves that standard smartphones can deliver an immersive experience powerful enough to predict adoption intention, aligning with emerging evidence that perceived engagement outweighs hardware quality (Boel et al., 2023; Liang et al., 2024). Furthermore, by establishing cultural value as a significant independent predictor of behavioral intention, the study provides an empirically grounded rationale for embedding local heritage into digital learning designs (Gan et al., 2025; He et al., 2024; Zhu & Huang, 2023). Ultimately, these outcomes provide educators and developers with a clear, scalable blueprint for designing culturally situated metaverse platforms that drive meaningful user engagement and broaden educational access.

5.2 Practical Implications

Practically, these findings translate into a clear, actionable blueprint for both mobile learning designers and tourism education developers. To maximize adoption, designers must prioritize measurable pedagogical value within the exploration experience, ensuring learners recognize the tangible benefits of their interaction (Moray, 2023; Solmaz et al., 2024). This utility

must be supported by intuitive interaction mechanics optimized specifically for smartphone constraints, as effort expectancy remains critical even for digitally literate users (Chen et al., 2024; Kumar et al., 2026). Crucially, culturally authentic content should be treated as a foundational design element rather than a mere aesthetic supplement, given its substantial and independent influence on user adoption (He et al., 2024; Mabina et al., 2025). To prevent novelty decay, this initial engagement must be sustained through continuous content updates and narrative progression (Albakri et al., 2025; Hwang & Lee, 2024). Ultimately, for policymakers and educational developers—particularly in culturally rich regions like North Sumatra—this study confirms that mobile metaverse platforms offer a highly viable, scalable solution for advancing digital cultural literacy in communities where smartphone penetration far outpaces access to specialized VR hardware (Alowayr, 2021; Shahrol et al., 2023).

5.3 Limitations and Future Research

While this study provides a robust foundation for understanding mobile metaverse adoption, it also highlights compelling avenues for future research to build upon its constraints. Because the current cross-sectional design captures adoption intention at a single point in time, there is a clear need for longitudinal studies capable of tracking sustained, actual usage over time (Di Natale et al., 2024). Furthermore, relying on purposive sampling and self-reported measures introduces potential bias and limits broader generalizability. Future investigations can strengthen these findings by triangulating self-reported responses with behavioral platform logs and by pursuing cross-cultural validations—particularly across collectivist and individualist contexts—to determine if the observed cultural value effects generalize globally (Gan et al., 2025; Mabina et al., 2025). Methodologically, while the 15-minute minimum interaction criterion provided a baseline, varying exposure durations in subsequent designs will yield deeper insights into how users evaluate immersive qualities. Finally, examining how these strong behavioral intentions translate into actual, measurable learning performance will be a crucial next step, ultimately solidifying the pedagogical case for mobile metaverse education.

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