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Teachers in the metaverse: the influence of avatar appearance and behavioral realism on perceptions of instructor credibility and teaching effectiveness

Manuel B. Garcia [a,b,c]

[a]University of the Philippines Diliman, Quezon City, Philippines; [b]FEU Institute of Technology, Manila, Philippines; [c]Korea University, Seoul, South Korea

ABSTRACT

Teaching in the metaverse presents a dynamic frontier for educational innovation. Avatars, serving as digital representations of teachers, play a pivotal role in shaping virtual learning experiences. This study explores the impact of avatar design and behavioral realism on student perceptions of credibility and teaching effectiveness in avatar-mediated environments. True experimental research with a 2×2 factorial design was conducted involving students from three campuses. Across all experimental conditions, students consistently favored realistic avatars over cartoonish ones. A crisscross pattern emerged in relation to behavioral realism. Cartoonish avatars exhibiting realistic behaviors received higher ratings for instructor credibility but not for teaching effectiveness, whereas realistic avatars with the same gestures received higher ratings for teaching effectiveness but not for instructor credibility. From an educational standpoint, leveraging realistic avatars with authentic behaviors holds great promise for enhancing the teaching and learning experiences in the metaverse. Overall, this study contributes to the growing body of literature on educational metaverse and avatar-mediated teaching and learning by shedding light on the importance of avatar design and behavioral realism in shaping student perceptions and experiences.

Introduction

An avatar serves as a digital representation of a user within virtual environments (Zimmermann et al., 2023). This incarnation acts as the medium through which individuals interact, communicate, and present themselves in digital spaces. In educational literature, avatars are studied across various immersive technologies, such as digital games (Segaran et al., 2021), virtual reality (Kasapakis et al., 2023), and metaverses (Garcia et al., 2023), focusing on diverse educational experiences like student engagement (Hara et al., 2021), learning motivation (Hu et al., 2023), and academic achievement (Zhang & Wu, 2024). A key aspect of virtual presence in avatar-based technologies is embodiment, which refers to the degree to which users feel their digital avatars represent their physical selves. Much like in video games and interactive digital media (Szolin et al., 2023), avatar embodiment plays a critical role in enhancing user enjoyment. Translating this concept to educational settings, the enjoyment derived from a high level of embodiment can have a profound impact on learning outcomes. Makransky and Petersen (2021) also emphasized the assertion of the

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embodiment principle that deeper learning occurs when onscreen characters exhibit gestures, movements, eye contact, and facial expressions that mimic human behavior (Mayer, 2014). Given their considerable influence on learning and engagement, avatars naturally evolve into a significant research topic within the educational domain.

While much of the existing research focuses on how users perceive their digital representations within virtual worlds, a notable research gap emerges in understanding how they perceive other users' avatars in these spaces. This gap is particularly evident in the metaverse context, as most studies are still currently focused on technology acceptance (Chua & Yu, 2023) and adoption (Alfaisal et al., 2024). Moreover, educational metaverse research predominantly focuses on students as the primary users (Han et al., 2023), often overlooking the critical role of educators in these virtual settings. This is a significant oversight that neglects the influential presence of educators within these virtual environments, whose digital representations could significantly shape their virtual persona and, by extension, their ability to effectively convey information and facilitate learning. As observed by Pan and Steed (2019), avatar appearance, or the visual design and characteristics of an avatar, has a notable effect on the credibility of the information shared. Their study also underscored how the visual characteristics of an avatar can impact its perceived credibility among users interacting with it. Kim et al. (2023) likewise pointed out behavioral realism as another critical aspect of avatar design. Behavioral realism refers to the degree to which an avatar's gestures, movements, and interactions authentically reflect those of a real person. When both the visual and behavioral aspects of an avatar correspond to real-world expectations, it may enhance the trustworthiness of the virtual persona. This trustworthiness, or perceived credibility, is intricately linked to teaching effectiveness, as educators who are perceived as more credible are likely to be more effective in their instructional roles (Kianinezhad, 2023).

Therefore, this study aims to examine the effects of avatar appearance and behavioral realism on the perceptions of instructor credibility and teaching effectiveness of virtual educators in the metaverse. Understanding the influence of these avatar-related characteristics is paramount to enhancing teaching effectiveness and learner engagement in these digital spaces. Avatar appearance plays a critical role in shaping first impressions, as realistic features can enhance trust and authority, both of which are fundamental to establishing credibility. Meanwhile, behavioral realism reinforces these perceptions by simulating authentic human behavior. Together, these two variables are central to how students perceive and interact with virtual educators, as their alignment can influence both the perceived trustworthiness of the instructor and the quality of the teaching experience. By investigating how avatar appearance and behavioral realism impact student perceptions, this study offers valuable insights into optimizing the design of virtual educators in the metaverse. This research extends the literature by focusing specifically on the role of avatar design in educational settings within the metaverse, thus contributing to a deeper understanding of how this new interactive learning environment can be leveraged for effective teaching and learning experiences. Such insights will be instrumental in guiding metaverse adopters, developers, and educators in making informed decisions about avatar design that best supports educational goals. As the metaverse continues to emerge as an interactive learning environment, the significance of avatar design becomes increasingly pronounced. To guide this investigation, the study seeks to answer the following research questions (RQs):

- RQ1. What are the main effects of avatar appearance (realistic vs. cartoonish) and behavioral realism (expressive vs. idle) on students' perceptions of instructor credibility and teaching effectiveness in the metaverse?
- RQ2. How do avatar appearance and behavioral realism interact to affect students' perceptions of instructor credibility and teaching effectiveness in the metaverse?

