

HYPER-REALISTIC AVATARS IN EDUCATION: A SYSTEMATIC REVIEW FOR HYPER-REALISTIC AVATAR DESIGN IN EDUCATION

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Abstract

Instructor presence remains a widely researched topic in pedagogy, yet findings are mixed across studies that examine both human instructors and human-like virtual avatars. In videos featuring human instructors, several analyses report no reliable gains in learning and, in some cases, heightened cognitive load, although learner motivation tends to increase (Alemdag, 2022). By contrast, research on virtual instructors indicates modest benefits: across multimedia settings, pedagogical agents are associated with minor average improvements in learning (Castro-Alonso, 2021). In immersive virtual reality, human-like avatars have been shown to enhance retention, transfer, and social presence, with cognitive load largely unchanged (Zhang, 2025). Even within a single medium, however, effects can vary considerably. A key gap concerns the extent to which results generalize between studies of human instructor presence and studies of virtual avatars. As hyper-realistic avatar creation platforms become increasingly accessible, bridging this gap is essential to determine how insights from both literatures can inform the design of educational content. This study presents an umbrella synthesis of existing reviews spanning instructor types (human and virtual), delivery platforms (image, video, and virtual reality), stylistic features (talking head and full body), and instructional roles (instructional tutor, mentor, and demonstrator). It provides a comprehensive synthesis of the pedagogical and cognitive theories pertinent to evaluating instructor presence, together with a review of the evaluation methodologies employed in the literature. Practical recommendations are offered on when and how to include instructors across modalities for educators and instructional designers. Finally, the study identifies gaps in the evidence base to motivate future research in this field.

Keywords: *Educational avatars, pedagogical agents, generative artificial intelligence, educational videos, virtual reality.*

1. Introduction

Instructor presence, defined as the perceptible involvement of an instructor in a learning environment, is widely recognized as a key factor in effective education. Across disciplines, researchers have examined how an instructor's visible or perceptual presence influences student engagement and learning. In the context of online and blended education, this concept intersects with learning sciences, educational psychology, and instructional design through theories of social interaction and guidance in learning. It also extends into multimedia learning research on video-based instruction and into Human-Computer Interaction (HCI) in education where virtual tutors and avatars are designed to emulate human teaching behaviors. The interdisciplinary nature of instructor presence is evident: it encompasses both the teaching role (structuring content and providing feedback) and the social role (connecting with learners). Understanding how to optimize instructor presence is thus a concern for those designing e-learning experiences, studying cognitive and motivational processes, and developing emerging AI-driven educational agents.

This paper aims to address the following research questions through an umbrella synthesis of systematic literature surveys in human and virtual instructor research:

- 1) Which pedagogical and psychological theories are used to assess the effectiveness of human and virtual instructors in the literature?
- 2) Which methodologies and evaluation frameworks are used to assess the effectiveness of human and virtual instructors in the literature?
- 3) What recommendations can be synthesised for instructional designers using hyper-realistic avatars as instructors?

The paper is organised as follows; Section 2 provides background information about human and virtual instructor research, and the new gap created by hyper-realistic avatar platforms; Section 3 outlines the umbrella synthesis methodology used in this study; Section 4 discusses the shortlisted reviews and their coverage of the area, while Section 5 synthesises the findings into recommendations and Section 6 offers some concluding remarks and future directions.

2. Background

2.1. Human instructor presence in multimedia learning

One thread of research has focused on human instructors in video and online course contexts. A debate has emerged on whether showing the instructor's face or image in instructional videos improves learning outcomes or merely adds extraneous information. Empirical findings in the past decade have been mixed and sometimes contradictory (Alemdag, 2022; Polat, 2023). On one hand, some studies report that learning from videos with a visible instructor is more effective or engaging than from videos with voiceover alone. For example, certain experiments found higher student performance and satisfaction when the instructor appeared on-screen, suggesting that gestures, eye contact, and other social cues can foster engagement. On the other hand, other studies have found little to no learning benefit, or even noted that an on-screen teacher might distract learners from the content (Polat, 2023). This heterogeneity in results has prompted meta-analytic investigations to identify general trends. Recent evidence indicates that instructor presence yields nuanced effects: including a lecturer's image in videos produces small but significant gains in factual retention of material, yet does not reliably improve deeper transfer learning. Notably, however, having the instructor visible tends to enhance learners' subjective experience - increasing their reported social presence, interest, and motivation (Beege et al., 2023). Intriguingly, this social benefit may even extend to cognitive processing: contrary to what a strict cognitive load perspective might predict, seeing the instructor can reduce students' perceived extraneous cognitive load in some cases (Beege et al., 2023). In other words, an on-screen instructor might make students feel more guided and at ease, offsetting potential visual processing costs. These findings illustrate that human instructor presence can have positive affective and cognitive effects, but its impact on measurable learning performance remains context-dependent.

