



Human beings of all ages are deeply social creatures, and it is no surprise that creators of instructional content have begun to explore ways that we might leverage this characteristic to improve learning outcomes. A growing body of research considers this possibility by evaluating the effectiveness of on-screen pedagogical agents (or avatars) in digital learning contexts. Driving this new wave of research is the following question: if the presence of other people (a teacher, peers, collaborators) is advantageous for learners, might a similar boost occur when a character is incorporated into on-screen content in a meaningful manner?

Which agent attributes matter most for optimizing learning outcomes?

Education researchers have experimented with pedagogical agents that serve as a guide, coach, expert, a peer or learning companion, virtual teammate, and, in some cases, a combination of these roles. Furthermore, they have explored a range of avatar attributes, including gender, ethnicity, age, likeability, formality, politeness, responsiveness, and visual appeal, among others (Meij et al., 2015). The manner in which the agent interacts with the learner varies: in some cases, the agent provides enthusiastic comments intended to keep the learner motivated and interested, while in other cases, the agent actively instructs or guides the learner, providing content-related feedback.

Across a number of studies conducted with various age groups, subject areas, and instructional tasks, researchers have generally found that pedagogical agents are most effective when they:

- Actively signal the learner's attention to relevant information through commentary, gestures, facial expressions, or other methods (e.g., Clark & Choi, 2005; Johnson & Lester, 2016; see also Schroeder, Adesope, & Gilbert, 2013).
- Behave in a genuinely social and interactive manner (Kim & Baylor, 2016; Schroeder & Gotch, 2015; Veletsianos, 2007).
- Have some level of perceived expertise or knowledge (Kim & Baylor, 2016), though numerous studies demonstrate that both peer-like and expert-like agents can be effective.

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Muldner, 2011). Given the tightly coupled relationships between motivation, self-efficacy, self-stereotyping, effort, and learning outcomes, it is likely that many of the affective benefits provided by pedagogical agents might be deeply interrelated with the cognitive benefits seen in many cases [i.e., improved retention, transfer, generalization, and explanation of concepts].

While early experimentation with avatars (Lester et al., 1997; Moreno, Mayer, Spires, & Lester, 2001) aimed at making the learning experience more enjoyable and effectively satisfying in its own right, a more complex—and even more pedagogically promising—picture is taking shape. Several researchers have noted that the presence of a pedagogical agent may support learning outcomes by decreasing anxiety and also helping to orient the learner's attention to key elements and concepts embedded in the instructional content (Johnson & Lester, 2016; Meij et al., 2015; Wang et al., 2008). The emerging explanation is a sort of dual effect: agents can improve learning both by directly supporting cognitive processing and by creating a more positive, satisfying learning environment (Cook et al., 2016).

Are agents more effective in certain subject areas than others?

An unexpected finding that has recently surfaced through meta-analysis [i.e., when researchers examine many studies together and look for patterns] is that the benefit of pedagogical agents appears to be somewhat greater for STEM instructional contexts than humanities subjects (Schroeder et al., 2013). The reason is unclear. It may mask a slightly different fact: pedagogical agents' ability to signal information may be most critical and impactful when learning abstract content or processes, which arguably occur more frequently in STEM contexts [or, at least, in those used in most of the experiments in this domain]. Researchers have also posited that if learners carry the perception that STEM content is more challenging than content within the humanities, then the boosted engagement effect of the agent may help them persist and work harder, thus leading to better learning outcomes (Baylor, 2011).

It is also important to note that STEM contexts have been more frequently studied in pedagogical agent research thus far, and as this field of research continues to expand, future studies may provide further support to the effectiveness of agents in contexts within the humanities or in certain subsets of humanities learning tasks.

Concluding Remarks

Interestingly, as research has unfolded the past two decades, there has been a debate about the perplexing “mixed bag” of results across experiments using widely varying avatars and tasks. From the perspective of improving instructional materials, however, it is worth noting that this mixed bag is a reassuring one. While there have been a few studies that found no benefit when an agent was included, no studies reporting have found that including an agent was detrimental to learning outcomes (e.g., Heidig & Clarebout, 2011; Schroeder & Adesope, 2014). Refining our understanding of precisely which avatar design attributes, student characteristics, and learning environments enable success will help guide future efforts.



A recent meta-analysis found that the benefit conferred by pedagogical agents is even stronger

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