Literature review

Virtual learning environments

The education sector is perpetually in pursuit of innovative content delivery methods to accommodate the diverse needs of learners worldwide. Among these emerging alternatives, virtual learning environments represent a notable advancement – a trend further emphasized by the global shift to online learning during the COVID-19 pandemic (Al Mazrooei et al., 2022). Caprara and Caprara (2022) broadly defined virtual learning environment as an online space that facilitates the delivery of curriculum content, assessment, and communication between educators and students. Common examples include platforms like Moodle, Blackboard, and Canvas, which offer a suite of tools that enable the creation of a comprehensive online classroom experience. Recently, there has been a shift of interest towards creating more immersive and interactive virtual learning environments. This transition has been made possible through the integration of various technologies such as virtual reality (van der Meer et al., 2023), augmented reality (Garzón et al., 2019), artificial intelligence (Ilić et al., 2023), and, most recently, the metaverse (Pradana & Elisa, 2023). A common theoretical foundation underpinning these integrations is the cognitive theory of multimedia learning (Mayer, 2014). This theory suggests that people learn more effectively when information is presented through both visual and auditory channels, rather than through text alone. Lampropoulos and Kinshuk (2024) observed that the immersive and interactive characteristics of these technologies can pave the way for innovative teaching strategies, fostering learning spaces that are more captivating, stimulating, and motivating for students. As a fully immersive virtual environment, the metaverse represents the pinnacle of integrating digital realms with educational methodologies. The level of immersion it offers facilitates not just the replication of real-life classrooms but also the creation of experiential learning scenarios that can enhance understanding and retention of complex concepts (Di Natale et al., 2024). Thus, the metaverse stands as a transformative frontier in the evolution of virtual learning environments and is presently a key area of educational research.

Teacher avatars in the metaverse

Much like other virtual environments, the metaverse is navigated through avatars. Nowak and Rauh (2005) suggested that the way avatars are viewed can affect not only how individuals see themselves and others but also how messages are received and remembered. This concept aligns with the principles of Social Cognition Theory, which posits that our understanding and interpretation of social interactions are significantly influenced by our observations and perceptions within a social context (Kunda, 1999). Given this framework, the role of avatars used by teachers (subsequently referred to as teacher avatars) in the metaverse becomes critically important. Teacher avatars serve as the primary interface between educators and students in these virtual learning environments. Their role as the digital representation extends into the crucial aspect of presence – or how present, engaged, and tangible an educator feels to students in a virtual environment. Presence is a key concept of the Embodied Social Presence Theory, which emphasizes the importance of physical representation and behavior in creating a sense of social and emotional connection in digital spaces like the metaverse (Garcia et al., 2023). Adhering to the principles of this theory, a more embodied and realistic representation through teacher avatars is posited to significantly improve the learning experience. This improvement comes by fostering a stronger sense of connection, engagement, and trust between students and educators, thereby enhancing educational interaction within the metaverse (Chua & Yu, 2023; Pradana & Elisa, 2023). Despite the strong theoretical underpinnings underscoring the crucial role of teacher avatars in the metaverse, there remains a notable gap in empirical research exploring the direct impact of these avatars on educational outcomes. This absence points to a critical area for investigation, especially as education continues to explore the potential of the metaverse and its impact on key educational dynamics (Hwang et al., 2023;

Kurniawan et al., 2023; Zhao et al., 2022). Consequently, it is essential to examine the impact of teacher avatars on virtual learning experiences to improve the efficacy of online teaching methodologies.

Instructor credibility and teaching effectiveness

The humanization of avatars represents a pivotal area of focus when examining the impact of teacher avatars. Anthropomorphism, or the process by which users attribute human-like qualities to avatars, plays a critical role in how these digital entities are perceived and engaged within virtual environments (Dubosc et al., 2021). As users anthropomorphize computer-based entities, teacher avatars may significantly affect student motivation, engagement, and cognitive absorption of the material presented. Nowak et al. (2015) observed that associating an anthropomorphic image with a message or its source results in it being perceived as having greater social potential. Consequently, this perception raises expectations regarding credibility, intelligence, and suitable social responses. Previous studies have shown that individuals tend to dedicate more cognitive effort and construct more intricate mental representations of entities they consider having social potential (Blascovich et al., 2002; Lee, 2010). This process then leads to the assignment of social categories and the formation of corresponding judgments. Building on this understanding, the believability of instructors within the metaverse emerges as a pivotal factor. When an avatar is perceived as believable, it significantly enhances the trustworthiness of both the source and its messages. This increase in perceived instructor credibility is crucial, as students need to have faith in their teachers (Myers & Martin, 2017). Trust in the instructor is foundational for a productive educational experience, which enables students to confidently rely on the accuracy and reliability of the information provided. The implications of such credibility extend into the concept of teaching effectiveness, where the perceived authenticity and reliability of the instructor directly influence instructional outcomes. Enhanced credibility not only fosters a more engaging and immersive learning environment but also encourages a deeper understanding and retention of the material. Therefore, it is imperative to thoroughly examine the avatars of teachers in the metaverse and determine the optimal way they should be presented to maximize perceived instructor credibility and perceived teaching effectiveness.