2.2. Virtual instructors and digital pedagogical agents

Parallel to the work on human instructors in videos, an extensive body of research in educational technology and HCI has explored virtual instructors - including animated pedagogical agents on computer screens and avatars in virtual or augmented reality. These digital "instructors" serve a similar purpose of providing guidance and social interaction cues in the absence of a live teacher. Like their human counterparts, virtual agents have yielded heterogeneous findings in the literature. Many studies (across domains like educational psychology and AI in Education) have shown that pedagogical agents can enhance learners' motivation, engagement, and even academic performance by leveraging the so-called "persona effect" - the idea that students respond socially to on-screen characters (Li et al., 2025). For instance, an agent that gestures and converses in a friendly manner may increase learners' interest and effort. Other researchers have raised concerns that adding a talking avatar or cartoon tutor might impose extra cognitive processing demands. According to some cognitive load theorists, a graphical agent could act as a distractor, forcing learners to split attention between the agent and the instructional content, thereby increasing mental load or creating interference (Li et al., 2025). Indeed, the empirical results on this issue have been far from uniform. A recent meta-analysis (Li et al., 2025) synthesized a decade of studies and identified three divergent positions: some experiments find that pedagogical agents reduce students' cognitive load (by focusing attention or providing support), others find that agents increase cognitive load (by introducing extraneous visual information), and many find no significant difference at all. Similarly, while some implementations of virtual tutors lead to better learning outcomes or stronger feelings of social presence, other implementations show negligible effects. In sum, the pedagogical impact of virtual instructor agents appears highly contingent on design features and context. This inconsistency mirrors the conflicting findings with human instructors in videos, suggesting a need for a broader synthesis to understand under what conditions an instructor's presence - whether human or virtual - truly benefits learning.

2.3. Hyper-Realistic avatars and need for a cross-medium review

Historically, research on traditional online video instruction and research on virtual/AI instructors have often progressed in separate silos. Reviews note that pedagogical agent studies rarely extended into fully immersive VR until recently, meaning insights from one medium have not readily translated to the other. With the rapid convergence of these domains (e.g., instructors on camera, animated tutors on desktops, and VR avatars coexisting in today's educational landscape), it is crucial to integrate lessons

learned across modalities. The present umbrella review is motivated by this gap. By comparing human instructors and virtual agents/avatars side by side, we seek to reconcile the conflicting findings regarding learning outcomes, cognitive load, motivation, and social presence across the two strands of research.

3. Methodology

We conducted an umbrella review (an overview of reviews), following PRISMA (Page et al., 2021) search practices. Searches were run in ERIC, SCOPUS, and IEEE Xplore to identify systematic reviews and meta-analyses on instructor presence in learning contexts. The search terms were filtered to systematic reviews that investigated the use of human or virtual instructors in any medium, specifically in an educational context. Only articles published in English between 2022 and 2025 were included to narrow the scope to reviews from the period when hyper-realistic avatar creation platforms became more accessible, while recognising that the reviews may also include source studies published before this time frame.

Titles/abstracts and full texts were screened against predefined criteria. Of 53 search results, 20 reviews passed the initial title/abstract screening, and 8 passed the full-text screening for inclusion in this synthesis. Data were extracted at the review level using a structured form aligned to the paper's organizing framework: instructor type (human vs virtual), platform (image, video, VR), stylistic features (talking head vs full body), as reported in Section 4.

4. Results

Eight systematic reviews were synthesised for this study, shown in Table 1. They included a mix of human and virtual instructor studies across different forms of media, including video, VR, multimedia and blended learning settings. Only studies investigating instructional (educational) settings were considered.

Table 1. Selected reviews for synthesis.

