Nonverbal Communication: The Impact on Emotion Design of Pedagogical Agents and Learning Outcomes

Cassandra E. Buffington-Bates
Department of Learning Technologies
University of North Texas, United States
Cassandrabuffington-bates@my.unt.edu

Abstract: This literature review examines the role of nonverbal communication in enhancing pedagogical agents' effectiveness in educational settings. As technology becomes more integrated into learning environments, virtual agents, embodied, human-like characters, use nonverbal cues to foster emotional engagement and learning. By examining facial expressions, gestures, and appearance, this study explores their impact on students' motivation, emotional involvement, and learning outcomes. Grounded in cognitive load theory, persuasive technology, and socio-agency theories, the study provides a theoretical foundation for understanding how nonverbal cues promote cognitive and affective learning. It addresses three key questions: how do nonverbal cues impact learner engagement, which behaviors are most effective for pedagogical agents, and how emotional design shape educational outcomes.

Keywords: Nonverbal Communication, Pedagogical Agents, Emotional Design, Learning Outcomes, Cognitive Load, Motivation, Engagement

Introduction

Nonverbal communication involves behaviors and contextual factors that convey messages without words (Matsumoto et al., 2012). These behaviors can include facial expressions, gestures, posture, eye contact, and contextual factors such as physical environment, personal space, and time (Hall et al., 2019). Teachers use nonverbal cues in educational settings to gauge student understanding and adjust their teaching strategies accordingly (Miller, 1988). Effective pedagogical agents use nonverbal communication to enhance emotional engagement and improve learning outcomes (Guo & Guh, 2015). They are designed to simulate human interaction through appearance, emotional cues, body movements, and verbal communication. Pedagogical agents provide personalized support in online learning, using nonverbal cues to increase student enjoyment and motivation (Wang et al., 2023). Emotional design, which uses design elements to evoke positive emotions, can further enhance engagement and motivation (Plass et al., 2014). By incorporating nonverbal cues and emotional design, pedagogical agents can create a more engaging and effective learning experience for students.

The review explores how nonverbal communication by pedagogical agents can enhance emotional design and improve learning outcomes. It identifies effective strategies and best practices for designing emotionally intelligent educational technologies. The review is guided by several theories: Persuasive technology theory (Fogg, 2002), socio-agency theory, emotional response theory, cognitive load theory (Paas et al., 2010), Piaget's theory of cognitive development, and Vygotsky's sociocultural theory of cognitive development. These theories provide a framework for understanding the role of nonverbal cues in promoting cognitive and affective outcomes. They help explain how nonverbal communication and emotional design can influence learning, motivation, and engagement. By examining these theories, researchers can gain insights into how to design more effective pedagogical agents.

Literature Review

Research shows that the effectiveness of pedagogical agents' facial expressions varies with instructional type (Baylor & Kim, 2015). For example, facial expressions may be more effective for attitudinal content than for procedural tasks. Social cues must be carefully designed to avoid adverse reactions (Fogg, 2002). For instance, overly enthusiastic expressions may lead to negative emotions and unrealistic expectations. Virtual agents mimic human nonverbal behaviors to illustrate ideas, show responsiveness, and convey emotions (Wang & Ruiz, 2021). This can include gestures, body movements, and eye contact. Emotional response theory explains that instructors'

enthusiastic verbal and nonverbal cues significantly impact learners' emotional states (Liew et al., 2017). Therefore, it is essential to find a balance in the level of enthusiasm to avoid overwhelming learners.

Most research focuses on pedagogical agent design rather than usage conditions. Animated and static agents showed no significant difference in retention, but affected transfer performance and engagement. Feedback mode and whether explanations were spoken or printed also influenced learning outcomes (Heidig & Clarebout, 2010). Nonverbal behaviors, particularly facial expressions, are universally understood and helpful in assessing emotional states in professional settings (Matsumoto et al., 2012). Positive nonverbal cues and enthusiastic expressions by pedagogical agents enhance learning outcomes by improving retention without increasing cognitive load (Beege & Schneider, 2023). This suggests that nonverbal communication can be a valuable tool for enhancing learning.

Pedagogical agents can take on roles as Experts, Motivators, or Mentors, each with distinct communication styles (Kim & Baylor, 2015). Experts use formal speech and authoritative gestures, Motivators use enthusiastic speech and emotional expressions, and Mentors blend friendly, informative, and motivating communication. The potential of these agents to enhance learning outcomes and motivation is highlighted by research that emphasizes a shift from intelligent guidance to providing social and emotional support for learners. This suggests that pedagogical agents can be more effective when they focus on building relationships with learners.