Avatar appearance and behavioral realism

According to the Computers are Social Actors (CASA) paradigm proposed by Nass et al. (1994), it is the presence of social cues within technology that triggers social perceptions and attitudes among users. These cues, which are varied and encompass elements such as humanlike facial expressions, emotions, voice, language, unpredictability, and interactivity, play a critical role in how users relate to and interact with technological systems (Xu et al., 2022). In the metaverse, Kim et al. (2023) applied the CASA perspective to underscore the profound impact avatar characteristics have on shaping user interactions and social connections. These attributes, ranging from appearance and abilities to traits and behaviors, are pivotal in facilitating or hindering interactions in computer-mediated communication (Nowak & Fox, 2018). Considering avatars are digital embodiments of users in virtual environments, the level of realism is pivotal in enabling social exchanges. Within immersive social virtual environments, more realistic avatars tend to foster a greater sense of acceptance of the virtual form as one's own (Latoschik et al., 2017). Kim et al. (2023) further emphasized that avatar realism – whether through visual elements (e.g. anthropomorphic features) or behavioral traits (e.g. social conformity) – significantly influences its perception of authenticity by other metaverse inhabitants. Drawing from these insights, it is reasonable to assume that the principles underlying the CASA paradigm and the significance of avatar realism extend into the educational usage of metaverse technologies (Garcia et al., 2023). Given that avatars are the principal conduit for interaction between teachers and students in virtual learning

environments (Zhang & Wu, 2024), the attributes of teacher avatars likely have a significant impact on the educational experience. Nevertheless, the specific attributes of avatar realism, both in terms of visual and behavioral aspects, within the metaverse remain to be clearly defined. This ambiguity underscores a vital area of research that necessitates a detailed investigation into how distinct characteristics of teacher avatars influence perceptions of instructor credibility and teaching effectiveness in the metaverse.

Methods

Research design

This study adopted a true experimental research methodology to examine the effects of avatar appearance and behavioral realism on perceived instructor credibility and perceived teaching effectiveness within the metaverse. Experimental research is a systematic and scientific approach that involves deliberate manipulation and controlled observation to understand how variable changes influence results. In educational studies, this methodology is often employed to examine the effectiveness of teaching innovations, such as new learning resources, curriculum, and pedagogy (Taber, 2019). This method is particularly suitable to this study because it allows for a direct examination of the cause-and-effect relationship between the design characteristics of avatars and their impact on perceived instructor credibility and teaching effectiveness. Among the types of experimental research, true experimental is considered the gold standard due to its rigorous structure (Dawes, 2010). This design was selected because it provides a high level of control over the research environment that enables precise measurement of how variations in avatar appearance and behavioral realism affect perceptions of instructor credibility and teaching effectiveness. To thoroughly investigate these effects, the study utilized a 2×2 factorial design using a between-subjects approach to assess the effects of two dichotomous variables: avatar appearance (cartoonish and realistic) and behavioral realism (idle and expressive). The factorial design allowed the study to separately assess the main effects of each variable on the dependent measures while also examining the interaction effects – how their combination jointly influences perceived instructor credibility and teaching effectiveness. Through this methodological approach, this study aims to yield insights into how subtle differences in avatar-mediated education can significantly influence learners' perceptions of virtual instructors.

Study setting

The investigation was conducted within the three campuses of the Far Eastern University (FEU) Group of Schools in the Philippines, comprising FEU Institute of Technology, FEU Diliman, and FEU Alabang. This selection is strategic due to the institutions' early adoption and pioneering development of an educational metaverse known as the MILES Virtual World (Garcia et al., 2023). The project was initiated in 2021 to provide a digital space where students and teachers can engage in a variety of activities resembling real campus life. MILES Virtual World sets itself apart with its precise virtual renditions of the campuses, which offers an immersive experience that closely mimics the real-world layout and architecture of the FEU Group of Schools. Originally featuring cartoonish graphics, the platform has been undergoing continuous development to incorporate more realistic graphics (Figure 1). Its latest version is now capable of hosting school events and activities in the metaverse (Garcia et al., 2024), with the expected level of realism and interactive features enhancing the virtual experience (See Figure 2). In addition to these visual enhancements, efforts have been made to introduce features that improve behavioral realism, such as dynamic expressions and gesture capabilities for avatars. This progression offers a unique opportunity to study the effects of avatar appearance and behavioral realism within an established educational metaverse environment. The availability of these advancements has made it possible to create four distinct

Figure 1. Cartoonish and realistic teacher avatars in the MILES virtual world.

versions of the application, each with different implementations of avatar appearance and behavioral realism.

