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## Article

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Digital Business

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*Suggested Citation:* Tri Quan Dang et al. (2025) : From reality to virtuality: Unveiling Gen Z's purchasing behavior through virtual influencers in the metaverse, Digital Business, ISSN 2666-9544, Elsevier, Amsterdam, Vol. 5, Iss. 2, pp. 1-25, <https://doi.org/10.1016/j.digbus.2025.100141>

This Version is available at:

<https://hdl.handle.net/10419/338013>

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# From reality to virtuality: Unveiling Gen Z's purchasing behavior through virtual influencers in the metaverse

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## ARTICLE INFO

### Keywords:

VIs  
Metaverse  
Gen Z  
Purchasing behavior  
Customer satisfaction  
PLS-SEM  
fsQCA  
ANN

## ABSTRACT

The primary aim of this study is to examine the factors influencing Generation Z's (GenZ) purchase intentions through their interactions with virtual influencers (VIs). Utilizing judgmental sampling, a sample of 352 individuals with prior experience as VIs was selected to address the research objectives. The data were analyzed using a mixed-method approach, incorporating fuzzy-set Qualitative Comparative Analysis (fsQCA), Partial Least Squares Structural Equation Modeling (PLS-SEM), and Artificial Neural Networks (ANN techniques). The findings highlight the pivotal roles of virtual influencer quality and social presence in shaping purchase intentions, mediated by customer satisfaction. These results underscore the necessity for practitioners to consider the influence of VIs on purchase behavior via customer satisfaction. The study offers valuable insights to firms, aiding in the development of strategies to enhance the effectiveness of VIs in capturing customer attention. By investigating the interplay between virtual influencer quality, social presence, customer satisfaction, and purchase intentions, the research contributes to a deeper understanding of consumer behavior in the context of virtual influencers.

## 1. Introduction

Virtual influencers (VIs) have accounted for a significant share of advertising spending (Byun & Ahn, 2023). Expanding rapidly, this emerging industry is predicted to reach \$42.6 billion in China by 2030 (Davlembayeva et al., 2024; Hu et al., 2015). As these digital personas have become more and more popular and developed, the distinction between them and human influencers (in terms of the level of customer engagement) is fading into obscurity (Sorosrungruang et al., 2024; Conti et al., 2022; E. Kim et al., 2023). Kim et al. (2023) reveals that 58 % of consumers have engaged with at least one VI, while 35 % have made purchases affected by them.

The widespread adoption of VIs mainly results from their unique advantages such as customization, flexibility, ownership, and automation (Penttinen, 2023). These advantages combined with other distinct features, including source credibility (Chaihanchanchai et al., 2024; Sorosrungruang et al., 2024), emotional appeal (Jiang et al., 2024),

manifested authenticity (Koles et al., 2024), the level of interactivity (Yang et al., 2023), and gender and identity presentation (Lee & Yuan, 2023) all constitute the convincing impacts of VIs. VIs particularly resonates with Gen Z consumers, who are often portrayed as tech-savvy digital natives. Studies suggest that this group of customers prioritize overall enjoyment of shopping, convenience, authenticity, and social values over conventional brand loyalty (Allende et al., 2024; Ismail et al., 2020; Sudirjo et al., 2023). The characteristics make Gen Z particularly receptive to metaverse environment in general and VIs based marketing in particular.

Building on the existing research on VIs, our study expands the understanding of VI's impact on purchasing decisions by addressing three critical gaps - theoretical/conceptual framework gap, methodological gap and contextual gaps. In term of theoretical/conceptual framework gap, although existing studies have identified isolated factors shaping consumer engagement with VIs, such as the sense of connection and empathy driven by warmth, relatedness, and credibility as engagement

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<https://doi.org/10.1016/j.digbus.2025.100141>

Received 24 December 2024; Received in revised form 28 July 2025; Accepted 28 July 2025

Available online 30 July 2025

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enablers (El Hedhli et al., 2023), trustworthiness and credibility (Chaihanchanchai et al., 2024; Yoo et al., 2025), attitudes toward VIs (Kim & Park, 2024; Lou et al., 2022), the complex interactions and conditions of these mechanisms remain underexplored (Kalińska-Kula, 2023). Moreover, little has been studied about their combined effects of virtual influencer quality attributes (credibility, attractiveness, trustworthiness) and social presence elements (closeness, interactivity and Perceived human-likeness) in shaping consumer satisfaction and behavior independently (Akhtar et al., 2024; Kumar & Shankar, 2024; H. Lee et al., 2024; Yu et al., 2024). More precisely, the primary theoretical limitation lies in the absence of a comprehensive framework that integrates the technological, social, and psychological dimensions in explaining VIs effectiveness. Moreover, the lack of a unifying model results in inconsistency in measurements and (thus) analytical pathways that hinder systematizing disparate findings. In other words, without a unifying model, many contradictions in research findings persist, and important questions are left unanswered when it comes to the impact of VIs. In particular, while some studies suggest VIs can engender greater sharing and purchase intentions (Yi et al., 2024), others indicate that human influencers are still more effective for Gen Z consumers (Dondapati & Dehury, 2024; Kholkina et al., 2024). Some argue that when enhanced with trustworthy, relevant, and entertaining features, VIs are perceived with even greater credibility, positively driving purchasing decision (Gerlich, 2023; Liu, 2022). In the same vein, debates persist over whether perceived authenticity and trustworthiness (Chaihanchanchai et al., 2024; Yoo et al., 2025) or factors like interactivity and attractiveness (Yang et al., 2023) play a more significant role in shaping consumer decisions. Similarly, there is no consensus on whether high human-likeness alone is sufficient to establish trust, or whether trust is contingent upon a balance between social presence and credibility. This leads to the inability to explain the effectiveness of different VIs - why some VIs generate high engagement but do not necessarily convert into purchasing decisions. To address these limitations, our study extends Uses and Gratifications Theory (UGT) to develop a holistic framework that captures how VIs' quality and social presence collectively drive consumer engagement, satisfaction, and purchase intention. By integrating technological (perceived human-likeness, interactivity), psychological (trustworthiness, credibility), and social (closeness, engagement) dimensions, our model provides a comprehensive explanation of VIs' influencing consumer behavior and reconciling inconsistencies in previous findings.

In term of methodological gap, there is a tendency to oversimplifying the inherently complex decision-making processes involved in virtual influencer-driven purchases (Fowler & Thomas, 2023; Franke & Groeppel-Klein, 2024; Kalińska-Kula, 2023; Park et al., 2023; Zhao et al., 2024). Although some scholars have turned to non-linear models (Chintagunta & Lee, 2012; Durham et al., 2015), or mixed method approach (Kim, Ki, et al., 2024), these efforts remain limited. As a result, studies using traditional models often fail to capture nonlinear effects, threshold effects, and interaction effects, leading to incomplete explanations of why VIs succeed or fail in different contexts (Hruschka, 2007; Mize, 2019; L. Yang et al., 2021). Moreover, the reliance on linear models have reinforced a reductionist view of consumer behavior in virtual environments, perceiving each influencing factor as independent rather than recognizing the dynamic, interactive relations among them (Mishra et al., 2024; Tao, 2023). To address this methodological gap, this study employs a multi-method analytical approach that integrates PLS-SEM, fsQCA, and artificial neural networks (ANN) to capture both linear and nonlinear relationships, as well as complex configurational patterns in consumer responses to VIs explained in UGT. Specifically, PLS-SEM is best to understand the direct relationships between, for example, source credibility, content validity, and purchase intentions (as demonstrated in the study by Hair et al., 2019). FsQCA, on the other hand, provides an asymmetric approach that can identify multiple pathways leading to high purchase intentions (on non-purchase intention), complementing the findings from PLS-SEM (for example, please

see Chen et al., 2023; Gligor & Bozkurt, 2020). Additionally, ANN techniques can be employed to model complex, non-linear relationships and predict consumer behavior based on large datasets, which further enrich the outcome from PLS-SEM and FsQCA analysis (Ashfaq et al., 2023). Employing this triangulated methodology is expected to provide a more robust, predictive, and theoretically coherent understanding of consumer-VI interactions.

Finally, for contextual gap, while most research on virtual influencers (VIs) has focused on Western markets or China (Dondapati & Dehury, 2024; Yi et al., 2024), the Vietnamese market remains underexplored, despite its rapid digital transformation and increasing adoption of AI-driven technologies. This gap is particularly significant given that cultural and contextual factors also play a crucial role in shaping consumer attitudes toward VIs and their purchasing decision (Kikumori et al., 2025; Li et al., 2023). To our knowledge, there is limited, even virtually no examination of how cultural dimensions—such as collectivism, power distance, and trust in technology—affect Vietnamese consumers' perceptions of authenticity and trustworthiness in VIs. Without empirical insights into these cultural dynamics, it is difficult, if not impossible, to determine whether existing findings on VI credibility and effectiveness can be generalized to Vietnam's consumer landscape. The current study, with 100 % respondents are Vietnamese, has a great chance to add crucial insight into the impact of VIs on Gen Z in Vietnam.

As virtual influencers continue to redefine digital marketing and consumer-brand interactions, a deeper understanding of their effectiveness is no longer just an academic pursuit, but rather a strategic necessity. By addressing the theoretical, methodological, and contextual gaps in current research, this study not only advances scholarly discourse on VIs but also provides brands with actionable insights to optimize their influencer marketing strategies in an increasingly AI-driven world.

## 2. Literature review

### 2.1. Virtual influencers (VIs)

Virtual influencers (VIs) are computer-generated personas that communicate with audiences in the first person like social media influencers (Yan et al., 2024). VIs can portray a scandal-free image and control material more easily than human influencers (Gao et al., 2023). There are several types of VIs depending on their look and perceived realism. Recent literature classifies VIs into three types: mimic-human VIs, which are nearly indistinguishable from real humans; animated-human VIs, which resemble stylized cartoon-like characters; and non-human VIs, which take the form of anthropomorphic objects, animals, or fantasy creatures (Bai et al., 2024; Dabiran et al., 2024). Each form of VI employs distinct interaction tactics and targets various audience categories. VIs began as entertainment and commercial digital avatars. Social media platforms enabled them to engage with audiences in new ways, making them popular (Masuda et al., 2022). VIs, unlike human influencers, develop content and govern their narratives, ensuring marketing message consistency and audience engagement (Dang Quan et al., 2024). VIs depend on technology. These synthetic identities replicate human interactions utilizing strong CGI and AI-driven behavioral modeling. AI VIs may respond to user comments, generate material, and adapt their online identities to audience behavior (Tafesse & Wood, 2021). Their appearance and interactions' realism affects their perceived authenticity, which is crucial for consumer trust and emotional connection (Dabiran et al., 2024). VI sincerity and ethics are major considerations. VIs work for corporations or content providers, raising transparency and consumer trust concerns compared to human influencers (Yan et al., 2024). The "uncanny valley" effect, where incredibly accurate mimic-human VIs seem like humans but are artificial, may make viewers uneasy (Oh et al., 2018). There is also debate about whether VIs should disclose their artificial origin to prevent fooling viewers (Goel & Garg, 2025). VIs' growing use in digital

marketing shows their potential for long-term brand engagement despite these challenges. They help organizations target younger audiences, particularly Generation Z, by maintaining consistency, avoiding difficulties, and producing properly managed content (Yan et al., 2024). As research on emotional attachment and consumer behavior toward VIs advances, social presence and authenticity will be crucial to audience engagement (Biocca et al., 2003; Gao et al., 2023).

VIs are, by definition, digital creations, often designed to mimic human influencers in appearance, traits and ability (such as warmth, empathy, and interactivity) designed to engage audiences on social media platforms (Gerlich, 2023; Miyake, 2023; Mrad et al., 2022) and tailored to fit specific brand narratives or marketing strategies (Choudhry et al., 2022; Conti et al., 2022; Moustakas et al., 2020). Such advanced features enable them to adapt quickly to changing trends and audience preferences (Penttinen, 2023). Indeed, several VIs have emerged as significant marketing “figures” across social media platforms. Table 1 illustrates leading VIs’ market presence, highlighting key metrics such as follower count, platform distribution, geographical focus, and brand partnerships, exemplifying their integration into contemporary digital marketing strategies.

When compared to human influencers’ fostering follower relationships, VIs’ distinctive advantages in terms of cultural flexibility, engagement, controlled image, and perceived authenticity make them have the upper hand. First, VIs vary in their level of human likeness, ranging from hyper-realistic to more stylized or animated forms, allowing them to appeal to different audience segments and marketing needs (Franke & Groeppel-Klein, 2024; Ju et al., 2024; Yan et al., 2024). Second, VIs enable brands to maintain a consistent image through their immunity to personal controversies or behavioral unpredictability. This control helps brands avoid reputational risks associated with human influencers (Allal-Cherif et al., 2024). And finally, consumers who have a strong belief in the machine heuristic, tend to acknowledge the authenticity in VIs more than that in human influencers (Lee et al., 2024)

However, VIs is not risk-free. Apart from the technology-based risk, VIs’ creators must carefully balance their human-like characteristics to avoid crossing into the uncanny valley, where they might appear unsettling to consumers, particularly when they exhibit high form realism without corresponding behavioral realism (De Ciccio et al., 2024; Kim, Kim, & Lee, 2024). Additionally, disclosing the non-human nature of VIs can diminish their perceived anthropomorphism and credibility (Muniz et al., 2023). The emergence of VIs, therefore, introduces a need to reevaluate how purchase intentions are formed in digitally mediated environments, which will be explored in the following section. Previous researches about VIs are in Table 2.

Table 2 provides a systematic overview of existing research on Virtual Influencers, organizing studies by their key variables and methodological approaches. This mapping exercise serves to establish the empirical foundation and demonstrate the breadth of research activity in this emerging field. The Table 2 preserves original terminology from

source studies to accurately represent how different researchers have conceptualized and operationalized constructs related to Virtual Influencers.

While this overview reveals the diversity of approaches and variables examined, the theoretical synthesis of these findings—including identification of research gaps, contradictory results, and pathways to hypothesis development—is systematically addressed in Section 3. This structure allows readers to first understand the research landscape before engaging with our theoretical integration and model development.

This research investigates the effect of Virtual Influencers (VIs) on consumer satisfaction and purchase intention using three important dimensions: technical, social, and psychological dimensions. This categorization is based on the convergence of influencer marketing ideas, human-computer interface (HCI), and consumer psychology. The technology side is critical since VIs are developed using artificial intelligence and computer-generated imagery. Interactivity and human-likeness are key factors in how customers perceive and react to VIs. Ruijten et al. (2019) found that perceived human-likeness promotes sentiments of familiarity and trust, while interaction improves shopping experiences and customer engagement. The social factor is examined since VIs serve as both technical constructions and social influences. Previous research suggests that intimacy and social presence are important in developing trust and consumer satisfaction (Sands et al., 2022). VIs provide a feeling of connection with customers via continuous interactions and individualized content, which impacts purchasing decisions. The psychological component describes how customers interpret VIs. Perceived attractiveness and trustworthiness are important variables in generating credibility for influencers. While VIs are not human, research shows that their AI-optimized look has a significant influence on customer appeal and engagement (Arsenyan & Mirowska, 2021). These parameters were chosen after a review of theoretical frameworks and practical investigations in influencer marketing and human-computer interaction. By concentrating on these three characteristics, the research offers a more holistic view of how VIs impact customer behavior in digital contexts.