Author	Instructor	Medium	Style
Beege et al., 2023	Human	Video	Talking head / Torso
Polat, 2023	Human	Video	Talking head / Torso
Stap et al., 2024	Human	Blended Learning	Not specified/controlled
T. Liu, 2025	Virtual	Multimedia	Animated/Embodied characters
Wang et al., 2023	Virtual	Multimedia	Talking head / Torso
Zhang & Pan, 2025	Virtual	VR	Animated/Embodied characters
Q. Zhang & Yu, 2023	Human	Video	Talking head / Torso
Zhu et al., 2024	Human	Video	Talking head / Torso

5. Discussion

5.1. Pedagogical theory considerations

Cognitive Load Theory (CLT) is often employed as one of the main critical frameworks in instructor presence research (Beege et al., 2023; Stap et al., 2024; Q. Zhang & Yu, 2023), establishing a baseline that instructor presence might impose extraneous load, but the consensus is that affective elements can mitigate this. The Cognitive-Affective Theory of Learning with Media (CATLM) posits that social cues from instructors can increase emotional engagement, reducing cognitive load and increasing motivation (Beege et al., 2023; Polat, 2023; Wang et al., 2023; Zhu et al., 2024). Similarly, Social Agency Theory (SAT) is frequently invoked (Beege et al., 2023; T. Liu, 2025; Wang et al., 2023) to suggest that human-like cues (gaze, gestures, etc.) foster a sense of partnership, activating social schemas that boost retention and transfer.

Virtual instructor research often draws on Embodiment Theory and Situated Learning Theory (SLT) (T. Liu, 2025; Wang et al., 2023; Y. Zhang & Pan, 2025), emphasising immersive VR interactions that simulate real-world contexts to promote deeper engagement and enhance knowledge retention.

5.2. Methodological considerations

Measurements of motivation, affect, and learner satisfaction repeatedly show up in the literature, mostly as self-report surveys, and are often where instructor presence shows clearer benefits, especially for affective instructors (Beege et al., 2023; Polat, 2023; Zhu et al., 2024). Similarly, cognitive load is also measured using subjective ratings. Beege et al. and Zhu et al. also include studies incorporating (visual) attention measurement mechanisms, such as those which compare dwell time on the instructor vs. the relevant visual material, often finding that attention can be increased overall by adding instructors, but not necessarily to the learning material. Studies measuring learning outcomes usually tracked retention and learning transfer.

5.3. Guidelines for Instructional Designers

Designers should navigate the conflict between social presence and cognitive load. While Stap et al. argue for maximizing social presence to foster interaction, Beege et al. (2023) argue that high social presence (via video) can be extraneous. The compromise appears to be instructional relevance: high-fidelity/high-presence avatars should be used for motivation, feedback, and social bonding, but potentially removed or minimized during deep cognitive processing tasks.

When using hyper-realistic avatar platforms in educational settings, preference should be made for systems which allow the learning designer to specify expressive emotions (leaning towards positivity in most cases), and use gestures and gaze based on the context to direct learner attention. If hyper-realistic avatars are used merely as "talking heads" without meaningful interaction, they may suffer the same distractive effect as that observed in some human videos - increasing extraneous cognitive load without aiding comprehension. Conversely, if these avatars can perfectly mimic the "positive instructor" behaviors identified by Zhu et al. - such as natural smiling and enthusiastic tone - they could theoretically replicate the emotional contagion effects previously exclusive to human actors.

Bearing in mind the sometimes conflicting reports in the literature, testing in small groups is important as results may not generalize across ages, educational levels and subjects being taught. When feasible, experiments should measure learning outcomes (including retention and transfer), attention (if eye-tracking software or a similar method is available), and self-reported motivation, satisfaction, and cognitive load.

6. Conclusion

This work covered the intersection of human and virtual instructor research, laying out the pedagogical theories and methodologies to be taken into consideration when designing learning experiences with human and/or human-like instructors. It sets the stage for future research incorporating hyper-realistic avatars into educational settings, which promises the social benefits of having human instructors while being programmatically controllable. This enables the scaling of educational content creation beyond what is imaginable at the moment. This paper aims to inspire future work in educational avatars that not only push the boundaries of realism, but also consider the importance of other controllable characteristics such as gestures, facial expressions, avatar appearance and tone of voice, while taking into account the ethical considerations of hyper-realistic human cloning, such as consent and misrepresentation of real humans.

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