Instrument and procedures

The research instrument was composed of four variables, with the independent variables (i.e. avatar appearance and behavioral realism) being assessed through a self-created questionnaire. For the dependent variables, adaptations of the Measure of Source Credibility Scale (McCroskey & Teven, 1999) and the Online Teaching Effectiveness Scale (Reyes-Fournier et al., 2020) were utilized to assess perceived instructor credibility and perceived teaching effectiveness, respectively. To

Figure 2. Valentine's day school event hosted in the MILES virtual world.

ensure the instrument's clarity and relevance, three instructors with experience in using the meta-verse for education reviewed it for readability and completeness. Their feedback resulted in minor adjustments to question wording and the removal of one redundant item. A pilot test with a subset of the target population ($n = 20$) was then conducted to affirm the tool's reliability and validity. Participants were selected using convenience sampling and completed the questionnaire in a controlled virtual setting. Reliability was assessed using Cronbach's alpha, with values for all constructs exceeding the established threshold ($a > 0.70$). A validity check was also conducted to ensure that the avatars were perceived by participants as intended across the two dimensions of appearance and behavior. This step was critical for confirming the effectiveness of the experimental manipulations. Participants rated four distinct avatars based on appearance and behavior using single-item measures, specifically: "*On a scale from 1 (completely cartoonish/idle) to 7 (completely realistic/expressive), how would you rate the appearance/behavior of this avatar?*" A single-item measure was used for efficiency in capturing unidimensional constructs and minimizing participant fatigue. Although sufficient for this context, future studies could adopt multidimensional scales for deeper insights into avatar-related perceptions. After these preliminary steps, the evaluation was extended to freshmen who had yet to explore the MILES Virtual World. Each student was randomly assigned to one of four treatment groups and attended a five-minute lecture delivered by their designated avatar. To ensure consistency across treatments, each avatar taught the same content in the same manner, with the same voice tone and pacing.

Data collection and analysis

After engaging in a standardized five-minute lecture delivered by their designated avatar, participants completed a questionnaire capturing their perceptions of instructor credibility and teaching effectiveness. Data collection was completed within a single session for each participant to minimize potential environmental distractions or interruptions. Nonparametric statistical methods were employed to account for the ordinal nature of the data and potential deviations from normality. The Wilcoxon signed-rank test was used to validate the experimental manipulations, ensuring that participants perceived the avatars as intended across appearance and behavior dimensions. On the other hand, Kruskal–Wallis H tests were applied to evaluate the main effects of avatar appearance and behavioral realism on the dependent variables, providing insights into the individual impact of these factors. To examine potential interaction effects between appearance and behavior, a Friedman test was conducted, which is particularly suited for assessing combined effects in a

factorial design. Lastly, Mann–Whitney U tests were employed as post hoc analyses to pinpoint specific differences between treatment groups. Lastly, descriptive statistics were also calculated to summarize and provide an overall picture of participant perceptions across conditions.

Results

Before the experiment, a Wilcoxon signed-rank test was conducted to confirm whether the avatars were appropriately differentiated along the appearance and behavior continua. The results showed a clear differentiation between the realistic ($M = 6.24$; $SD = 0.85$) and cartoonish ($M = 2.14$; $SD = 1.05$) avatars for avatar appearance ($Z = -8.672$, $p < 0.001$) as well as between the idle ($M = 2.54$; $SD = 1.23$) and expressive ($M = 5.93$; $SD = 1.17$) avatars for behavioral realism ($Z = -7.636$, $p < 0.001$). These findings confirm that students perceived the avatars according to the intended manipulations of appearance and behavior. This validation step ensures that the experimental manipulations were effective, allowing confidence that any observed differences in the dependent variables (instructor credibility and teaching effectiveness) can be attributed to the experimental conditions. Building on these validated manipulations, this experiment recruited 160 students per campus, resulting in a total intended sample size of $N = 480$. However, only 435 students were able to participate at the time of the experiment, yielding a participation rate of 90.63%. Among the participants, there were 372 males and 63 females, with an average age of 20.56 years ($SD = 1.69$). While most of the students are familiar with the metaverse ($N = 453$; 94.38%), only a few of them reported having experience interacting with it ($N = 49$; 10.21%).

During the experiment, a total of 214 (49.20%) students rated the cartoonish avatars, with 108 of them observing idle behavioral realism and 106 experiencing expressive behavioral realism. On the other hand, a total of 221 (50.80%) students rated the realistic avatars, with 108 of them observing idle behavioral realism and 114 experiencing expressive behavioral realism. As presented in Table 1, the participants provided ratings on perceived instructor credibility and perceived teaching effectiveness for each combination of avatar appearance and behavioral realism. Results of the Kruskal–Wallis H tests indicate that the ratings from all campuses are consistent ($p > 0.05$). Conversely, significant differences were found among the treatment groups for both perceived instructor credibility ($\chi^2(3) = 264.225$, $p < 0.001$) and perceived teaching effectiveness ($\chi^2(3) = 236.463$, $p < 0.001$), indicating that different combinations of avatar appearance and behavioral realism had a significant impact on participants' perceptions. These findings suggest that the interplay between avatar appearance and behavioral realism plays a crucial role in shaping students' perceptions.