2.2. Purchasing intention

Defined as an individual’s conscious plan or likelihood to purchase a specific product or service in the future, purchase intention is considered as one of the most critical constructs in consumer behavior research, (Dodds et al., 1991). Studies have shown that purchase intention formation is driven by multiple factors, ranging from consumer perceptions (Anantharaman et al., 2022; Bo et al., 2024; Singh et al., 2023), attitudes (Shukla et al., 2021), to contextual influences (Hsu et al., 2013; Kurtz et al., 2021; Mathur et al., 2021). In the context of digital media, the pivotal role of social media influencers on platforms like YouTube, Instagram, and TikTok in shaping consumer behavior through mechanisms of social proof, expertise demonstration, and authentic

Table 1  
Leading VIs’ market presence.

No	VIs	Followers	Platforms	Locations	Brands	References
1	Lu from MagaLu	30+ Million	Instagram, Facebook, YouTube, TikTok	Brazil	Adidas, McDonald’s, Red Bull, MAC, Maybelline, Samsung	(Molenaar, 2024; Siavash, 2024)
2	Lil Miquela	7.7+ Million	Instagram, Facebook, YouTube, TikTok	USA	Channel, Calvin Klein, Burberry, Fendi, Samsung	(Molenaar, 2024; Siavash, 2024)
3	Shudu	4+ Million	Instagram, Facebook, YouTube	South Africa	Cosmopolitan, Vogue, Balmain, Smart, Prada	(Molenaar, 2024; Siavash, 2024)
4	Knox Frost	2+ Million	Instagram, Facebook, YouTube, TikTok	South Africa	Forbes, Business Insider, CNN, the World Health Organization	(Molenaar, 2024; Siavash, 2024)
5	Guggimon	14+ Million	Instagram, YouTube, TikTok, Twitter	USA	Gucci, Rico Nasty, Snoopy Dogg	(Siavash, 2024)
6	Noonoouri	0.5+ Million	Instagram, YouTube, TikTok	Japan	IKEA, Amazon, Valentino, Dior, Puma, Nike	(Siavash, 2024)

Source: by authors.

**Table 2**  
Previous research about VIs.

Key study	Independent Variable	Mediator	Moderator	Dependent Variable	Method
(Ozdemir et al., 2023)	Influencer Type (Real Vs. Virtual)	Perceived Credibility	Language Type	Brand Attitude	Anova, T-Test
(Dondapati & Dehury, 2024)	Influencer Type (Virtual Vs. Human) And Product Type (Utilitarian Vs Hedonic)	Parasocial Interaction and Perceived Homophily	Perceived Authenticity	Purchase Intent	ANOVA
(Jin et al., 2019)	Celebrity Type	Social Presence	Self-Discrepancy	Trustworthiness, Brand Attitude, Envy	SEM
(Conti et al., 2022)	Influencer Type	N/A	N/A	Engagement Rate, Followers, Trustworthiness, Brand Perception	Qualitative Exploratory Methods
(R. E. Lim & Lee, 2023)	VIs Identity Origin (Disclosed vs Not Disclosed)	Para-Social Interaction	Emotional Post (Positive vs Negative)	Influencer Credibility	Statistical Analysis (E.G., Regression, ANOVA, Or Other Appropriate Techniques)
(Y.-H. Lee & Yuan, 2023)	Gender of VIs	N/A	Number of Followers	Authenticity Presentations, Followers'	MANOVA
(Lou et al., 2023)	Perceived Uncanniness, Perceived Authenticity, Similarity, Parasocial Relationship, Follower Motivations	Perceived Authenticity, Similarity, Parasocial Relationship	Curated Flaws, Self-Justification	Brand Awareness, Brand Image, Purchase Intention	Qualitative Analysis
(Ma & Li, 2024)	Human-Likeness and Human Influencer	Perceived Anthropomorphism, Parasocial Interaction		Brand Attitude, Purchase Intention	Statistical Techniques
(Jin, 2023)	Perceived Humanness of VIs, Perceived Eeriness of VIs	Empathy With VIs, Engagement with VIs	Loneliness, Trait Reactance, Perceived Threat to Human Identity	Behavioral Intention to Purchase, Situational Reactance	Descriptive Statistics, Inferential Statistics, Moderation Analysis
(Al Masri et al., 2023)	Attractiveness, Likeability, Expertise, Similarity, Trustworthiness	Brand Associations		Brand Associations, Purchase Intentions	Structural Equation Modeling

Source: by authors.

engagement is evidenced by many studies (Davlembayeva et al., 2024; Gursoy et al., 2022; Hu et al., 2015). The emergence of VIs, however, introduces novel dynamics to this relationship, challenging conventional understanding of how purchase intentions develop in digitally mediated environments.

From a theoretical perspective, engaging with VIs exposes consumers to cognitive, emotional process as well as bodily performances which are fundamentally different from engaging with conventional human influencer (Gomes et al., 2022; Q.-Q. Huang et al., 2022) Consider how a digital user might interact with Lu do Magalu, a virtual influencer when he/she were thinking of making a purchase: while the interaction may appear simply as an exchange about product recommendation, it represents a more complex relationship. At its core lies the interplay between rational product evaluation and emotional connection even as the user is fully aware of the artificial nature of his/her chat partner (Koles et al., 2024; Zeng et al., 2024). This means that a comprehensive understanding of the VIs-consumer interaction necessitates a careful examination of the interplay of two seemingly conflicting cognitive states, namely the pursuit of gratification (both utilitarian and psychological need) and consumers' maintaining awareness of the artificial nature of the interaction (Jhawar et al., 2023).

Therefore, it is obviously unwise to apply traditional purchase intention models to explain the impact of VIs on consumer behavior due to their inability to account for the unique psychological dynamics of synthetic engagement and the diverse gratifications consumers seek from these artificial entities (El Hedhli et al., 2023; Kim & Park, 2024; Yoo et al., 2025). It is our content that a theoretical framework capable of capturing such a distinct nature of VIs-consumer interaction must, at least, sufficiently account for both the complexity of synthetic engagement, taking into account the unique VIs' features and explain the gratification mechanism driving consumer behavior. We propose that Uses and Gratification Theory (UGT) potentially provides such a comprehensive framework, offering insights into not only why consumers actively engage with VIs but also how these engagements translate into purchase intentions through various gratification mechanisms and satisfaction pathways (Che et al., 2023; Flecha-Ortiz et al.,

2023; Zeng et al., 2024). The next section, thus, explores UGT as a theoretical lens to explain how VIs' feature and gratification mechanisms shape purchase intentions in virtual influencer contexts.

### 2.3. Uses & gratifications theories (UGT)

#### 2.3.1. The appropriateness of uses and gratifications theory (UGT)

Selecting a conceptual framework necessitates consideration of a few critical factors if it is to ensure the relevance and applicability of research's findings (W. M. Lim et al., 2023). While the alignment between the chosen model and the research goals is a prerequisite (Hou & Li, 2024; Kezios, 2021; Petter et al., 2012), scholars must also evaluate frameworks based on their explanatory power (Bordage, 2009; Howie & Bagnall, 2020; Rogers, 2016). According to MacInnis and Folkes (2010), effective conceptual frameworks should focus on consumer roles related to the acquisition, consumption, and disposal of marketplace products. Additionally, the framework's potential to facilitate the discovery of novel relationships and patterns (for example please see Hollebeek (2011)) should also be taken into consideration. MacInnis (2011) proposes that strong theoretical frameworks must demonstrate creativity through identification of novel phenomena or revision of existing perspectives, provide clear explication through detailed delineation and logical summarization. Furthermore, the framework should possess parsimony while accommodating complexity, demonstrate interestingness by challenging or extending existing assumptions, and utilize appropriate reasoning skills—whether divergent thinking for envisioning new concepts, logical reasoning for explicating relationships, comparative reasoning for establishing connections, or syllogistic reasoning for debating positions (Elrod et al., 2012; Matharu et al., 2024; Reeves & Barksdale, 1984).

As a user-centric framework, the uses and gratifications theory (UGT) is one of the best for comprehending how consumers engage with media platforms to satisfy their social and psychological needs (Dolan et al., 2016; Quan-Haase & Young, 2010). Although, originally developed prior to the digital revolution era, UGT has been utilized in research concerning Internet usage and social media adopt (Dhir & Tsai,

2017; Yen et al., 2019) examining factors such as convenience, medium appeal, and amusement (Alhabash & Ma, 2017). More importantly, UGT's focus on active media selection and gratification-seeking behavior make it particularly suitable for understanding how various dimension of VIs' engagement, such as VI's quality as well as VI's social presence, such as closeness, interactivity and perceived human-likeness contribute to engagement itself and the outcome (Dolan et al., 2016).

Unlike traditional media channels where UGT is commonly used, virtual influencers are digital entities that don't physically exist, don't genuinely experience the products they promote, and cannot interact naturally like real humans. This challenges the suitability of UGT in explaining the relationship between VIs and consumer purchasing decisions. This, however, is not true. Three key arguments establish UGT as the appropriate framework for understanding VI influence on purchase decisions:

First, the active selection process central to UGT is clearly evident in VIs engagement. Recent studies by Park and Kim (2022) demonstrate that consumers deliberately choose to follow VIs with specific expectations regarding content quality, entertainment value, and information utility. This conscious selection process aligns perfectly with UGT's foundational premise that media consumers actively seek content that satisfies particular needs. Unlike passive media effect theories, UGT acknowledges the consumer agency that is especially pronounced in the VI context, where users must overcome the "uncanny valley" to engage with digital entities (Jung et al., 2024). Second, the gratifications sought from VIs directly parallel those identified in established UGT literature. (H. Kim & Park, 2024) comprehensive analysis revealed that followers of virtual influencers like Lil Miquela and Imma seek and obtain the same core gratifications documented in traditional media research: information acquisition, entertainment, social interaction, and personal identity construction. The consistency of these gratification categories across both human and virtual influencers validates UGT's applicability regardless of the influencer's ontological status. Third, UGT provides a clear explanatory mechanism linking VI engagement to purchase behavior (D. Yang et al., 2024) empirically demonstrated that gratification fulfillment mediates the relationship between VI content exposure and purchase intention. When consumers receive the anticipated gratifications from VI content, this satisfaction creates positive affect transfer to promoted products - a process that UGT explicitly accounts for through its articulation of how fulfilled media needs translate into subsequent consumer behaviors. This mediating role of gratifications explains why consumers purchase products promoted by entities they know are not real - the fulfilled needs matter more than the influencer's authenticity.

Together, these arguments demonstrate that UGT not only applies to virtual influencers but offers unique explanatory power for understanding their influence on consumer purchasing decisions. Additionally, insights from (Hanafizadeh & Ailipour, 2025), which discuss theory selection in emerging technology research, while traditional theories explain human-technology interaction from trust, emotional, or exchange-based perspectives, UGT is particularly relevant because Metaverse and VIs represent a new form of media consumption, where user engagement is largely driven by gratification-seeking behaviors. This aligns with the notion that theory selection should be context-specific and aligned with user behavior in emerging digital ecosystems.

This study proposes adapting UGT with modifications to better accommodate both the synthetic nature of engagement and the unique ways consumers seek gratifications. VIs' quality aspects (perceived credibility, trustworthiness, and attractiveness) and social presence characteristics (closeness, interactivity, and perceived human-likeness) are two main dimensions of our modified framework. In particular, the quality dimension includes the perceived credibility (Lee et al., 2024) and perceived trustworthiness (Kareklas et al., 2015), while the emotional aspect is represented through perceived attractiveness (de Boissieu & Baudier, 2023; Kim & Park, 2024). The social presence characteristics comprise closeness (Taillon et al., 2020), interactivity

(Yang et al., 2023), and perceived human-likeness (Lee et al., 2024); Stein et al., 2024). The benefits obtained from virtual influencers enhance customer satisfaction and purchasing inclinations (Ghouri et al., 2021), demonstrating the significance of UGT in comprehending consumer behaviors in virtual environments. Unlike passive adoption models such as TAM and TPB, UGT emphasizes active media consumption, making it ideal for studying consumer engagement with virtual influencers motivated by entertainment, information seeking, and social connection (Katz et al., 1973).

### 2.3.2. Interaction effects in virtual influencers study

Research on the impact of VIs on consumer behavior is not limited to direct relationships but also considers how different factors interact to produce outcomes (Jayasingh et al., 2025). According to Allal-Cherif et al. (2024) and Sorosrungruang et al. (2024), credibility and attractiveness do not operate independently but interact to create a combined effect on customer satisfaction. Similarly, (Ma & Li, 2024) indicates that perceived human-likeness combined with interactivity can produce synergistic effects.

Particularly in the context of VIs, the interaction between perceived attractiveness and perceived human-likeness is especially important, as demonstrated by Koles et al. (2024) and Sorosrungruang et al. (2024). When VIs possess both high attractiveness and human-like characteristics, studies have shown that the ability to generate satisfaction and purchase intention increases significantly compared to when only one of these factors is present. Conversely, in some cases, the absence of certain factors does not necessarily lead to negative outcomes (Lee et al., 2024). For example, the absence of human attributes can be compensated for by strategic positioning and association (Igarashi et al., 2024). Zhao et al. (2024) and Thomas and Fowler (2021) also suggest that complex interactions between elements of VI quality and social presence may lead to multiple pathways to purchase intention, rather than a simple linear model.

These complex interaction effects necessitate methodological approaches beyond traditional linear modeling, with configurational methods such as fsQCA being particularly suitable for capturing the multiple, asymmetric pathways through which combinations of VI attributes influence consumer behavior.

### 2.4. Source credibility theory, signaling theory, and Parasocial interaction theory

This study propose that VI quality and social presence are two forces that shape consumer emotional and behavioral reactions. VI quality refers to how consumers scrutinize these digital beings' attributes and performance while social presence denotes the psychological bonds people form with entities they know aren't real. Our approach acknowledges something peculiar about VI marketing. We're accepting—rather than ignoring—the key contradiction in VI marketing: consumers see VIs as both technology that can be judged for quality and as social beings that create real emotional connections (Conti et al., 2022; Joshi et al., 2023; Laszkiewicz & Kalinska-Kula, 2023; Lou et al., 2023; Mouritzen et al., 2024; J. P. Stein et al., 2024).