Nonverbal communication in pedagogical agents can distract or overwhelm learners, requiring a careful balance to enhance learning (Guo & Goh, 2015). Creating effective agents involves challenges such as promoting learning without disrupting problem-solving, ensuring realistic behaviors support educational tasks, and maintaining perceived authenticity despite automation (Lester & Stone, 1997). Motivational agents boost self-efficacy but may not meet learning goals, whereas expertise-focused agents improve outcomes and credibility. Mentor agents most effectively enhance self-efficacy and engagement (Kim & Baylor, 2015). This highlights the importance of carefully designing pedagogical agents to meet the specific needs of learners.

Discussion

Instructional designers should align pedagogical agents' nonverbal communication with learning outcomes, often needing a single animation for effectiveness. People expect human-like robots to follow human norms and perform better than machine-like robots (Złotowski et al., 2015). Animated agents offer customizable nonverbal behaviors, enhancing instruction quality (Baylor & Kim, 2009). Future research should explore the impact of nonverbal behaviors on human-agent interactions, as cues like eye, face, hand, and body movements enhance social presence and message delivery effectiveness (Fogg, 2002). Additionally, research is needed to understand how emotional design affects learning and creates positive emotions in learners, considering factors like gender, culture, and prior material knowledge. Future research should examine the influence of other design elements, such as sound, on emotions and learning outcomes (Macken et al., 1999). In nonverbal communication, emotion design in pedagogical agents can change cognitive activities like causal reasoning, deliberation, goal appraisal, and planning (D'Mello & Graesser, 2012). Nonverbal communication mixed with emotional design is a powerful medium for education technology. By carefully considering these factors, instructional designers can create more effective pedagogical agents.

Using pedagogical agents for emotional design affects how learners perceive the emotional elements of a lesson. These agents are not programmed to perceive cognitive elements, indicating that learners are more conscious of their emotions than their thought processes. Future research should explore differences in learners' understanding of their emotions versus their thinking during online learning. This could involve examining how learners' emotional states influence their cognitive processing and learning outcomes. By understanding these differences, researchers can develop more effective strategies for designing pedagogical agents.

Conclusion

Nonverbal communication is a critical factor in the effectiveness of pedagogical agents, influencing emotional design and learning outcomes. While current research supports the role of facial expressions, gestures, and social cues in enhancing engagement, gaps remain in understanding their long-term educational impact (Beege & Schneider, 2023). Studies largely focus on short-term cognitive benefits, with less attention to deep learning, knowledge transfer, and emotional variability (Kim & Baylor, 2015). A key limitation in current research is the underrepresentation of diverse learner-agent interactions.

Addressing this gap requires more inclusive agent designs that account for cultural, gender, and individual differences (Cheng et al., 2020). Additionally, most research emphasizes the benefits of positive emotions without fully exploring how negative emotions shape learning experiences. Future studies should incorporate biometric

measures and real-world testing to provide more comprehensive insights (D'Mello & Graesser, 2012). The growing sophistication of pedagogical agents presents opportunities to refine their design through adaptive nonverbal communication, real-time emotional responses, and personalized learning strategies. By addressing these gaps, future research can enhance the effectiveness of pedagogical agents, ensuring they serve as meaningful, interactive learning companions in digital education environments (Fogg, 2002).

Implications

The findings from this literature review have several implications for instructional design, technology integration, and future research:

- **Designing for Diversity:** Pedagogical agents should reflect a wider range of cultural, gender, and individual differences to create more inclusive learning experiences. This could involve incorporating diverse facial features, body types, and cultural backgrounds. Future research should explore how diverse agent characteristics influence student engagement and comprehension (Kim & Baylor, 2015).
- **Longitudinal Studies and Real-World Effectiveness:** More longitudinal studies are needed to determine the long-term impact of pedagogical agents on knowledge retention, motivation, and critical thinking skills. Research should move beyond controlled lab studies to assess real-world applicability in varied learning environments (Stark et al., 2018; Beege & Schneider, 2023). This could involve studying how pedagogical agents are used in online courses or other educational settings over an extended period.
- **Balancing Nonverbal Cues:** While nonverbal communication enhances engagement, excessive gestures or emotional cues may distract learners. Future design frameworks should integrate adaptive, context-aware pedagogical agents that can adjust their expressiveness based on learner needs (Fogg, 2002). This could involve developing algorithms that can detect when learners are becoming overwhelmed and adjust the agent's behavior accordingly.
- **Exploring Emotional Variability:** Most research focuses on the positive emotional impact of pedagogical agents. More work is needed to examine how negative emotions—such as frustration or disappointment—affect learning experiences and whether pedagogical agents can mitigate these effects through adaptive emotional responses (D'Mello & Graesser, 2012). This could involve studying how learners respond to pedagogical agents that express negative emotions or how agents can be designed to help learners manage their negative emotions.

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