Main effects of avatar appearance and behavioral realism

In terms of perceived instructor credibility, the results revealed distinct patterns based on avatar appearance and behavioral realism. Students rated cartoonish avatars lower than realistic avatars, indicating a potential preference for more lifelike representations. Additionally, cartoonish avatars with expressive behaviors received notably higher ratings ($M = 3.32$, $SD = 1.35$) compared to their idle counterparts ($M = 2.55$, $SD = 1.21$), a difference found to be statistically significant ($U = 3959.000$, $p < .001$). This result suggests that the addition of expressive behaviors to cartoonish avatars may enhance their perceived credibility among students. Conversely, for realistic avatars, ratings remained consistently high irrespective of behavioral realism ($U = 5348.500$, $p = .122$), with idle and expressive avatars receiving a mean rating of 5.77 ($SD = 1.02$) and 5.98 ($SD = 0.76$), respectively. These findings underscore the influence of expressive behaviors on the perceived credibility of cartoonish avatars while indicating a generally positive perception of realistic avatars regardless of their behavioral characteristics. Therefore, the inclusion of expressive features in cartoonish avatars could be beneficial for enhancing perceived instructor credibility in virtual learning environments and the metaverse, while realistic avatars may inherently convey a sense of credibility regardless of their behavioral realism.

Table 1. Descriptive statistics of perceived instructor credibility and perceived teaching effectiveness.

Avatar Appearance	Behavioral Realism	Dependent Variables	All Mean ± SD	N	FEU-A Mean ± SD	N	FEU-D Mean ± SD	N	FEU-T Mean ± SD	N
Cartoonish	Idle	PIC	2.55 ± 1.21	108	2.36 ± 0.95	37	2.47 ± 1.19	33	2.83 ± 1.43	38
		PTE	2.85 ± 1.54		2.68 ± 1.23		3.01 ± 1.68		2.85 ± 1.53	
	Expressive	PIC	3.32 ± 1.35	106	3.17 ± 1.11	36	3.43 ± 1.42	33	3.35 ± 1.35	37
		PTE	3.15 ± 1.64		3.12 ± 1.67		3.03 ± 1.22		3.29 ± 1.76	
Realistic	Idle	PIC	5.77 ± 1.02	108	5.66 ± 0.98	35	5.73 ± 1.19	34	5.91 ± 1.28	39
		PTE	4.35 ± 1.58		4.36 ± 1.58		4.42 ± 1.54		4.27 ± 1.43	
	Expressive	PIC	5.98 ± 0.76	114	6.04 ± 0.79	38	5.88 ± 0.78	36	6.01 ± 0.76	40
		PTE	6.35 ± 0.42		6.36 ± 0.39		6.51 ± 0.30		6.19 ± 0.58	

Note: PIC = Perceived Instructor Credibility; PTE = Perceived Teaching Effectiveness; FEU-A = FEU Alabang; FEU-D = FEU Diliman; FEU-T = FEU Institute of Technology

Similarly, realistic avatars garnered more favorable ratings for perceived teaching effectiveness compared to cartoonish avatars. When examining the influence of behavior, it was observed that cartoonish avatars with expressive behaviors received notably higher ratings ($M = 3.15$, $SD = 1.64$) compared to their idle counterparts ($M = 2.85$, $SD = 1.54$). However, although this disparity was statistically significant for perceived instructor credibility, it did not hold significance for perceived teaching effectiveness ($U = 5065.000$; $p = .207$). This discrepancy brings to light an intriguing aspect of student perceptions: while expressive behaviors may enhance the perceived instructor credibility of cartoonish avatars, they may not have a similar impact on their perceived teaching effectiveness. For realistic avatars, idle avatars ($M = 4.35$, $SD = 1.58$) also received lower ratings than expressive avatars ($M = 6.35$, $SD = 0.42$). However, while this difference did not reach statistical significance for perceived instructor credibility, the behavior of avatars significantly affected perceived teaching effectiveness ($U = 2645.000$; $p < .001$). This additional discrepancy suggests that expressive behaviors may only augment the perceived teaching effectiveness of realistic avatars and not cartoonish avatars. These findings imply that the effectiveness of behavioral features may vary based on the realism of the avatar, particularly when perceived teaching effectiveness is considered. Overall, the results of this experiment underscore the importance of considering both avatar appearance and behavioral realism when designing avatars for educational contexts, as they may have differential impacts on student perceptions.