### 2.5. Reflexivity on theory assumptions and reasoning mechanisms

Unlike their human counterparts, VIs raise distinct questions regarding quality due to their algorithmic nature (Franke & Groeppel-Klein, 2024) and lack of authentic lived experiences (Lou et al., 2023). Conceptualizing VIs' quality, therefore, requires theoretical frameworks that balance multidimensional complexity with the peculiar, human-like characteristics of VIs (Choudhry et al., 2022; D. Kim & Wang, 2023; Miyake, 2023). Drawing on Source Credibility Theory (Hovland & Weiss, 1951) and Signaling Theory (Connelly et al., 2011), we focus on perceived credibility, perceived attractiveness, and perceived trustworthiness as three core dimensions of VI quality. Additionally, building

on Parasocial Interaction Theory (Giles, 2002; Rubin & McHugh, 1987), we examine closeness, interactivity, and perceived human-likeness as three key dimensions of social presence that capture how consumers form emotional connections with VIs despite their artificial nature.

Using ideas from other theories to apply to new technology areas means we can't just assume they'll work; we need to examine whether their foundational assumptions and reasoning mechanisms still hold (Hanafizadeh & Alipour, 2024). For this study, it's essential to explain why Source Credibility Theory, Signaling Theory, and Parasocial Interaction Theory make sense for conceptualizing and empirically studying VIs in the context of the metaverse before making any hypotheses (Table 3).

## 2.6. Hypothesis development

### 2.6.1. Quality of virtual influencers (VI) and its impact on consumer responses

**2.6.1.1. Brand-curated VI credibility.** Perceived credibility serves as a quality signal that reduces uncertainty in information-asymmetric environments (Tseng, 2022) but operates through brand-mediated signaling rather than individual expertise demonstration. In this study, perceived credibility is defined as the extent to which consumers judge the brand-curated algorithmic agent to possess adequate expertise and honesty for delivering reliable product information, even though the agent itself lacks human volition (e.g. (Bach et al., 2024; J. Kim et al., 2022)). This content-centric credibility assessment enables consumers to develop confidence in AI-generated information despite explicit awareness of the entity's artificial nature (Kugler, 2023).

The mechanism underlying our hypotheses operates through technologically mediated credibility cues. That is, when VIs demonstrate content accuracy, maintain information consistency, and exhibit professional presentation quality, audiences interpret these signals as indicators of underlying brand commitment to reliable information delivery (Ham et al., 2023). This credibility perception enhances both satisfaction—through expectation confirmation of information quality—and purchasing intention—through reduced uncertainty and increased confidence in VI-endorsed products (Choudhry et al., 2022).

**2.6.1.2. VI attractiveness.** More than just physical appearance, perceived attractiveness of VIs embodies a combination of three elements, namely aesthetic sensibilities (Chan et al., 2023), refined design elements (Luo & Kim, 2023), and a general sense of likability (Xie-Carson, Benckendorff, & Hughes, 2023). To explain the phenomenon when consumers recognize VIs' appeal as artificially constructed yet still find visually compelling, researchers employ what might be termed as "hyperreal attractiveness", denoting VI's hyper-realistic appearances, personalities, and characteristics derived from algorithmic optimization and freedom from physical constraints (D. Kim & Wang, 2023; Lv et al., 2023).

Hyperreal attractiveness denotes a design-level quality cue. This is the extent to which a brand-curated algorithm attains an "optimal aesthetic" that exceeds ordinary human appearance standards and epitomizes Baudrillard et al. (1983) notion of hyperreality. This unique type of appeal strengthens emotional bonds through what is commonly known as parasocial relationship formation, activating visual processing mechanism similar to those triggered by human faces and forms (Canoluk et al., 2023; J. J. Chung et al., 2023; Jhawar et al., 2023).

Moreover, building on our signaling theory justification, we also approach hyperreal attractiveness as a functional quality evaluation rather than an affective reaction. That is, Hyperreal attractiveness in VI contexts operates through a signaling mechanism where brands invest in visual sophistication that exceeds ordinary human appearance standards to signal production investment, design sophistication, and technological capability (Figueiredo et al., 2024; Sharma & Klein, 2025; Shi et al.,

**Table 3**

Summary of core assumption and reasoning mechanism of Source Credibility Theory, Signaling Theory, and Parasocial Interaction Theory.

Theory	Core Assumptions	Reasoning Mechanisms
Source Credibility Theory	<p><b>Expertise-Based Credibility Assumption:</b> Perceived expertise—the communicator's capacity to deliver accurate information—regulates source credibility (Hovland &amp; Weiss, 1951; Serman &amp; Sims, 2022)</p> <p><b>Trustworthiness-Based Credibility Assumption:</b> Credibility hinges on trustworthiness, defined as the willingness to provide truthful information irrespective of self-interest (Hovland &amp; Weiss, 1951; Kumkale et al., 2010). Trustworthiness reflects the degree of confidence in "the communicator's intention to transmit assertions that they regard as valid and accurate" (Serman &amp; Sims, 2022)</p> <p><b>Persuasion Effectiveness Assumption:</b> Sources that are both expert and trustworthy are more likely to create stronger attitude changes than non-expert, non-trustworthy sources (Hussain et al., 2017; Weismueller et al., 2020).</p>	<p>When people are either uninterested in the message or simply don't have the cognitive resources to think deeply, source credibility functions as a mental shortcut. Instead of scrutinizing every detail, individuals utilize source credibility as a preliminary filter—"if I trust the source, I'll trust the message"—which enables them to make instant judgments without the cognitive burden (Javed et al., 2024).</p> <p>Even when people are paying full attention and have the mental capacity to think deeply, they can't escape source credibility bias. The mechanism is as follows: when a highly credible source presents fuzzy or unclear arguments, audiences unconsciously interpret the ambiguity in the most favorable light possible (Chaiken &amp; Maheswaran, 1994).</p>
Signaling Theory	<p><b>Information Asymmetry Assumption.</b> At the heart of signaling theory is the degree of asymmetric information, where signalers possess private knowledge about their quality or capabilities that receivers cannot directly verify (Connelly et al., 2011, 2025).</p> <p><b>Cost-Quality Correlation (Handicap Principle).</b> A signal is credible only when its production cost is inversely related to the signaler's underlying quality: it must be more expensive for low-quality actors and relatively cheaper for high-quality actors. It means that if someone is displaying the signal, they've likely paid the "authentic quality tax" that only genuine high performers can afford (Connelly et al., 2025).</p>	<p><b>Signaling Process.</b> Faced with information asymmetry, the signaler strategically selects and emits signals that convey otherwise hidden traits—such as competence or product quality—to the receiver. The receiver, in turn, interprets these signals to revise expectations or make decisions regarding the signaler (Connelly et al., 2011)</p> <p><b>Credibility Mechanism.</b> High-quality signalers are willing to incur the higher costs associated with credible signals because they can more readily afford them, whereas low-quality signalers are deterred. This cost differential ensures that only genuinely superior actors will pay the "handicap," safeguarding the authenticity of the signal (Koh &amp; Li, 2025).</p>
Parasocial Interaction Theory	<p><b>One-Sided Emotional Bonding and Illusory Social Presence</b> Viewers experience authentic feelings of being cared for and understood and subsequently develop genuine affective bonds with media personas, as if engaged in meaningful conversation despite complete interaction asymmetry—no feedback, no reciprocal awareness, no real dialogue (Y. Huang &amp; Mohamad, 2025). This illusion of mutual interaction becomes the foundation of parasocial bonding—what researchers call a "fake conversation that feels real" (Dibble et al., 2016; Hartmann, 2016).</p>	<p>The human brain mistakes parasocial familiarity for actual friendship, and suddenly you're making trust-based purchases from a complete stranger (Huang &amp; Mohamad, 2025). The feedback loop takes shape: when people feel heard by a creator—even though it's completely imaginary—they keep coming back for more interaction.</p> <p>Each interaction—watching, commenting, feeling acknowledged—builds on the last, creating an emotional snowball effect that eventually transforms casual viewing into something resembling actual friendship (Tukachinsky &amp; Stever, 2019).</p>

Source: by authors.

2021). **Creating and sustaining VIs** collectively create costly signaling barriers where only brands with significant production resources can achieve and maintain convincing hyperreal attractiveness, thereby preserving the signaling mechanism's filtering function while providing measurable indicators of brand quality investment (D. Kim & Wang, 2023; Luo & Kim, 2023; Lv et al., 2023).

We hypothesize that VI attractiveness—reflecting brand signaling through visual production investment and design sophistication—significantly impacts both customer satisfaction and purchasing intention as a legitimate functional quality dimension that signals brand sophistication rather than triggering mere aesthetic preference. This hypothesis specification reflects our theoretical argument that attractiveness assessment shifts from human physical appeal to brand-signaled hyperreal aesthetic achievement while preserving Signaling Theory's core cost-quality correlation mechanisms.

**2.6.1.3. VI Trustworthiness.** Perceived trustworthiness pertains to broader judgments about the VI's behavioral consistency, transparency, and dependability over time (D. Kim & Wang, 2023). It also refers to the belief that the brand-controlled VIs will act consistently, transparently, and non-opportunistically over time, thereby mitigating relational risk despite its non-human nature (Gerlich, 2023). Consistent with our justification that Source Credibility Theory's core dimensions remain psychologically meaningful through alternative cue systems, trustworthiness in VI contexts operates through brand-mediated reliability signals, such as predictable behavioral patterns, transparent disclosure practices, and consistent content quality (Thomas & Fowler, 2021), rather than personal integrity assessment. That is, brand-mediated trust cues rather than character-based trust formation play the crucial role in trust building.

Notably, while credibility (expertise) operates through content accuracy and consistency assessment, trustworthiness operates through behavioral predictability and brand-mediated transparency evaluation. This distinction clarifies that consumers evaluate VIs across all three source credibility dimensions—expertise through content quality, attractiveness through production investment, and trustworthiness through brand behavioral consistency—with each dimension operating through adapted but preserved credibility assessment mechanisms.

We hypothesize that VI trustworthiness—enabled through consistent brand-controlled behavior and transparency rather than personal character assessment—significantly impacts both customer satisfaction and purchasing intention. This hypothesis specification reflects our theoretical argument that trustworthiness assessment shifts from human character evaluation to institutional reliability cues while preserving Source Credibility Theory's three-dimensional credibility framework.

**2.6.1.4. Complementary dynamics of the three dimensions of VI quality.** Before concluding, we want to emphasize the complementary dynamics of the three dimensions of VI quality. Our theoretical framework reveals that brand-curated credibility (content accuracy cues), hyperreal attractiveness (production investment signals), and institutional trustworthiness (behavioral consistency indicators) function as interconnected signaling systems rather than independent evaluation dimensions.

These complementary dynamics operate through adapted credibility assessment pathways. For instance, superior hyperreal attractiveness signals substantial brand production investment, which in turn can partially offset moderate content credibility concerns (Crnjak-Karanović et al., 2023). Conversely, strong institutional trustworthiness demonstrated through consistent brand-controlled behavior might enhance perceived content credibility despite visual design limitations by establishing overall reliability frameworks (Khan et al., 2010). This interconnectedness reflects our theoretical argument that Source

Credibility Theory's three dimensions remain psychologically meaningful while operating through technologically mediated rather than person-based cue systems.

Furthermore, these adapted credibility pathways explain why VI quality dimensions impact purchase intentions both directly through heuristic processing and indirectly through satisfaction-mediated cognitive elaboration. Consistent with Source Credibility Theory's dual-processing framework, direct effects occur through credibility-based heuristic shortcuts and signaling-based quality inferences, while indirect effects emerge from enhanced engagement experiences that increase systematic evaluation and overall satisfaction (El Hedhli et al., 2023). This dual-pathway model demonstrates how technologically mediated credibility dimensions can influence purchasing decisions independently through heuristic credibility assessment while also enhancing systematic processing through improved interaction quality.

Based on this integrated theoretical foundation, we propose the following hypotheses:

**H1.** Brand-curated VI credibility—assessed through content accuracy and consistency cues rather than personal expertise—has a significant positive impact on customer satisfaction.

**H2.** Brand-curated VI credibility—assessed through content accuracy and consistency cues rather than personal expertise—has a significant positive impact on purchasing intention.

**H3.** VI hyperreal attractiveness—reflecting brand signaling through visual production investment and design sophistication—has a significant positive impact on customer satisfaction.

**H4.** VI hyperreal attractiveness—reflecting brand signaling through visual production investment and design sophistication—has a significant positive impact on purchasing intention.

**H5.** VI trustworthiness—enabled through consistent brand-controlled behavior and transparency rather than personal character assessment—has a significant positive impact on customer satisfaction.

**H6.** VI trustworthiness—enabled through consistent brand-controlled behavior and transparency rather than personal character assessment—has a significant positive impact on purchasing intention.

## 2.6.2. The social presence of VIs and its effects on consumer responses

**2.6.2.1. Algorithmic closeness.** Closeness, traditionally denotes geographical affection, including both objective distances, such as travel and transportation expenses, and subjective distance, denotes the consumers' sense of psychological proximity and social rapport toward VIs (Yan et al., 2024). This kind of connectedness often develops over long-term exposure and perceived relational continuity, in which customers identify common identities and mutual confidence (Bove & Johnson, 2001; Hwang et al., 2022).

Closeness works differently with VIs to conventional human influencers mainly because algorithmic closeness in the case of VIs is only built on artifacts and simulations to make felt-like relationship development. We, however, posit that this algorithmic closeness extends beyond fleeting moment of affective responses to encompass perceived relational trajectory development. It is through repeated, brand-designed interactions that the companionship is established albeit its illusionary nature. In other words, VI becomes symbolically anchored in consumers' social worlds. This closeness fulfills deeper social needs for recognition and companionship through engineered responsiveness rather than aesthetic appreciation (Balters et al., 2023).

As a result, when consumers unconsciously interpret VIs' programmed behaviors as indicators of social significance despite explicit knowledge of their algorithmic nature, satisfaction emerges and improves with VI's fulfilling social connection needs through technological simulation (Robinson, 2020). Furthermore, when people cultivate

intimacy feelings toward VIs, this apparent bond also amplifies their receptiveness to purchase recommendation (Escalas & Bettman, 2015; Sokolova & Kefi, 2020).

**2.6.2.2. Engineered interactivity.** Interactivity represents another key dimension of social presence (Doan, 2022). Traditional research demonstrates that interactive experiences create stronger persuasive effects by fostering sense of control, personalization, and active participation in the communication process (Sundar & Kim, 2005). The emergence of VIs introduces the systematic design of responsive communication patterns that create the illusion of bidirectional engagement despite the fundamentally programmed nature of VI responses (Gambino et al., 2020). VIs utilize real-time personalized feedback systems, customized product demonstrations, and adaptive conversation patterns (Allal-Cherif et al., 2024) to create immediate feedback loops that fulfill consumers' psychological needs for personalized attention and meaningful dialogue (J. Kim & Song, 2016; J. E. Lee & Watkins, 2016). Consumers, then, interpret contextually relevant responses, interaction memory, and adaptive communication styles as indicators of genuine attention and care (Kocaballi et al., 2019), despite explicit awareness of the technological framework. Consequently, engineered interactivity enhances purchasing intentions through intensified cognitive and emotional involvement, increased confidence in algorithmically generated endorsements, and satisfaction of individual consumer needs through programmed rather than authentic care (Jia et al., 2022; Lopes et al., 2024).