Interaction effects between avatar appearance and behavioral realism

Lastly, the interaction effects showed interesting patterns. The Friedman test revealed a significant interaction effect for perceived teaching effectiveness ($p < 0.001$), indicating that the influence of behavioral realism on teaching effectiveness depends on the level of avatar appearance. Specifically, realistic avatars with expressive behaviors were rated significantly higher than all other groups. This result underscores the powerful combination of a lifelike appearance and realistic behaviors, which seem to align well with user expectations for humanlike interactions in a virtual learning environment. On the other hand, cartoonish avatars, while benefiting modestly from expressive behaviors, did not achieve comparable levels of perceived teaching effectiveness. This result suggests that behavioral realism alone is not enough to bridge the gap created by their less realistic appearance. In contrast, the results showed no significant interaction effect for perceived instructor credibility ($p = 0.112$), indicating that avatar appearance and behavioral realism operate independently in shaping credibility perceptions. Realistic avatars consistently received high ratings for credibility, regardless of whether they displayed expressive or idle behaviors. This finding suggests that a lifelike appearance alone is sufficient to convey credibility. For cartoonish avatars, however, expressive behaviors played a more critical role. This avatar design significantly boosted their perceived credibility compared to idle behaviors. Interestingly, this improvement did not depend on the realism of the avatar's appearance, suggesting that when it comes to credibility, students rely more heavily on appearance realism as a baseline indicator.

Discussion

Teaching in the metaverse is an evolving frontier. Presently, virtual learning environments are already well-established for remote education. With immersiveness and interactivity being sought after in these environments, an educational metaverse offers promising opportunities to revolutionize traditional teaching methods and foster engaging learning experiences (Di Natale et al., 2024). In the metaverse, teachers are embodied by avatars that serve as their digital representations. Given the significant role teachers play in facilitating learning and building rapport with students, it is reasonable to assume that their digital image holds similar importance in the metaverse (Chua & Yu, 2023; Pradana & Elisa, 2023). Just as their appearance and demeanor are carefully considered in real-life interactions, the choice of avatar and its attributes can significantly influence student

perceptions and engagement in virtual environments. Specifically, the anthropomorphic features and social conformity of avatars can affect their perception of authenticity by other metaverse inhabitants (Kim et al., 2023). Unfortunately, there is a paucity of literature concerning the precise attributes of avatar realism that may affect teacher avatars. This study addressed this gap by examining the role of avatar appearance and behavioral realism using a true experimental research approach. Understanding the role of avatar-related characteristics is vital to metaverse adopters, developers, and educators, as it provides essential insights into how digital representations impact interactions and perceptions within the metaverse.

Role of anthropomorphism in avatar design

Like in other avatar-based immersive learning environments, it is evident that avatar anthropomorphism is a vital aspect of the metaverse. The consistent ratings obtained across various campuses suggest a universal appreciation for avatars with anthropomorphic features. This finding is unsurprising and resonates with similar observations made in other contexts. For instance, Arora et al. (2024) noted that robots with anthropomorphic characteristics can facilitate advanced forms of social interaction and collaboration with humans. They observed that anthropomorphic robots tend to elicit stronger human-robot interactions, which enables intentional social cues and fosters a deeper sense of connection. Just as in robotics, anthropomorphism plays a crucial role in shaping user interaction and engagement with intelligent agents. According to another experiment (Zhang & Patrick Rau, 2023), people tend to develop higher emotional attachments towards intelligent agents possessing anthropomorphic characteristics. Specifically, their analysis of interaction effects revealed that users hold distinct expectations from agents with varying levels of anthropomorphism. These studies and other similar works have elucidated their findings by referencing the CASA theory (Nass et al., 1994). This framework posits that users respond socially to inanimate objects unconsciously, considering them as actual people. By embodying anthropomorphic characteristics, non-human entities invoke social responses from people, which can lead to enhanced engagement and attachment. Thus, the incorporation of anthropomorphism in avatar design holds significant implications for user interaction and experience within virtual environments like the metaverse. Building upon this understanding, this study extends the existing literature by specifically focusing on teacher avatars and their perceived credibility and teaching effectiveness. By investigating how different levels of avatar anthropomorphism influence student perceptions of teachers, it contributes to a deeper understanding of the role of avatar design in educational contexts within the metaverse.

Across all experimental conditions, students consistently favored realistic avatars over cartoonish ones, irrespective of behavioral realism. This inclination suggests a robust perception among students that avatars resembling humans are inherently more credible and effective as teachers in the metaverse. The interaction results further highlight this trend, showing that realistic avatars with expressive behaviors were rated significantly higher for teaching effectiveness compared to other combinations of appearance and behavior. This finding suggests that the alignment between a realistic appearance and expressive behaviors reinforces the perception of teaching effectiveness. Nowak et al. (2015) explained that images perceived as more anthropomorphic tend to be judged as more attractive and credible due to their influence on the perceived social potential and credibility of the source and its associated message. From an educational standpoint, the preference for realistic avatars aligns with the need for effective communication and engagement between teachers and students in virtual learning environments. Realistic avatars that resemble human features may convey a sense of familiarity and trust that are essential for establishing a conducive learning environment (Myers & Martin, 2017). Consequently, a teacher avatar designed to be approachable, authoritative, and visually representative of the subject matter can enhance students' perceptions of credibility and relatability. The inclination towards realistic avatars also underscores the importance of visual fidelity in the metaverse, as also noted in virtual reality environments (e.g. Mathis et al., 2021). However, prior works have primarily focused on digital self-representations, using similar

concepts such as self-avatars (Ma & Pan, 2022), virtual twins (Salagean et al., 2023), or virtual doppel-gangers (Gorisse et al., 2019). This study fills this gap by demonstrating that users hold similar preferences when evaluating avatars representing others, such as teachers. It also highlights the generalizability of the preference for realistic avatars across various avatar types and underscores the importance of considering visual fidelity in avatar design across diverse virtual contexts.

In educational settings, where establishing trust and authority is paramount, the adoption of realistic avatars may indeed serve to enhance student engagement and learning outcomes. However, while the preference for realistic avatars is evident, it is essential to acknowledge the potential limitations associated with overly humanlike representations in the metaverse. The phenomenon known as the Uncanny Valley suggests that as humanoid entities become increasingly realistic, there is a point at which minor deviations from the human appearance or behavior can evoke feelings of eeriness or discomfort in observers (Mori et al., 2012). This uncanny sensation can undermine the intended rapport-building and trust-building efforts in educational interactions. Literature on this matter presents divergent perspectives. Kim et al. (2023) argued that excessive realism causes cognitive overload and reduces the sense of presence in the virtual environment, which can induce an Uncanny Valley effect and be detrimental to digital social presence. This heightened cognitive load can distract learners and diminish their focus on the educational content. In contrast, Salagean et al. (2023) argued that photorealistic avatars could potentially mitigate this effect, presenting them as less eerie and more appealing compared to less photorealistic counterparts. These insights suggest practical implications. Careful attention must be paid to the balance between avatar realism and user comfort. Developers should aim for avatars that are realistic enough to establish trust and authority without triggering discomfort from excessive realism or imperfections. For instance, subtle, expressive behaviors aligned with an avatar's appearance can mitigate potential discomfort while enhancing engagement. Meanwhile, educators can select or customize avatars that resonate with their teaching style. For example, a science teacher could use a realistic avatar with lab attire and precise gestures to convey expertise, while an arts instructor might opt for a more creative, semi-realistic avatar with fluid, expressive movements to foster a sense of approachability and creativity.

Impact of behavioral realism on perceptions

Behavioral realism is another crucial aspect in an avatar-mediated environment, and the present study unveils intriguing findings in this regard. Cartoonish avatars exhibiting behavioral realism enhance the perceived instructor credibility but not perceived teaching effectiveness. Conversely, realistic avatars doing the same gestures significantly improved their perceived teaching effectiveness but not the perceived instructor credibility. This crisscross pattern underscores the interplay between avatar appearance, behavioral realism, and their respective effects on the perceptions of instructor credibility and teaching effectiveness. The emergence of a crisscross pattern may be explained by considering the theory of cognitive dissonance (Festinger, 1957). This theory suggests that individuals experience psychological discomfort when they hold conflicting beliefs, attitudes, or behaviors. When faced with cognitive dissonance, individuals are motivated to reduce this discomfort by either changing their beliefs or behaviors to align with one another or by rationalizing the inconsistency. In the context of avatar-mediated environments, cognitive dissonance can arise when viewers encounter incongruities between the appearance and behavior of avatars. For example, when cartoonish avatars exhibit realistic behaviors, viewers may experience cognitive dissonance due to the conflicting information presented by the avatar's appearance and behavior. In an effort to reduce this discomfort, viewers may adjust their perceptions by attributing higher credibility to the avatar, as the realistic behaviors provide evidence of competence or expertise. For realistic avatars, the presence of realistic behaviors may not induce the same level of cognitive dissonance, as their appearance already aligns with the behaviors being exhibited. Therefore, viewers may

readily accept the behaviors as consistent with the avatar's appearance, resulting in enhanced perceptions of teaching effectiveness without a significant impact on perceived instructor credibility.

While behavioral realism has varying effects depending on the context and viewer perceptions, it is essential to recognize the overarching significance of employing behavioral realism in avatar design. Avatar expressiveness holds significance as it is believed that avatars with greater expressiveness contribute to a more immersive and dynamic social experience that closely resembles real-life social interactions (Fraser et al., 2022). Realistic behaviors also play a crucial role in enhancing interactions by promoting naturalistic communication and rapport-building between avatars (Chua & Yu, 2023; Zhang & Wu, 2024). Achieving this requires careful attention to detail in replicating human-like behaviors. The teacher avatars in our metaverse are designed to exhibit a range of realistic behaviors, including natural gestures, facial expressions, and body movements. These avatars are programmed to engage in behaviors that enhance their perceived authenticity and credibility, such as making eye contact, nodding in agreement, and using appropriate hand gestures during lectures or discussions. As noted by McDonnell (2012), the animation of virtual characters plays a pivotal role in shaping user perceptions and responses. It can also amplify the potential for acceptance or revulsion, depending on the coherence between appearance, animation, and behavior (Volante et al., 2016). Drawing from the Proteus Effect (Yee & Bailenson, 2007), these realistic behaviors are intentionally designed to leverage the psychological phenomenon where individuals tend to conform to the behaviors and traits associated with their digital representations. By embodying realistic behaviors, our teacher avatars aim to invoke positive behavioral changes and foster a deeper sense of engagement and immersion in the virtual learning environment. This attention to detail in replicating human-like behaviors contributes to the overall sense of realism and immersion in the virtual learning environment.