**2.6.2.3. Human-likeness.** Perceived human-likeness captures how consumers recognize VIs as resembling real humans based on facial features, expressive behavior, and embodied realism (Ciechanowski et al., 2019). Human-likeness operates as a perceptual trigger that activates social cognition, which in turn generates agency, emotion association even when the virtual dimension is explicit (Hortensius & Cross, 2018). Unlike perceived attractiveness which emphasizes aesthetic evaluation and visual appeal, human-likeness focuses on activating social cognition processes similar to human-human interaction that fosters satisfaction by aligning the VI with familiar social categories and relational expectations (Nowak et al., 2015; van der Schalk et al., 2011). When VIs are perceived as highly human-like figures, consumers (almost) automatically apply social heuristics and interaction expectations typically reserved for humans (J. Kim et al., 2019; Nowak & Fox, 2018). Such associations make the VIs appear socially legitimate and psychologically approachable, then without any doubt, leading to heightened purchase intention through similarity-based persuasion and social reflexes (Jin & Ryu, 2020).

While traditional literature makes anthropomorphism as an antecedent of the presence perception which is social (Biocca et al., 2003; Nowak & Biocca, 2003), virtual influencers are an exception and require rethinking. Unlike traditional computer-mediated communication, where human-likeness may arouse social presence later, this represents a new paradigm altogether for consumers engaging with VIs as explicitly synthetic symbols of characters in society (Mouritzen et al., 2024). Here, human-likeness is not just a precursive aspect of social presence but an integral part of the experience. When consumers meet VIs, they not only recognize human-like characteristics but achieve social intercourse and feel connected (J. P. Stein et al., 2024b). So, human-likeness becomes a constituent element instead of evoking cause. This approach reflects the changed nature of digital social interactions. Traditional linear causality analyses are not enough to describe the simultaneous condition of perception and experience in virtual environments.

Based on this integrated theoretical foundation, we propose:

**H7.** Algorithmic closeness with VIs has a significant positive impact on customer satisfaction.

**H8.** Algorithmic closeness with VIs has a significant positive impact on

purchasing intention.

**H9.** Engineered interactivity with VIs has a significant positive impact on customer satisfaction.

**H10.** Engineered interactivity with VIs has a significant positive impact on purchasing intention.

**H11.** Anthropomorphic human-likeness of VIs has a significant positive impact on customer satisfaction.

**H12.** Anthropomorphic human-likeness of VIs has a significant positive impact on purchasing intention.

### 2.6.3. Satisfaction and purchase intentions

In line with C. Kim et al. (2008), this study defines customer satisfaction as the assessment of customers' consumption, expectations, and experiences. This notion plays a pivotal role in essential for forecasting online purchase behavior. Within metaverse environment, where VIs significantly affect customer experiences, satisfaction is even more tightly linked to purchase decisions (Dwivedi et al., 2022). In particular, as argued in Lin et al. (2024), when users find value in their interactions with virtual influencers through informative content, tailored suggestions, or a sense of community, they tend to feel more satisfied overall, which, in turn, leads to stronger purchase intentions. Our conceptual model adopts a dual-route framework that recognizes both direct and indirect pathways from VI characteristics to purchase intentions. This approach is grounded in dual-processing theories of consumer behavior (Chaiken & Trope, 1999; Evans, 2008) and aligns with recent empirical findings in digital environments (Pappas, 2018). Specific VI features—particularly interactivity and human-likeness—can trigger automatic cognitive responses that influence purchase decisions through peripheral processing routes, without requiring comprehensive satisfaction evaluations (Chattaraman et al., 2012). In particular, this direct influence is particularly relevant in metaverse contexts where Novelty effects of AI-powered VIs may create immediate behavioral responses before satisfaction can be fully evaluated (Kim, Kim, & Lee, 2024). Real-time interactivity also exhibits the similar effect, enabling instant persuasion through conversational engagement (Eroglu et al., 2003). Thus, we hypothesize as follows:

**H13.** Customer satisfaction has a significant positive impact on purchasing intentions.

Based on the above discussion, the Fig. 1 presents conceptual model for the study.

## 3. Methodology

This study employs a multi-method analytical approach combining Partial Least Squares Structural Equation Modeling (PLS-SEM), Artificial Neural Networks (ANN), and Fuzzy-set Qualitative Comparative Analysis (fsQCA). While the conceptual justification for this triangulation is detailed in the introduction, its methodological implementation warrants further explanation. Each technique serves a distinct yet complementary purpose in our analytical framework. PLS-SEM provides a foundation for testing our hypothesized linear relationships between variables, allowing us to examine direct and indirect effects within our theoretical model. It offers robust path analysis for complex models with multiple constructs and is particularly suitable for exploratory research (Hair et al., 2019).

ANN extends beyond PLS-SEM's capabilities by capturing non-linear relationships and complex interactions that traditional statistical methods might miss. Though often used for prediction, ANN in this context serves an explanatory function by uncovering hidden patterns in the data, particularly the non-linear effects of virtual influencer characteristics on consumer responses (Leong et al., 2019). This addresses a key methodological gap identified in our literature review—the over-reliance on linear models that fail to capture the inherent complexity

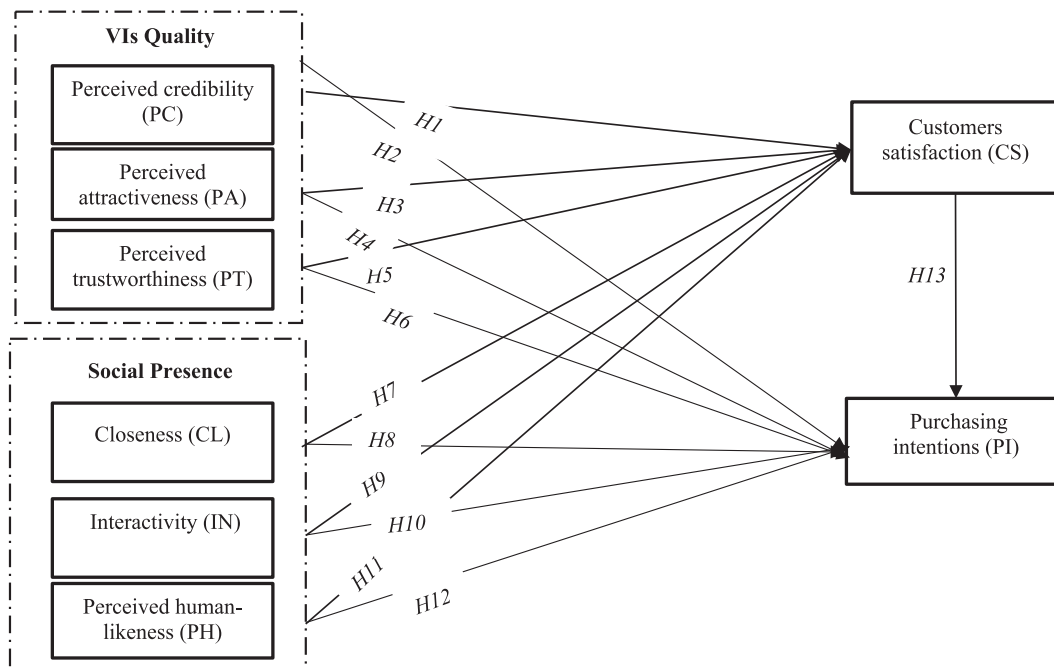


Fig. 1. Conceptual model.

of consumer-VI interactions. fsQCA complements these approaches by identifying multiple configurational pathways to the same outcome, addressing the equifinality inherent in consumer behavior. Unlike variable-centered approaches, fsQCA recognizes that different combinations of factors may lead to similar outcomes, providing a nuanced understanding of how virtual influencer characteristics work together rather than in isolation (Pappas & Woodside, 2021). Together, these methods provide a comprehensive analytical framework that addresses different aspects of our research questions while compensating for the limitations inherent in each individual approach. This triangulation enhances the robustness of our findings and provides a more holistic understanding of the complex relationships being studied.

### 3.1. Data collection method, measurements, and sample characteristics

The present study employed a nonprobability judgmental sampling approach to purposefully select respondents who aligned with the study's objectives and scope (Higginbottom, 2004; Rahman et al., 2022). The target population comprised Generation Z (individuals born between 1995 and 2010), a cohort widely recognized for its intensive Internet usage and early adoption of emerging technologies, including engagement with metaverse commerce. The study specifically focused on Vietnamese Gen Z consumers who demonstrated interest in purchasing experiences within the metaverse environment. Ho Chi Minh City (HCMC) was selected as the sampling location due to its strategic relevance. The city is home to more than 80 % of Vietnam's higher education institutions (Duc et al., 2024; Nguyen, Dang, & Duc, 2024), accommodates the highest volume of domestic flights, and contributes the largest portion to Vietnam's GDP (Binh, 2024). These factors establish HCMC as a dynamic hub for education, innovation, and digital transformation, making it a prime environment for metaverse platform development and a significant aggregation point for Gen Z consumers (Cong Doan, 2022). Therefore, this can be considered the center of metaverse platform development in Vietnam.

Although probability sampling is often preferred for enhancing generalizability, judgmental sampling was deemed more suitable for this study due to the need to recruit individuals with specific experiences—namely, familiarity with and exposure to virtual influencers (VIs) in the metaverse. The absence of a formal sampling frame for

metaverse users in HCMC further necessitated the use of targeted, experience-based sampling. Informed by prior research (T. Nguyen et al., 2022; Nguyen, Phan, et al., 2023; Phan et al., 2025), participants were selected based on their demonstrated awareness of VIs and their intention to engage in metaverse-based purchasing, ensuring the relevance and richness of the data collected for behavioral analysis.

The robustness of our approach is supported a number of factors. First, our final sample size of 352 respondents significantly exceeds the calculated minimum required sample size, providing sufficient statistical power for our analyses. Second, our use of multiple analytical techniques (PLS-SEM, ANN, and fsQCA) provides methodological triangulation that helps compensate for any limitations inherent in the sampling approach. Third, while our sampling was judgmental, the demographic profile (presented in Table 6) demonstrates a reasonable distribution across gender, income levels, and online shopping behaviors, capturing important variations within our target population.

In addition, the authors utilized Google Forms to gather data for this conceptual framework and distributed the questionnaire over social media platforms and instant messaging services from August to November 2024. With each response the respondent receives a link to the learning materials. We offered respondents access to learning materials after completing the questionnaire yet avoided any monetary incentives to guarantee unbiased responses. We recognize that participant familiarity with VIs might affect study outcomes yet opted to implement this factor as a sample selection criterion instead of a control variable because of three main reasons. The study requires participants to have minimal baseline familiarity with virtual influencers to ensure they can provide meaningful feedback regarding Gen Z's interactions. At the initial growth phase of the VIs industry, consumer familiarity levels remain consistent, which minimizes the impact of this variable on study results. The chosen method follows prior research patterns in new technology areas which show sample homogeneity regarding initial awareness levels tends to be more effective than statistical control (Kuzudisli et al., 2023).

Measurement scales assign numbers to variables, transforming qualitative aspects into quantitative data for analysis (Alhanbali et al., 2019; Shen et al., 2016). To enhance response variance, data dispersion, and precision in distinguishing respondents' viewpoints (Zhang, 2013), this study used a 7-point Likert scale instead of a 5-point scale. The 7-

point scale improves precision, reliability, validity, and stability (Fischer et al., 2022; Hartman et al., 2017) while minimizing respondent time compared to open-ended questions (Baburajan et al., 2020). Studies by L. H. Nguyen et al. (2021) that translating the questionnaire into Vietnamese reduced bias from cultural and linguistic differences, improving accessibility and comprehension for respondents in Vietnam. The measurement constructs and the corresponding references for the structures are provided in Table 4. In addition, the authors used G-Power 3.1 for power analysis to calculate the sample size for this study. The analysis considered the power level (1-β), significance level, and population effect size (Erdfelder et al., 1996). The required sample size was 98, calculated using the F-test for linear multiple regression (effect size, f<sup>2</sup> = 0.15, probability of error, α = 0.05, power level, (1 - β) = 0.8, and number of predictors = 6). Notably, the term “minimum” in this context indicates the smallest possible sample size, which fulfills specific SEM power and significance requirements (Duarte & Raposo, 2010).

### 3.2. Respondent profile

Table 5 shows the respondents’ characteristics. The total number of respondents is 439 but we only report 167 of them who have interacted with VIs. The breakdown of gender of respondents in the survey result is almost equal, with the female representing 50.30 % and male 49.70 %. A great proportion of respondents were students (80.84 %), and more than 95.81 % are studying in a university. A larger percentage of the sample’s monthly income was found to be below VND 4,999,000 (52.69 %). This was then followed by an income ranging from VND 5000,000 to VND 14,999,000 (33.53 %). After that, there were a few participants whose income ranges from VND 15,000,000 to VND 19,999,000 (8.38 %), and those whose income was above VND 20,000,000 make up 5.39 %. The most used device to shop online is the smartphone, with 77.84 % of the responses. In terms of social platforms, Facebook is the main choice at 34.73 %, followed by Instagram at 28.74 % and TikTok at 28.14 %. Lastly, the questions about the experience with VIs show that most participants interact with them sometimes, at 83.23 %, and those who said that they frequently interact with VIs were 16.77 %. In conclusion, the analysis of the basic demographics and respondents’ profiles of the research provides an insight into the study sample’s different characteristics.

## 4. Data analysis

### 4.1. Common method bias (CMB)

Collecting data for both exogenous and endogenous factors from the same source increases the possibility of common method bias (Russo & Stol, 2021). The author employed statistical and procedural approaches for analyzing the study data (Mertler et al., 2021) and selected a cross-sectional research design (Boulos & Fikretoglu, 2018). Before the survey, participants received assurances that their replies would be anonymous and confidential, enabling them to answer the questions honestly and genuinely without concerns about reliability (Roehl & Harland, 2022). Furthermore, this study also found that the Kaiser-Meyer-Olkin measure and Bartlett’s test score of 0.981 were both higher than the 0.5 level. It also found that a single factor explained 69.39 % of the total variance, which is less than the 70 % level that is considered acceptable (Fuller et al., 2016; X. Pan et al., 2020; Rahimzhan et al., 2020). The VIF indices shown in Table 6 were within the critical threshold of 5, hence minimizing the possibility of common method bias (Kock, 2015; Sinniah et al., 2022). Therefore, common method bias cannot affect the dataset.