The findings on behavioral realism carry significant practical implications for educational institutions planning to use avatar-mediated learning environments. From a pedagogical standpoint, incorporating realistic behaviors into teacher avatars during lesson delivery can help bridge the gap between virtual and face-to-face teaching. For example, using avatars that make eye contact, nod in agreement, or utilize expressive hand gestures can create a more immersive and interactive classroom experience (Kasapakis et al., 2023). Such behaviors not only make virtual interactions more engaging but also foster a sense of connection between students and their virtual instructors. According to Vallis et al. (2024), students continue to value student – teacher relationships and personal communication, even in the presence of AI-generated avatars. The interaction between students and teacher avatars is perceived as a form of social communication, akin to parasocial relationships (Garcia & Yousef, 2022). By embodying expressive behaviors, avatars can simulate the nuances of real-world teacher-student interactions. This can be particularly important in creating a supportive learning environment, as students may feel more comfortable and engaged when they perceive their instructor as approachable and responsive. Realistic behaviors can also enhance students' motivation to participate and pay attention, as these behaviors mirror the social cues they typically rely on in traditional classroom settings. Therefore, focusing on behavioral realism not only enhances the functionality of avatars but also helps maintain the interpersonal dynamics that are central to effective teaching and learning.

Limitations and future research directions

This study is subject to several limitations that warrant consideration for future research. First, there is a noticeable gender disparity in the sample. While no gender-specific effects were explored, this imbalance may affect the generalizability of the findings to a more balanced population. Future research could examine potential gender-based differences to ensure broader applicability of the results. In terms of avatar designs, it primarily contrasts cartoonish and realistic avatars, overlooking other potential avatar types, such as photorealistic avatars. These avatars boast intricate textures, lifelike skin tones, and detailed facial expressions, often indistinguishable from reality. As proposed by Salagean et al. (2023), photorealistic avatars might offer a solution to mitigate the Uncanny Valley effect. Moreover, future studies could explore unconventional approaches by investigating non-human entities as

teachers, such as anthropomorphic animals, animated objects, or abstract representations. Krekhov et al. (2019) noted that non-human avatars offer unique opportunities to break away from traditional avatar stereotypes. Investigating avatar gender represents another crucial area for future research. In this study, gender was not systematically manipulated, which may have overlooked its impact on student perceptions and interactions. Avatar gender has been recognized as a significant element in avatar-mediated interactions (Lehdonvirta et al., 2011) and within virtual learning contexts (Chang et al., 2019). Meanwhile, while the study examines the impact of expressiveness and gestures on student perceptions, it may not capture the full range of behaviors exhibited by teachers in educational settings. Exploring a broader spectrum of behaviors, such as tone of voice, pacing, and interaction style, could provide a more comprehensive understanding of the role of behavioral realism in avatar-mediated teaching. Overall, addressing these limitations and expanding the scope of investigation into avatar design and behavior can enrich our understanding of the complex dynamics at play in avatar-mediated educational environments.

Conclusion

With the metaverse emerging as an educational platform, exploring it as a virtual learning environment has become imperative. This study provides insights into the role of avatar design and behavioral realism in avatar-mediated environments. Our findings indicate a clear preference for realistic avatars over cartoonish ones, with realistic avatars being perceived as more credible and effective by students. Moreover, the study highlights the importance of behavioral realism in enhancing the credibility of cartoonish avatars and the teaching effectiveness of realistic avatars, with the latter exhibiting natural gestures significantly outperforming their cartoonish counterparts in this aspect. From an educational standpoint, leveraging realistic avatars with authentic behaviors holds great promise for enhancing the effectiveness of virtual teaching and learning experiences. Metaverse adopters, including educational institutions and technology developers, can leverage these findings to inform their strategies for creating metaverse environments. For educators, these insights serve as a roadmap for effectively leveraging avatar-mediated environments in their teaching practices. Understanding the impact of avatar representations on student perceptions allows educators to tailor their virtual presence to better meet the needs and preferences of their students. Overall, this study contributes to the growing body of literature on educational metaverse and avatar-mediated teaching and learning by shedding light on the importance of avatar design and behavioral realism in shaping student perceptions and experiences.

Disclosure statement

Notes on contributor

Manuel B. Garcia is a professor of information technology and the founding director of the Educational Innovation and Technology Hub (EdITH) at FEU Institute of Technology, Manila, Philippines. He is a graduate of Doctor of Information Technology from the University of the East and is presently a student of Doctor of Philosophy in Education at the University of the Philippines. His interdisciplinary research interest includes topics that, individually or collectively, cover the disciplines of education and information technology. He is a licensed professional teacher and a proud member of the National Research Council of the Philippines – an attached agency to the country's Department of Science and Technology (DOST-NRCP). Dr. Garcia has been recognized as one of the World's Top 2% Scientists and ranked 24th out of 50 in the Philippines in the latest Elsevier and Scopus citation rankings for the year 2023.

ORCID

Manuel B. Garcia http://orcid.org/0000-0003-2615-422X

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