### 4.2. Measurement model assessment

Prior to assessing the hypotheses in the structural model, it is essential to analyze and validate the outer model, which represents the

**Table 4**  
Items of the constructs and their references.

Constructs	Items	References
Closeness (CL)	CL1: I feel a personal connection with virtual influencers. CL2: VIs make me feel understood and valued. CL3: I consider VIs to be a part of my daily life. CL4: I share my thoughts and experiences with virtual influencers.	(Taillon et al., 2020)
Interactivity (IN)	IN1: VIs respond to my comments and messages promptly. IN2: I feel engaged when interacting with virtual influencers. IN3: I enjoy participating in live sessions or events hosted by virtual influencers.	(Jun & Yi, 2020; Yang et al., 2023)
Perceived attractiveness (PA)	PA1: I find the style and fashion of virtual influencers to be inspiring. PA2: The aesthetic quality of virtual influencers’ content attracts me.	(Kim & Park, 2024)
Perceived credibility (PC)	PC1: I believe the information provided by virtual influencers is reliable. PC2: Virtual influencers seem knowledgeable about the products they endorse. PC3: I trust the recommendations made by virtual influencers PC4: Virtual influencers provide accurate and helpful information. PC5: I feel confident in the credibility of virtual influencers’ content.	(Lee et al., 2024; Martins et al., 2019)
Perceived Trustworthiness (PT)	PT1: I trust the intentions of virtual influencers. PT2: Virtual influencers appear honest and sincere. PT3: I believe that virtual influencers have my best interests in mind.	(de Boissieu & Baudier, 2023)
Perceived Human-likeness (PH)	PH1: Virtual influencers look and behave like real humans. PH2: The actions and emotions of virtual influencers feel lifelike. PH3: Virtual influencers’ interactions mimic those of real people. PH4: I often forget that virtual influencers are not real humans. PH5: Virtual influencers appear to have realistic and human-like characteristics.	(Lee et al., 2024; Stein et al., 2024)
Customer Satisfaction (CS)	CS1: I am satisfied with the products recommended by virtual influencers. CS2: The quality of the products endorsed by virtual influencers meets my expectations. CS3: My overall shopping experience is enhanced by following virtual influencers.	(H. Kim & Park, 2024; Lin et al., 2024)
Purchasing Intentions (PI)	PI1: I am likely to purchase products recommended by virtual influencers. PI2: Virtual influencers’ endorsements increase my likelihood of making a purchase. PI3: I have purchased products based on virtual influencers’ recommendations. PI4: Virtual influencers influence my immediate purchase decisions. PI5: I frequently consider virtual influencers’ recommendations when shopping.	(Chiu & Ho, 2023)

Source: by authors.

**Table 5**  
Demographic Profile (Total Sample, N = 167).

Demographic Characteristics	Frequency	Percentage
<b>Gender</b>		
Male	83	49.70 %
Female	84	50.30 %
<b>Occupation</b>		
Student	135	80.84 %
Employee	30	17.96 %
Unemployed	2	1.20 %
<b>Academic Level</b>		
University	160	95.81 %
High school	7	4.19 %
<b>Income per month</b>		
Below VND 4,999,000	88	52.69 %
From VND 5000,000 to 14,999,000	56	33.53 %
From VND 15,000,000 to 19,999,000	14	8.38 %
Above VND 20,000,000	9	5.39 %
<b>Primary Device</b>		
Smartphone	130	77.84 %
Desktop computer	19	11.38 %
Laptop	15	8.98 %
Tablet	3	1.80 %
<b>Favorite Platform</b>		
Facebook	58	34.73 %
Instagram	48	28.74 %
TikTok	47	28.14 %
YouTube	12	7.19 %
Twitter	2	1.20 %
<b>Experience with Visualization</b>		
Occasionally interact with them	139	83.23 %
Frequently interact with them	28	16.77 %

Source: by authors.

measurement. To find out how adaptable the measurement model is, validity (convergent and discriminant) and reliability (Cronbach’s alpha, composite reliability, and Dijkstra-Henseler’s rho) must be evaluated (Cheah et al., 2018).

In Table 6 shows that the mean and standard deviations for all items and constructs reflect favorable assessments of the quality of VIs. The mean scores for perceived credibility (PC), perceived attractiveness (PA), and perceived trustworthiness (PT) are 5.615, 5.792, and 5.571, respectively, with standard deviations between 1.299 and 1.351, indicating diversity in answers. As measured by closeness (CL), interactivity (IN), and perceived human-likeness (pH), VIs have a generally positive social presence. These are shown by mean scores of 5.578 for CL, 5.695 for IN, and 5.722 for PH with standard deviations ranging from 1.310 to 1.558. The mean customer satisfaction score of 5.690 indicates positive interaction with VIs, corroborated by a low standard deviation of 1.263, which suggests uniform replies. Similarly, purchasing intentions (PI) exhibit a positive mean score of 5.670 and a standard deviation of 1.423, signifying limited variability in the responses provided by respondents.

Besides, in Table 7 illustrates the study’s commitment to reliability through the utilization of Cronbach’s alpha, composite reliability, and Dijkstra-Henseler’s rho, achieving minimum values of 0.743, 0.751, and 0.886, respectively, all above the 0.7 threshold (Cáceres-Matos et al., 2023; Hair Jr et al., 2020). These metrics confirm the constructions’ reliability. Convergent validity, which evaluates the degree to which various items assess the same concept, was analyzed by factor loadings (FL) and average variance extracted (AVE). The research attained convergent validity, evidenced by AVE values above 0.5 and factor loadings between 0.830 and 0.941, following the exclusion of items that failed to reach the 0.7 criterion (W. Ahmed et al., 2020; L.-T. Nguyen, Duc, et al., 2023). Furthermore, discriminant validity, which distinguishes constructs, was validated by the Fornell-Larcker criterion (Table 8) and cross-loadings (Table 9). The findings indicate that all square roots of AVE exceeded their corresponding correlation coefficients, while cross-loadings demonstrated robust loading on relevant variables and limited loading on insignificant constructs (Fornell & Larcker, 1981; Henseler et al., 2015). Consequently, the research

**Table 6**  
Mean and standard deviation of construct.

Construct	Item	Mean	Standard deviation	Average Mean	Average Standard deviation
CL	CL1	5.911	1.504	5.578	1.558
	CL2	5.465	1.127		
	CL3	5.620	1.775		
	CL4	5.440	1.731		
CS	CS1	5.695	1.246	5.690	1.263
	CS2	5.608	1.206		
	CS3	5.731	1.316		
IN	IN1	5.640	1.324	5.695	1.310
	IN2	5.636	1.321		
	IN3	5.809	1.261		
PA	PA1	5.569	1.399	5.792	1.351
	PA2	5.797	1.273		
	PA3	5.841	1.274		
	PA4	5.900	1.241		
	PA5	5.854	1.243		
PC	PC1	5.542	1.359	5.615	1.353
	PC2	5.610	1.247		
	PC3	5.572	1.431		
	PC4	5.670	1.310		
	PC5	5.679	1.417		
PH	PH1	5.699	1.215	5.722	1.290
	PH2	5.765	1.225		
	PH3	5.722	1.213		
	PH4	5.638	1.501		
	PH5	5.786	1.295		
PI	PI1	5.686	1.362	5.670	1.423
	PI2	5.583	1.334		
	PI3	5.692	1.506		
	PI4	5.658	1.526		
	PI5	5.729	1.389		
PT	PT1	5.490	1.360	5.571	1.349
	PT2	5.572	1.331		
	PT3	5.558	1.290		
	PT4	5.670	1.376		
	PT5	5.565	1.360		

Note(s): CL = closeness, CS = customer satisfaction, IN = interactivity, PA = perceived attractiveness, PC = perceived credibility, PH = perceived human-likeness, PI = purchasing intention, PT = perceived trustworthiness.

Source(s): by authors.

substantiates the dependability and validity of its measuring framework.

#### 4.3. Structural model assessment

The validation of the measurement model facilitated the examination of the structural model to assess the study hypotheses. Before this, the authors performed a collinearity test to examine the potential for multicollinearity (J. Hair, 2009). Table 6 indicates that the variance inflation factors (VIF) for all structures varied from 1.703 to 4.761, remaining within the threshold of 5 (Kock, 2015; Sinniah et al., 2022), thereby eliminating multicollinearity as an issue. Employing the bootstrapping method with 5000 subsamples, no sign alteration, and 99 % bias-corrected confidence intervals, inferential statistics were produced (Dang et al., 2023).

Table 10 reports the results, which confirm ten of thirteen hypotheses. The variables PC ( $\beta = 0.188$ ) and PT ( $\beta = 0.149$ ) have a substantial impact on CS, while PA ( $\beta = 0.054$ ) exhibits a more nuanced influence. With p-values < .05, these findings support hypotheses H1 and H5, but not H3. Likewise, CL ( $\beta = 0.221$ ), IN ( $\beta = 0.181$ ), and PH ( $\beta = 0.165$ ) substantially influence CS, hence validating hypotheses H7, H9, and H11. Furthermore, PC ( $\beta = 0.152$ ), PT ( $\beta = 0.210$ ), and CL ( $\beta = 0.243$ ) exert a substantial influence on PI, with p-values < .05, hence corroborating hypotheses H2, H6, and H8. The association between PA ( $\beta = 0.218$ ) and PI, with a p-value of 0.000 (< 0.05), supports hypothesis H4. However, the hypotheses concerning IN ( $\beta = -0.030$ ) and PI (H10), and PH ( $\beta = 0.000$ ) and PI (H12) were not substantiated, since their p-values of 0.502, and 0.996, respectively, are beyond the 0.05 significant

**Table 7**  
Convergent validity and construct reliability.

Constructs	Items	Factor loadings (FL)	Cronbach's alpha (CA)	Dijkstra Henseler rho_a (pA)	Composite reliability (CR)	Average variance extracted (AVE)
CL	CL1	0.941	0.943	0.945	0.959	0.855
	CL2	0.898				
	CL3	0.927				
	CL4	0.930				
CS	CS1	0.912	0.884	0.884	0.928	0.812
	CS2	0.890				
	CS3	0.901				
IN	IN1	0.868	0.829	0.837	0.898	0.746
	IN2	0.891				
	IN3	0.830				
PA	PA1	0.906	0.743	0.751	0.886	0.795
	PA2	0.876				
PC	PC1	0.909	0.922	0.923	0.945	0.811
	PC2	0.885				
	PC3	0.899				
	PC4	0.909				
PH	PH1	0.853	0.920	0.923	0.940	0.758
	PH2	0.871				
	PH3	0.873				
	PH4	0.860				
	PH5	0.895				
PI	PI1	0.897	0.947	0.947	0.959	0.824
	PI2	0.893				
	PI3	0.921				
	PI4	0.909				
	PI5	0.919				
PT	PT1	0.914	0.900	0.901	0.938	0.834
	PT2	0.914				
	PT3	0.911				

Note(s): CL = closeness, CS = customer satisfaction, IN = interactivity, PA = perceived attractiveness, PC = perceived credibility, PH = perceived human-likeness, PI = purchasing intention, PT = perceived trustworthiness.  
Source(s): by authors.

**Table 8**  
Formell and Larcker.

	CL	CS	IN	PA	PC	PH	PI	PT
CL	<b>0.924</b>							
CS	0.793	<b>0.901</b>						
IN	0.713	0.778	<b>0.863</b>					
PA	0.714	0.727	0.743	<b>0.891</b>				
PC	0.835	0.821	0.781	0.756	<b>0.901</b>			
PH	0.761	0.801	0.808	0.769	0.821	<b>0.870</b>		
PI	0.848	0.841	0.760	0.799	0.857	0.804	<b>0.908</b>	
PT	0.823	0.822	0.805	0.754	0.877	0.848	0.861	<b>0.913</b>

Source(s): by authors.

threshold. The study found a significant relationship between CS and PI ( $\beta = 0.216, p < .05$ ), supporting H13. In conclusion, the findings reveal that, with the exception of the associations between PA and CS, IN and PI, and PH and PI, all other variables exhibit significant interactions, as seen in Table 11.

All  $Q^2$  predictive values were positive, surpassing 0 (Table 11), thereby confirming the model's predictive efficiency (Hair Jr et al., 2021). It was found that the  $R^2$  values, which show how much variation in endogenous variables can be explained by outside factors, were higher than 0.1 (Achar, 2016; Loh et al., 2021). The study indicated  $R^2$  values of 0.769 for CS and 0.819 for PI, significantly exceeding the threshold of 0.67 (Peng & Lai, 2012), thus demonstrating robust predictive capability. These findings highlight the model's strong capacity to elucidate the relationships between external and internal variables, according to previous studies on structural model assessment (J. F. Hair et al., 2019; Nakagawa et al., 2017).

#### 4.4. Artificial neural network approach

The study of artificial neural networks (ANN) allows the assessment of both linear and nonlinear relationships between structures, resulting

in enhanced predicted accuracy (Deshpande et al., 2014). Conversely, partial least squares structural equation modeling (PLS-SEM) is solely concerned with linear interactions (Leong et al., 2019; Wong et al., 2021). This research is the first to use both PLS-SEM and ANN methodologies to furnish substantial evidence and precise forecasts concerning customer behavior toward VIs in the metaverse. Figs. 2 and 3 examine two ANN models: Model A and Model B. Despite being limited in number, the models exhibited complexity, each combining five neurons in their hidden layers.

To increase the reliability of the research results, the authors used an artificial neural network (ANN) method in addition to PLS-SEM. As shown in Table 12, two models (Model A predicting satisfaction - CS and Model B predicting purchase intention - PI) were tested through 10 different neural networks by dividing the data into 10 cross-validation times (Almansour et al., 2019; L.-T. Nguyen, Duc, et al., 2023). The results showed that Model A predicted better, with a significantly lower mean square error (RMSE) (0.6113 in training and 0.5638 in testing), while Model B had a higher error (0.7250 and 0.7359) (S. Yang & Zeng, 2018). In which, ANN6 and ANN5 networks were the two best performing models in Model A.

Table 13 further shows the importance of each input factor through

**Table 9**  
Cross loadings.

	CL	CS	IN	PA	PC	PH	PI	PT
CL1	<b>0.941</b>	0.785	0.707	0.723	0.815	0.759	0.824	0.797
CL2	<b>0.898</b>	0.721	0.684	0.671	0.775	0.714	0.759	0.761
CL3	<b>0.927</b>	0.728	0.624	0.613	0.760	0.648	0.781	0.740
CL4	<b>0.930</b>	0.695	0.618	0.627	0.736	0.688	0.769	0.742
CS1	0.730	<b>0.912</b>	0.738	0.658	0.755	0.734	0.736	0.750
CS2	0.700	<b>0.890</b>	0.690	0.626	0.728	0.740	0.747	0.737
CS3	0.714	<b>0.901</b>	0.677	0.681	0.734	0.692	0.789	0.735
IN1	0.612	0.637	<b>0.868</b>	0.602	0.683	0.696	0.629	0.682
IN2	0.691	0.738	<b>0.891</b>	0.690	0.725	0.709	0.724	0.739
IN3	0.533	0.633	<b>0.830</b>	0.627	0.607	0.687	0.608	0.660
PA1	0.657	0.676	0.649	<b>0.906</b>	0.680	0.665	0.767	0.681
PA2	0.613	0.617	0.679	<b>0.876</b>	0.668	0.710	0.651	0.664
PC1	0.772	0.773	0.739	0.702	<b>0.909</b>	0.769	0.774	0.800
PC2	0.714	0.719	0.698	0.697	<b>0.885</b>	0.737	0.767	0.795
PC3	0.770	0.724	0.666	0.638	<b>0.899</b>	0.702	0.778	0.778
PC4	0.751	0.738	0.709	0.686	<b>0.909</b>	0.749	0.770	0.787
PH1	0.606	0.663	0.677	0.636	0.686	<b>0.853</b>	0.615	0.689
PH2	0.663	0.689	0.674	0.675	0.694	<b>0.871</b>	0.700	0.723
PH3	0.592	0.649	0.724	0.660	0.692	<b>0.873</b>	0.646	0.695
PH4	0.755	0.730	0.680	0.656	0.784	<b>0.860</b>	0.766	0.805
PH5	0.678	0.745	0.758	0.714	0.711	<b>0.895</b>	0.751	0.765
PI1	0.782	0.763	0.730	0.831	0.797	0.745	<b>0.897</b>	0.804
PI2	0.712	0.755	0.731	0.719	0.769	0.754	<b>0.893</b>	0.767
PI3	0.766	0.760	0.671	0.698	0.775	0.713	<b>0.921</b>	0.768
PI4	0.793	0.764	0.626	0.661	0.776	0.691	<b>0.909</b>	0.772
PI5	0.794	0.775	0.693	0.712	0.773	0.744	<b>0.919</b>	0.794
PT1	0.742	0.761	0.740	0.700	0.790	0.774	0.776	<b>0.914</b>
PT2	0.764	0.768	0.751	0.683	0.836	0.771	0.807	<b>0.914</b>
PT3	0.748	0.721	0.713	0.684	0.775	0.777	0.775	<b>0.911</b>

Note(s): CL = closeness, CS = customer satisfaction, IN = interactivity, PA = perceived attractiveness, PC = perceived credibility, PH = perceived human-likeness, PI = purchasing intention, PT = perceived trustworthiness.  
Source(s): by authors.

**Table 10**  
Structural model.

Hypothesis	PLS Path	Original sample (O)	Sample mean (M)	Standard deviation (STDEV)	T statistics ( O/STDEV )	P values	Remark
H1	PC→CS*	<b>0.188</b>	0.184	0.066	2.836	<i>0.005</i>	Supported
H2	PC→PI*	<b>0.152</b>	0.149	0.054	2.835	<i>0.005</i>	Supported
H3	PA→CS	<b>0.054</b>	0.052	0.038	1.402	<i>0.161</i>	Unsupported
H4	PA→PI*	<b>0.218</b>	0.219	0.038	5.677	<i>0.000</i>	Supported
H5	PT→CS*	<b>0.149</b>	0.151	0.074	2.020	<i>0.043</i>	Supported
H6	PT→PI*	<b>0.210</b>	0.209	0.057	3.697	<i>0.000</i>	Supported
H7	CL→CS*	<b>0.221</b>	0.220	0.065	3.409	<i>0.001</i>	Supported
H8	CL→PI*	<b>0.243</b>	0.244	0.059	4.138	<i>0.000</i>	Supported
H9	IN→CS*	<b>0.181</b>	0.182	0.059	3.068	<i>0.002</i>	Supported
H10	IN→PI	<b>-0.030</b>	-0.029	0.045	0.671	<i>0.502</i>	Unsupported
H11	PH→CS*	<b>0.165</b>	0.168	0.061	2.732	<i>0.006</i>	Supported
H12	PH→PI	<b>0.000</b>	0.003	0.064	0.005	<i>0.996</i>	Unsupported
H13	CS→PI*	<b>0.216</b>	0.213	0.064	3.363	<i>0.001</i>	Supported

Note(s): CL = closeness, CS = customer satisfaction, IN = interactivity, PA = perceived attractiveness, PC = perceived credibility, PH = perceived human-likeness, PI = purchasing intention, PT = perceived trustworthiness; \*Significant at p\_value < 0.05 level.  
Source(s): by authors.

**Table 11**  
PLS - predict.

Latent construct	R-square	Q <sup>2</sup> predict	Predictive Relevant	RMSE	MAE
CS	0.769	0.755	Q <sup>2</sup> > 0	0.498	0.349
PI	0.819	0.790	Q <sup>2</sup> > 0	0.462	0.300

Notes: CS = customer satisfaction, PI = purchasing intention.  
Source: by authors.

sensitivity analysis (Leong et al., 2019). In Model A, perceived reliability (PT) is the most important factor in predicting satisfaction (accounting for 100 %), followed by perceived credibility (PC) with 87.6 % and interactivity (IN) with 70.5 %. This demonstrates how trust-related issues significantly impact consumers' emotions. PT (100 %) and CS (99.7

%) are the two variables in Model B that have the most effects on purchase intention. PC only has 41.1 %, indicating that feelings and contentment have a greater influence than just logical assessment.

Table 14 compares the results between ANN and PLS-SEM, showing that there are some similarities in Model A (such as PC → CS and IN → CS), but the results are completely different in Model B. ANN shows that some factors such as PT and CL have a large influence that PLS-SEM does not clearly show. In contrast, PLS highly values factors such as PA and CS. This difference is because ANN is able to identify complex and nonlinear relationships that are difficult to detect in traditional models. In short, using ANN not only increases prediction accuracy, but also helps to clarify the hidden factors in consumer behavior – especially trust, satisfaction, and emotional attachment – when they interact with and make purchase decisions from virtual influencers.

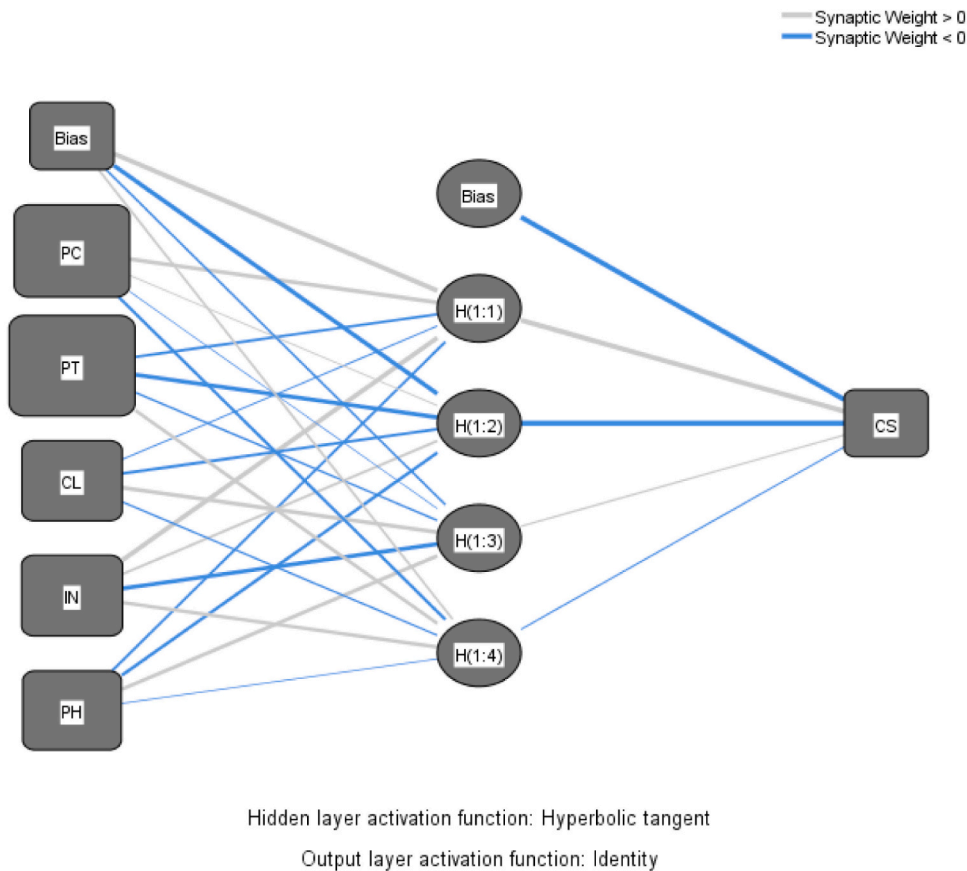


Fig. 2. ANN Model A.  
Source: SPSS.

4.5. Fuzzy-set qualitative comparative analysis

This study utilized FsQCA analysis to investigate the influence of VIs in the metaverse on purchasing intention, concentrating on variables including closeness, customer satisfaction, interactivity, perceived attractiveness, perceived credibility, perceived human-likeness, and perceived trustworthiness. Besides, FsQCA addressed complexities caused by inter-dimensional connections among these components. Subsequent to the advised calibration, the seven-point Likert scale was reorganized into three categories—“6” denoting complete membership, “4” representing the crossover point, and “2” (Pappas & Woodside, 2021)—prior to the transformation into fuzzy scores of “0” (low) and “1” (high) (Skarmeas et al., 2014). In addition, a membership score of 0.5 was included to guarantee that no cases were omitted in the computations (Ragin, 2008; L. Wang et al., 2021).

The necessary conditions analysis (Table 15) indicated that customer satisfaction (CS) was critical for purchasing intention (PI) with a consistency of 0.97237, whereas the absence of customer satisfaction (~CS) was requisite for the lack of PI at 0.79200. Perceived attractiveness (PA) demonstrated the highest consistency (0.95501) for the presence of purchasing intention, while perceived human-likeness (pH) showed strong consistency (0.96911) as well. For the negation of purchasing intention (~PI), the absence of perceived trustworthiness (~PT) exhibited the highest consistency at 0.82862. Using a frequency threshold of 2 and a consistency threshold of 0.8, a truth table in Table 16 (Yang et al., 2024) delineated eight configurations for forecasting PI, all showing “high” outcomes. The primary configuration comprised 307 “high” cases, whereas the others ranged between two and seven cases across various constructs. Additionally, utilizing fsQCA 4.1, four configurations surpassed the consistency threshold of 0.8 and

demonstrated adequate empirical correlation (J. F. Hair et al., 2019).

The configurations analyzed revealed varying causes, with three types: presence (\*), absence (~), and “don’t care” (blank). Symbols in Table 17 indicate core and peripheral conditions: a black circle (●) marks essential core conditions. Within the circle (⊗) represents the absence of a peripheral condition that has minimal influence on the outcome. Blank areas signify “Don’t Care” conditions, suggesting that the presence or absence of the condition does not significantly affect the outcome (Gil-Cordero, Ledesma-Chaves, Sánchez, & Mariano, 2024).

The analysis revealed four distinct pathways to high purchasing intention. Configuration C.1, featuring the presence of perceived credibility (●PC), perceived attractiveness (●PA), perceived human-likeness (●PH), perceived trustworthiness (●PT), and customer satisfaction (●CS), demonstrated the highest coverage (0.891959) and excellent consistency (0.990406), indicating this represents the most comprehensive pathway where all quality and satisfaction factors work together. Configuration C.2, characterized by the absence of closeness (~CL) and the presence of interactivity (●IN), perceived attractiveness (●PA), and perceived human-likeness (●PH), showed moderate coverage (0.8986) with high consistency (0.9901). Configuration C.3, with the absence of closeness (~CL) and interactivity (~IN) but presence of perceived attractiveness (●PA), demonstrated lower coverage (0.1357) but maintained strong consistency (0.9601). Configuration C.4, featuring the absence of closeness (~CL), perceived credibility (~PC), and perceived trustworthiness (~PT) while maintaining interactivity (●IN), perceived attractiveness (●PA), and perceived human-likeness (●PH), showed minimal coverage (0.1012) but achieved acceptable consistency (0.9167).

These findings reveal that perceived attractiveness (PA) and perceived human-likeness (pH) emerge as crucial factors across multiple

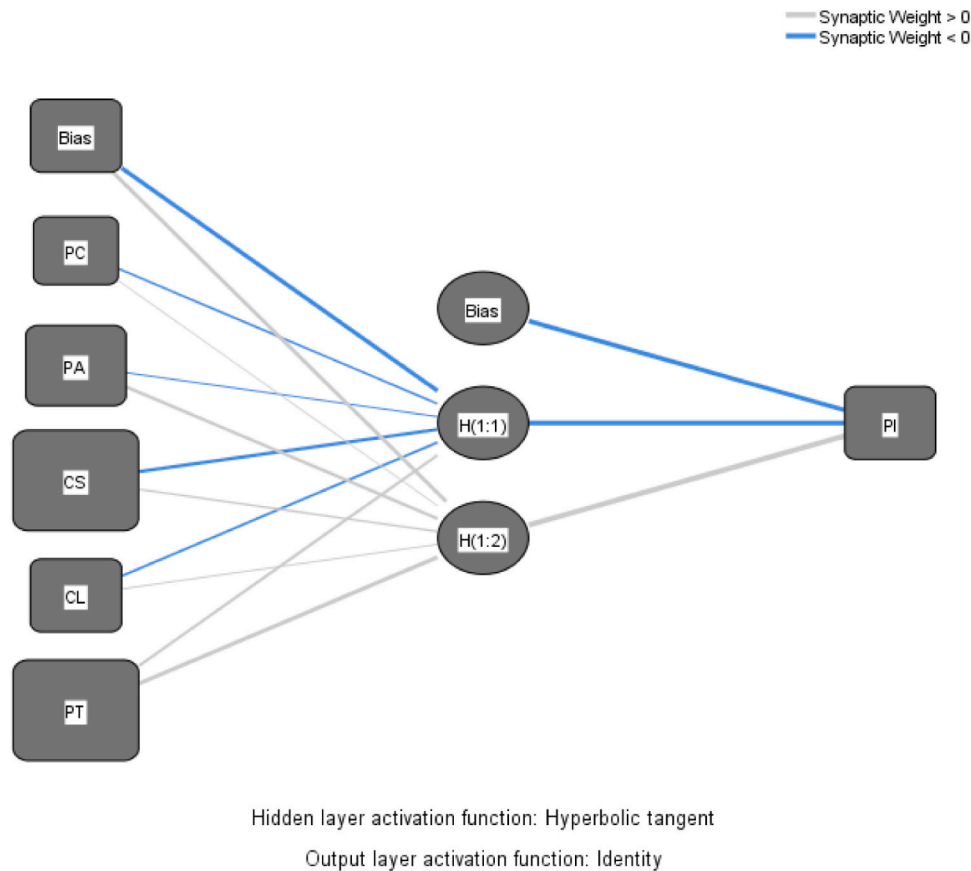


Fig. 3. ANN Model B. Source: SPSS.

Table 12  
RMSE values for CS and PI.

Neural network	Model A		Model B	
	Input: CL; IN; PC; PT; pH		Input: CL; CS; PC; PT; PA	
	Output: CS		Output: PI	
	Training	Testing	Training	Testing
	RMSE	RMSE	RMSE	RMSE
ANN1	0.646	0.673	0.744	0.688
ANN2	0.601	0.651	0.719	0.833
ANN3	0.618	0.522	0.722	0.780
ANN4	0.607	0.649	0.803	0.711
ANN5	0.580	0.453	0.678	0.773
ANN6	0.563	0.415	0.679	0.696
ANN7	0.599	0.540	0.687	0.722
ANN8	0.618	0.614	0.738	0.673
ANN9	0.600	0.571	0.708	0.733
ANN10	0.681	0.550	0.772	0.750
Means	<b>0.6113</b>	<b>0.5638</b>	<b>0.7250</b>	<b>0.7359</b>
SD	<b>0.033113</b>	<b>0.085817</b>	<b>0.040724</b>	<b>0.049004</b>

Notes: CL = closeness, CS = customer satisfaction, IN = interactivity, PA = perceived attractiveness, PC = perceived credibility, pH = perceived human-likeness, PI = purchasing intention, PT = perceived trustworthiness. Source: by authors.

configurations, suggesting their importance in driving purchase intentions through different pathways. Notably, closeness (CL) appears absent in three of the four configurations (C.2, C.3, C.4), indicating that emotional proximity may not be essential when other factors like attractiveness and human-likeness are present. The overall solution coverage of 0.931764 and consistency of 0.979997 demonstrate that

these four configurations collectively explain a substantial portion of high purchasing intention cases with excellent reliability.

Besides, perceived attractiveness (PA) and perceived human-likeness (pH) were key factors **across multiple configurations**, while the presence of perceived credibility (PC), perceived trustworthiness (PT), and customer satisfaction (CS) served as important factors in the most comprehensive pathway (see Table 17). The findings show that configuration C.1 had the highest unique coverage (0.022884) and raw coverage (0.891959). Configuration C.2, showed high raw coverage (0.8986) and consistency (0.9901). Configuration C.3 demonstrated lower raw coverage (0.1357) but maintained strong consistency (0.9601). Configuration C.4 showed minimal coverage (0.1012) but achieved acceptable consistency (0.9167). While fsQCA highlighted the critical importance of PA and PH combinations for purchasing intention (PI), PLS-SEM showed these variables had limited individual direct effects, illustrating fsQCA's value in uncovering complex configurational relationships that complement traditional linear modeling approaches. This study emphasizes fsQCA's utility in advancing understanding of intricate consumer behaviors by revealing multiple equifinal pathways to the same outcome, thereby providing marketers with diverse strategic options for leveraging virtual influencers effectively.

## 5. Discussions and implications

### 5.1. Discussions

This study utilized the uses and gratification theory (UGT) paradigm to investigate the effects of virtual influencer quality, social presence values, and customer satisfaction on purchasing intention. The results indicate that VIs significantly affect customer satisfaction and

**Table 13**  
Sensitivity analysis.

Neural network	Model A					Model B				
	Output: CS					Output: PI				
	PC	PT	CL	IN	PH	PC	PA	CS	CL	PT
ANN1	0.222	0.208	0.314	0.170	0.087	0.148	0.220	0.193	0.154	0.285
ANN2	0.205	0.293	0.172	0.152	0.178	0.119	0.221	0.216	0.156	0.287
ANN3	0.272	0.248	0.135	0.203	0.143	0.200	0.170	0.184	0.167	0.279
ANN4	0.256	0.107	0.208	0.177	0.252	0.249	0.210	0.190	0.136	0.215
ANN5	0.191	0.226	0.191	0.224	0.167	0.171	0.177	0.274	0.216	0.162
ANN6	0.191	0.245	0.199	0.219	0.146	0.198	0.201	0.193	0.154	0.253
ANN7	0.217	0.249	0.138	0.218	0.178	0.189	0.202	0.237	0.168	0.204
ANN8	0.170	0.221	0.134	0.273	0.201	0.146	0.238	0.193	0.150	0.273
ANN9	0.241	0.211	0.198	0.217	0.133	0.192	0.220	0.207	0.160	0.222
ANN10	0.214	0.272	0.178	0.172	0.164	0.218	0.209	0.136	0.199	0.238
Average relative importance						<b>0.116</b>	<b>0.179</b>	<b>0.281</b>	<b>0.142</b>	<b>0.282</b>
Normalize importance (%)	<b>87.6 %</b>	<b>100 %</b>	<b>69.6 %</b>	<b>70.5 %</b>	<b>67.7 %</b>	<b>41.1 %</b>	<b>63.5 %</b>	<b>99.7 %</b>	<b>50.5 %</b>	<b>100 %</b>

Notes: CL = closeness, CS = customer satisfaction, IN = interactivity, PA = perceived attractiveness, PC = perceived credibility, pH = perceived human-likeness, PI = purchasing intention, PT = perceived trustworthiness.

Source: by authors.

**Table 14**  
Comparison between PLS-SEM and ANN results.

PLS Path	Original Sample (O)/ Path Coefficient	ANN Results: Normalized Relative Importance (%)	Ranking (PLS-SEM) [Based On Path Coefficient]	Ranking (ANN) [Based On Normalized Relative Importance]	Remark
<b>Model A (Output: CS)</b>					
PC → CS	0.188	87.6 %	4	4	Match
PT → CS	0.149	100.0 %	1	5	Not match
CL → CS	0.221	69.6 %	5	2	Not match
IN → CS	0.181	70.5 %	3	3	Match
PH → CS	0.165	67.7 %	2	1	Not match
<b>Model B (Output: PI)</b>					
PC → PI	0.152	41.1 %	1	1	Match
PA → PI	0.218	63.5 %	4	3	Not match
CS → PI	0.216	99.7 %	3	4	Not match
CL → PI	0.243	50.5 %	5	2	Not match
PT → PI	0.210	100 %	2	5	Not match

Notes: CL = closeness, CS = customer satisfaction, IN = interactivity, PA = perceived attractiveness, PC = perceived credibility, PH = perceived human-likeness, PI = purchasing intention, PT = perceived trustworthiness.

Source: by authors.

**Table 15**  
FsQCA analysis of necessary conditions.

Conditions	Outcome variable: PI		Outcome variable: ~PI	
	Consistency	Coverage	Consistency	Coverage
CCL	0.93527	0.96483	0.64251	0.14039
~CCL	0.16673	0.68770	0.83905	0.73301
CIN	0.95636	0.93780	0.77844	0.16168
~CIN	0.14509	0.75561	0.70051	0.77271
CPA	0.95501	0.94520	0.74260	0.15567
~CPA	0.14691	0.72934	0.73856	0.77662
CPC	0.95735	0.96069	0.70338	0.14950
~CPC	0.15246	0.70817	0.81507	0.80190
CPT	0.95893	0.96353	0.69738	0.14842
~CPT	0.15248	0.70405	0.82862	0.81035
CPH	0.96911	0.94536	0.76671	0.15841
~CPH	0.13727	0.73533	0.73557	0.83454
CCS	0.97237	0.95666	0.74560	0.15537
~CCS	0.14150	0.72422	0.79200	0.85858

a: CL = closeness, CS = customer satisfaction, IN = interactivity, PA = perceived attractiveness, PC = perceived credibility, pH = perceived human-likeness, PI = purchasing intention, PT = perceived trustworthiness.

b: (~) Negative of a condition.

Source: by authors.

purchasing intentions via attributes like credibility, attractiveness, trustworthiness, and social presence, according to prior studies on consumer behavior (Davlembayeva et al., 2024; Xie-Carson, Magor, et al., 2023). Closeness ( $\beta = 0.221, p < .001$ ) emerged as the strongest linear predictor of customer satisfaction, followed by perceived credibility ( $\beta = 0.188, p < .05$ ) and perceived trustworthiness ( $\beta = 0.149, p < .05$ ). Notably, perceived attractiveness (PA) showed no significant effect on customer satisfaction ( $\beta = 0.054, p = .161$ ), as customers favored emotional connection and reliability over visual appeal (Liu, 2022). For purchasing intention, closeness demonstrated the strongest direct effect ( $\beta = 0.243, p < .001$ ), followed by perceived attractiveness ( $\beta = 0.218, p < .001$ ) and perceived trustworthiness ( $\beta = 0.210, p < .001$ ), while perceived credibility also showed significant influence ( $\beta = 0.152, p < .05$ ). Interestingly, while perceived attractiveness had no effect on satisfaction, it significantly influenced purchase intention, emphasizing different pathways for satisfaction versus conversion. Among social presence variables, closeness had the strongest effect on purchasing intention, while interactivity ( $\beta = -0.030, p = .502$ ) and perceived human-likeness ( $\beta = 0.000, p = .996$ ) showed no significant direct effects on purchase intention. This shows that emotional connections work better than hyper-realistic attributes to change people's behavior (J. Chung et al., 2023; Melnychuk et al., 2024).

However, the ANN analysis revealed fundamentally different importance patterns that capture complex, non-linear relationships

**Table 16**  
Truth table of high purchasing intention.

CL	IN	PA	PC	PT	PH	CS	Outcome (PI)	Raw consistency
High	High	High	High	High	High	High	Yes	0.9936
Low	High	High	High	High	High	High	Yes	0.9684
High	High	Low	High	High	High	High	Yes	0.9867
High	Low	Low	High	High	High	High	Yes	0.9769
High	Low	High	High	High	High	High	Yes	0.9871
Low	Low	High	High	High	High	High	Yes	0.9698
Low	High	High	Low	Low	High	High	Yes	0.9167
Low	High	High	High	High	Low	High	Yes	0.9692

Notes: CL = closeness, CS = customer satisfaction, IN = interactivity, PA = perceived attractiveness, PC = perceived credibility, pH = perceived human-likeness, PI = purchasing intention, PT = perceived trustworthiness.  
Source: by authors.

**Table 17**  
FsQCA results for high purchasing intention.

Condition	High Purchasing Intention			
	Configuration			
	C.1	C.2	C.3	C.4
CL	●		⊗	⊗
IN			●	●
PA		●	●	●
PC	●	●	●	⊗
PH	●	●		●
PT	●	●	●	⊗
CS	●	●	●	●
Raw coverage	0.891959	0.89864	0.13567	0.10117
Unique coverage	0.022884	0.01187	0.00453	0.00571
Consistency	0.990406	0.99006	0.96015	0.91671
Overall Solution Coverage	0.931764			
Overall Solution Consistency	0.979997			

a: CL = closeness, CS = customer satisfaction, IN = interactivity, PA = perceived attractiveness, PC = perceived credibility, pH = perceived human-likeness, PI = purchasing intention, PT = perceived trustworthiness.  
b: the black circle (●) indicates the presence of condition; a circle with a cross (⊗) indicates; and do not care (blank space). Large circles denote core conditions, and small circles signify periphery conditions.  
Source: by authors.

beyond traditional linear modeling. Most significantly, perceived trustworthiness (PT) emerged as the dominant factor with 100 % normalized importance for both customer satisfaction and purchase intention, suggesting that trust operates as a foundational multiplier rather than just an additive factor. For customer satisfaction (Model A), the ANN sensitivity analysis showed PT (100 %) as most critical, followed by PC (87.6 %) and IN (70.5 %), while closeness ranked fourth (69.6 %) - contrasting with the linear model where closeness showed the highest coefficient. For purchase intention (Model B), customer satisfaction achieved 99.7 % importance alongside PT (100 %), indicating that satisfaction serves as the primary conversion pathway while trust enables this process.

Our findings regarding perceived human-likeness (pH) and its relationship with purchase intentions provide interesting insights. While our PLS-SEM results showed no significant direct effect of human-likeness on purchase intentions, the fsQCA revealed that human-likeness can contribute to purchase intentions when combined with other factors such as perceived attractiveness (Configuration C.1). This nuanced finding aligns with research on the ‘uncanny valley’ effect (Gutuleac et al., 2024; S. Pan et al., 2024), suggesting that the relationship between human-likeness and consumer responses is not uniformly positive but rather contingent on other factors. The stronger influence of closeness (CL) compared to human-likeness on purchase intention suggests that emotional connection may be more important than visual realism in the VI-consumer relationship. However, the ANN analysis reveals that trustworthiness represents the role of fundamental enabler. This finding

has important implications for VI design in the Vietnamese market, indicating that developers might focus more on creating trustworthy and emotionally resonant virtual personalities rather than pursuing perfect human simulation, which risks triggering uncanny valley effects.

The research utilized sophisticated analytical techniques, such as PLS-SEM and ANN, to identify both linear and nonlinear correlations. PLS-SEM emphasized the direct impacts of factors, while ANN uncovered more complex interactions, revealing that trustworthiness and customer satisfaction jointly dominate the decision process through nonlinear pathways (G. Wang et al., 2022). The substantial differences in variable rankings between methods (only 3 out of 10 pathways matched) highlight the complexity of consumer-VI interactions that cannot be captured by linear models alone. Concurrently, FsQCA provided supplementary insights by delineating four unique configurations of elements that contribute to increased purchasing intention. Configuration 1 prioritized authenticity and trust, whereas Configuration 3 underscored social connection via perceived beauty and human-like qualities (Yoo et al., 2025). However, a number of studies (Cheung et al., 2024; De Andrés-Sánchez & Puchades, 2023) show that there is a wide range of consumer profiles and motivations, which means that a single linear model might not take into account how complicated customer behaviors are.

In summary, the integration of PLS-SEM, ANN, and FsQCA yielded a comprehensive understanding of the effect of VIs on purchasing intentions. While PLS-SEM showed linear relationships with closeness as the strongest coefficient, ANN revealed trustworthiness as the fundamental driver through complex interactions, and FsQCA showed different consumer pathways requiring various combinations of factors. This triangulation provides businesses with crucial insights: trust-building should be the foundation of VI strategy, while emotional closeness and other attributes can be optimized based on specific market segments and interaction contexts. Together, these studies gave businesses useful information they could use to strategically match VIs with different market segments, which would increase engagement and purchase behavior.

### 5.2. Theoretical implications

The UGT framework employed in this study explores the link between customer satisfaction and purchasing intention in the metaverse and VIs. This fills in gaps in previous studies that mostly looked at consumer engagement (da Silva Oliveira & Chimenti, 2021; Moustakas et al., 2020), brand knowledge (Andersson & Sobek, 2020; Kadekova & Hoilencinova, 2018), and attitudes toward influencers (Dao, 2023; Mohanty, 2021). Moreover, the scope of the Uses and Gratifications Theory (UGT) is broadened by applying it to the setting of virtual influencers (VIs), highlighting how consumers actively engage with and seek enjoyment from interactions with VIs. While classic UGT elements such as entertainment, informativeness, and social engagement remain important, they are tailored to the digital influencer ecosystem. Perceived human-likeness and interactivity are highlighted as

significant engagement drivers, acting as extensions of social presence and informativeness within UGT. Furthermore, this research focuses on how customers develop confidence in VIs via multiple satisfaction mechanisms, emphasizing VIs' importance in determining consumer behavior in the digital world.

### 5.2.1. VIs quality on customer satisfaction

The findings reveal that both social presence and source credibility factors significantly influence customer satisfaction. While PLS-SEM analysis shows closeness demonstrates the strongest linear relationship ( $\beta = 0.221, p < .001$ ), the ANN analysis reveals that perceived trustworthiness emerges as the dominant factor with 100 % normalized importance, indicating that trust operates as the foundational enabler of satisfaction through complex non-linear interactions rather than simple additive effects. Additionally, source credibility elements including perceived credibility ( $\beta = 0.188, p < .05$ ) and trustworthiness ( $\beta = 0.149, p < .05$ ) also significantly influence satisfaction, supporting the source credibility hypothesis. Interactivity ( $\beta = 0.181, p < .05$ ) and perceived human-likeness ( $\beta = 0.165, p < .05$ ) further contribute to satisfaction.

Notably, perceived attractiveness does not contribute to customer satisfaction ( $\beta = 0.054, p = .161$ ). The ANN sensitivity analysis further confirms this pattern, ranking trustworthiness (100 %) as most critical, followed by perceived credibility (87.6 %), with closeness (69.6 %) and other social presence factors showing lower relative importance. This suggests that while emotional connection matters in linear relationships, trust-building mechanisms fundamentally determine satisfaction outcomes in complex consumer-VI interactions, extending UGT by demonstrating how quality attributes serve as multiplicative rather than additive gratification mechanisms. These results demonstrate that consumers prioritize both emotional connection and trustworthiness, while also valuing reliability and authenticity in their interactions with VIs, with trust serving as the foundational multiplier for other attributes (Liu, 2022).

### 5.2.2. Social presence on customer satisfaction

The study confirms that social presence elements—closeness, interactivity, and perceived human-likeness—significantly influence customer satisfaction. Closeness creates emotional bonds between consumers and VIs, enhancing affection and connection when trust is established. Interactivity enhances engagement through immediate feedback and personalized experiences (Teo et al., 2003), while perceived human-likeness generates familiarity and comfort, aligning with the uncanny valley theory (Zhang, 2013). These elements collectively create an immersive and satisfying experience that resembles human-to-human interaction, despite consumers' awareness of VIs' artificial nature (Yang et al., 2023). However, the ANN analysis reveals that social presence elements (closeness: 69.6 %, interactivity: 70.5 %, human-likeness: 67.7 %) are all subordinate to trust-based quality factors (trustworthiness: 100 %, credibility: 87.6 %) in determining satisfaction. This expands UGT by demonstrating that while social presence attributes fulfill relational gratifications in digital environments, they operate effectively only when foundational trust mechanisms are established, suggesting a hierarchical rather than parallel gratification structure in VI contexts.

### 5.2.3. VIs quality on purchase intention

The research's findings reveal a complex pattern where emotional connection (closeness) demonstrates the strongest direct linear impact on purchase intention ( $\beta = 0.243, p < .001$ ), yet the ANN analysis uncovers that trustworthiness (100 % importance) and customer satisfaction (99.7 % importance) jointly dominate the conversion process through non-linear pathways, followed by perceived attractiveness ( $\beta = 0.218, p < .001$ ) and credibility ( $\beta = 0.152, p < .05$ ). Interestingly, perceived attractiveness emerges as a strong driver of purchase intention despite not affecting satisfaction, suggesting that hedonic gratifications (visual appeal) play a crucial role in conversion decisions alongside

utilitarian gratifications (reliability). This indicates that consumers employ different evaluation criteria for satisfaction versus purchase decisions - while emotional connection shows strong linear effects, trustworthiness and satisfaction fundamentally enable conversion through complex interactions, with visual appeal becoming significantly more important in the purchase context than in satisfaction formation. The finding contributes to UGT by identifying that both emotional and aesthetic gratifications are key conversion drivers in VI marketing, yet they operate within a trust-enabled satisfaction framework where relationship quality (closeness) and sensory appeal (attractiveness) work together under foundational trust mechanisms to influence purchase (Yoo et al., 2025).

The ANN Model B results fundamentally reshape our understanding of the purchase decision process, revealing that customer satisfaction serves as the primary conversion gateway (99.7 % importance) while trustworthiness enables this pathway (100 % importance). This finding validates our dual-route framework while demonstrating that satisfaction operates through more complex mechanisms than simple mediation - it functions as the dominant conversion trigger when supported by trust-based foundations. The relatively lower importance of other factors (attractiveness: 63.5 %, closeness: 50.5 %, credibility: 41.1 %) in the ANN model suggests that while these attributes matter for linear relationships, conversion ultimately depends on satisfaction achievement enabled by trustworthiness.

### 5.2.4. Social presence on purchase intention

Among social presence variables, closeness demonstrates the strongest direct linear impact on purchase intention, while interactivity and perceived human-likeness show no significant direct effects. However, the ANN analysis reveals that all social presence factors show relatively low importance for purchase intention (closeness: 50.5 %) compared to satisfaction (99.7 %) and trustworthiness (100 %), indicating that social presence primarily influences purchase decisions indirectly through satisfaction formation rather than direct persuasion. This reveals that while emotional connection matters in linear relationships, the conversion process is fundamentally driven by trust-enabled satisfaction mechanisms rather than direct social presence effects (Chung et al., 2023; Melnychuk et al., 2024). The finding contributes to UGT by identifying that emotional gratifications operate as secondary drivers within a trust-satisfaction framework in VI marketing, suggesting that relationship quality between consumers and VIs enhances conversion when foundational trust and satisfaction are established. This has profound implications for VI design and deployment strategies, emphasizing the need to cultivate meaningful connections rather than pursuing perfect human simulation, which could potentially trigger uncanny valley effects and inhibit purchase behavior (Gutuleac et al., 2024; S. Pan et al., 2024).

Additionally, this study uses a unique analytical framework that can be used in many areas by combining FsQCA, PLS-SEM, and ANN to look at both linear and nonlinear changes in consumer behavior (Allal-CherifAbiodun et al., 2019; Dang et al., 2023). The substantial differences between linear (PLS-SEM) and non-linear (ANN) findings - with only 3 out of 10 pathways matching in rankings - highlight the critical importance of methodological triangulation in understanding complex consumer-VI relationships. The integration of SEM with ANN reveals hidden importance structures and improves variable ranking, whereas FsQCA identifies configurations that influence customer satisfaction and purchase intentions, offering insights into both direct and configurational pathways in consumer decision-making affected by VIs (Shao, 2024). This technique exposes compensatory interactions among variables and illustrates how diverse elements converge to form distinct results, furthering research on virtual influencer marketing. This study broadens the UGT paradigm by showcasing its application to VIs, highlighting their ability to meet consumer needs through human traits and interactive features. This transition signifies a transformation in the digital economy, when VIs affect behavior similarly to real influencers

but retain unique digital attributes. By investigating emotional, social, and technological elements, this study gives vital insights into the future of virtual influencer marketing and its potential for changing customer purchasing behavior in the metaverse.

### 5.3. Managerial implications

VIs, with qualities like credibility, trustworthiness, attractiveness, and social presence, play a key role in enhancing consumer engagement and loyalty (Davlembayeva et al., 2024). As the metaverse grows, they offer businesses opportunities to influence behavior, improve experiences, and boost purchase intentions (Chiu & Ho, 2023; Rane, 2023). Companies can develop engaging marketing strategies by designing campaigns that resonate with consumer preferences and leveraging interactive features, such as virtual try-ons, to enhance satisfaction and loyalty (Idrees et al., 2023). Besides, building trust through transparency and authenticity is crucial and foundational for aligning virtual influencer personas with audience expectations, driving purchase behaviors (Kalla, 2022). Continuous innovation is also vital to keep VIs relevant, ensuring they meet evolving consumer needs and remain competitive (Xu et al., 2022). By utilizing VIs, businesses can create immersive experiences, foster loyalty, advocate for social causes, and enhance brand positioning in the digital marketplace.

#### 5.3.1. Designing and developing effective VIs

Based on our findings that perceived credibility and trustworthiness significantly impact both customer satisfaction and purchase intention, with trustworthiness emerging as the dominant factor (100 % ANN importance) businesses should prioritize developing VIs with strong trustworthiness and credibility markers rather than merely focusing on visual attractiveness. To build credibility, companies should design VIs with consistent behavioral patterns, domain-specific expertise, and transparent disclosure of their artificial nature (Chaihanchanchai et al., 2024). The significant impact of closeness on purchase intention in linear models suggests that VIs should be programmed to simulate relational behaviors such as personalized interactions, conversational memory across touchpoints, and demonstrating authentic interest in consumer concerns within a trustworthy framework (Zeng et al., 2024).

Since human-likeness showed no direct effect on purchase intention but influenced satisfaction, developers should aim for a moderate level of visual realism that avoids the uncanny valley effect while still maintaining sufficient authenticity to generate trust (Kim, Ki, et al., 2024). Additionally, companies should implement regular updates to VI behaviors based on audience feedback and interaction analytics to continuously refine their personality, communication style, and response mechanisms, thereby enhancing their trustworthiness and perceived credibility and strengthening emotional connections with consumers (Koles et al., 2024; Sorosrungruang et al., 2024). This approach aligns with the study's neural network analysis, which identified perceived trustworthiness (100 %) and credibility as the primary predictors of satisfaction, suggesting these attributes should be the cornerstone of effective VI design strategies.

#### 5.3.2. Marketing strategies using VIs

Organizations should leverage VIs across multiple marketing touchpoints to maximize their impact on consumer satisfaction and purchase intentions, as our findings indicate that VIs' influence operates through different pathways. The strongest path to purchase intention involves trustworthiness-enabled satisfaction alongside closeness and credibility. This means that marketing campaigns should prioritize trust-building and relationship-building content over transactional messaging. Since fsQCA results revealed multiple pathways to high purchase intention, marketers should segment their audience based on which VI attributes (credibility, human-likeness, or attractiveness) resonate most strongly with different consumer groups, then customize VI personas accordingly (Franke & Groeppel-Klein, 2024).

Cross-platform integration of VIs is essential, as consistent presence across social media, metaverse environments, and e-commerce platforms reinforces VI familiarity and strengthens emotional bonds with consumers (Thomas & Fowler, 2021). Businesses should also incorporate VIs into experiential marketing initiatives such as virtual events, product demonstrations, and interactive storytelling, which amplify the impact of interactivity on customer satisfaction while creating memorable brand associations that influence future purchase decisions (Kumar & Shankar, 2024). Finally, our neural network analysis showing the non-linear relationship between VI attributes and outcomes with trustworthiness as the dominant factor suggests that marketers should regularly test different combinations of VI characteristics rather than optimizing single attributes in isolation, thereby capturing the complex synergies that drive consumer engagement and conversion (Akhtar et al., 2024; Zhao et al., 2024).

#### 5.3.3. Enhancing purchase conversion through VIs

Since our research demonstrated that customer satisfaction significantly influences purchase intention ( $\beta = 0.251, p < .05$ ), companies should create satisfaction-enhancing touchpoints throughout the consumer journey, including personalized recommendations based on previous interactions, interactive product demonstrations that address specific consumer pain points, and seamless integration between VI engagement and purchase opportunities (H. Kim & Park, 2024). The strong impact of perceived trustworthiness (100 % ANN importance) and credibility on both satisfaction and purchase intention suggests implementing a "trust-first" strategy where VIs initially provide value through objective information and gradually introduce product recommendations once trust is established (Yoo et al., 2025).

To measure and optimize VI effectiveness, companies should employ sophisticated analytics systems that track not only traditional metrics like click-through and conversion rates but also relationship-building indicators such as interaction duration, conversation depth, sentiment analysis, and return engagement frequency (S. Ahmed et al., 2024; Dey & Das, 2023). The fsQCA findings revealing multiple pathways to purchase intention indicate the need for multivariate testing frameworks that evaluate different combinations of VI attributes (prioritizing trustworthiness and satisfaction) against conversion metrics across different audience segments and product categories.

#### 5.4. Limitations and future research directions

A significant limitation of this study is the absence of moderator and mediator variables in our research framework. While we provided theoretical reasoning for focusing on direct relationships to establish a foundational understanding of VI effects in the Vietnamese market, incorporating moderating variables such as brand trust, technological acceptance, and prior VI experience could provide deeper insights into conditional effects. Similarly, examining mediating mechanisms beyond customer satisfaction—such as perceived value, emotional attachment, or social identification—would offer a more granular understanding of the psychological processes underlying VI influence on purchase decisions (Chaihanchanchai et al., 2024; Sorosrungruang et al., 2024). Future studies should develop more complex theoretical models that include these intervening variables to capture the nuanced dynamics of consumer-VI interactions.

Additionally, our sampling approach, while justified for this exploratory study, presents limitations regarding generalizability. Future research should employ probability sampling methods across diverse demographic segments to validate and extend our findings. In the same vein, the cross-sectional design of this study limits causal inference by collecting data at a unique period, without variable sequencing (Bolander et al., 2017; Spector, 2019). Future research may utilize longitudinal methods to investigate the development of consumer satisfaction and purchase intentions through continuous engagement with VIs. The emphasis on an individual geographic area limits cross-

cultural significance, as consumer perceptions of VIs fluctuate across cultural, social, and economic contexts (Ikhsan et al., 2025; Kuehn, 2024; R. E. Lim & Lee, 2023).

To get industry-specific insights, it's important to do comparative studies across different markets and analyses of product-specific features, like how VIs have a big effect on visually-focused industries like fashion. Longitudinal studies are also needed to understand the effectiveness of virtual influencer marketing and make changes to strategies to stay competitive in a digital world that is always changing because AI and augmented reality are improving so quickly (Sze et al., 2024; Zalan & Toufaily, 2024). Addressing these gaps will improve comprehension of VIs' effects, facilitating culturally and contextually customized advertising strategies.

### 5.5. Conclusion

This research examines the influence of VIs within the metaverse on purchasing intention, emphasizing perceived credibility (PC), trustworthiness (PT), attractiveness (PA), closeness (CL), interactivity (IN), and human-likeness (pH) as determinants of customer satisfaction (CS) and purchasing intention (PI). Research indicates that credibility, trustworthiness, and closeness substantially improve satisfaction, which in turn significantly impacts purchase intention, however attractiveness, interactivity, and human-like characteristics show little direct effect. Businesses have to value trust and authentic connections to enhance the efficacy of VIs. The cross-sectional methodology, however, constrains causal inference; subsequent research should employ continuous methodologies and extend to cross-cultural and industry-specific studies for more comprehensive insights.

### CRedit authorship contribution statement

**Tri-Quan Dang:** Writing – review & editing, Methodology. **Tan-Minh Nguyen:** Writing – original draft, Investigation. **Phuc-Thien Tran:** Writing – original draft, Software, Formal analysis. **Tien-Thao Cong Phan:** Validation, Data curation. **Thach-Bao Huynh:** Writing – original draft, Conceptualization. **Luan-Thanh Nguyen:** Writing – review & editing, Supervision, Project administration, Formal analysis.

### Funding

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

### Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

### Acknowledgement

None.

### Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.digbus.2025.100141>.

### Data availability

Data will be made available on request.

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