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Understanding the Effects of LLM-Generated Conversation Initiations with Learners in Popular Science Video-Based Learning

Jingchao Fang, University of Chicago, jcfang@uchicago.edu
Qingxiaoyang Zhu, University of California, Davis, qinzhu@ucdavis.edu
Hao-Chuan Wang, University of California, Davis, hciwang@ucdavis.edu

Abstract: Recent breakthroughs in large language models (LLMs) make it possible to create learning companion agents that boost the interactivity in video-based learning. This study focuses on learning companion agents' role as *conversation initiators*. How do different styles of agents' conversation initiation influence learners' learning experiences? We conducted a controlled experiment (N=65) using a technology probe that sends varying types of conversation initiation messages to learners. We reveal how the *personas* and *message styles* of learning companion agents shape learners' experiences.

Introduction and background

Adopting conversational agents as learning companions has attracted increasing attention because of their potential to enhance the interactivity in online learning (Heffernan et al., 2002; Winkler et al., 2020; Heller & Procter, 2007). An important yet underexplored function that a learning companion agent can serve is to *proactively prompt interactions* rather than wait to be called upon (Park & Kulkarni, 2023; Kim et al., 2006). This study investigates how different ways an agent initiates conversations can affect learners' experiences during popular science video-watching as a form of informal learning (Xia et al., 2022). We focus on two key factors that shape a learning companion agent's initiation message: the *persona* of the agent (teacher or peer), and the *message type* (question or statement). These factors play essential roles in conversations in education: learners' awareness of whom they are interacting with (most often teacher/expert or peer learner/non-expert) largely shapes their interaction modes (Verba & Winnykamen, 1992); acquisition and presentation of information often involve asking questions or making statements (Tullis & Goldstone, 2020). We seek to answer two research questions: *RQ1.* How can a conversational agent that periodically sends learning prompts as conversation initiations to learners affect video-based learning experiences? *RQ2.* How does a conversational agent's messaging style (the persona and the message type) affect video-based learners' experiences?

Method

The IRB-approved study was rolled out in two rounds. The overall study procedures were the same—each adult participant recruited from Prolific (n.d.) read the consent form and study instruction, completed one learning session (using EduPrompt, a technology probe implemented for the study), and answered a post-study questionnaire. The study took about 35 minutes. We selected two 10-minute popular science videos as learning materials (Appendix A); both target a general audience and require no prior knowledge to understand.

Round 1 was a 2×2 between-subjects study investigating the effects of two independent variables: persona and message type. Regarding persona, the learning companion agent (named Alex) roleplays either *a teacher* or *a peer*. Regarding message type, the agent's conversation initiations are either all *questions* or all *statements* (Appendix B). We randomly assigned 43 recruited participants to one of four study conditions, resulting in a relatively balanced distribution across condition groups. To encourage active learning, the conventional approach adopted by major platforms (e.g., Coursera, n.d.; edX, n.d.) is to embed quiz questions in videos. How do *framing questions as conversation initiations* from a learning companion agent differ from *presenting them as quizzes*? In Round 2, we recruited 22 participants who used EduPrompt to watch a video with quiz questions without a companion agent, providing a baseline representing the most common mode of question delivery in online education. In both rounds, after the learning session, participants evaluated their emotional and cognitive engagement, self-efficacy of learning, distraction, and cognitive load. We measured these constructs using 7-point Likert scale items adapted from Burch et al. (2015), Pintrich (1991), and Hart and Staveland (1988). In Round 1, participants also evaluated their perceived rapport with the agent via 7-point Likert-scale items adapted from Zhang et al. (2011) and the agent's anthropomorphism, intelligence, and likeability via 5-point Likert-scale items adapted from Wang et al. (2021), and elaborated on their perceptions in open-ended responses.

We developed EduPrompt, a web application, to manipulate participants' study conditions. In Round 1, EduPrompt features one of the two popular science videos (randomly chosen) and a chat room with a learning companion agent, Alex. Alex's message style (i.e., persona and message type) aligns with the study condition to

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which the participant is assigned. When a participant finishes watching a video chapter, Alex initiates a conversation by sending a message pre-generated by LLM (GPT-3.5) using a system prompt template (Appendix C). If the participant responds, Alex replies with a uniform message ("Great, let's move on. Please continue to watch the video"). We intentionally disabled back-and-forth conversations to focus on conversation initiations, as multi-turn chats would introduce confounding variables. In Round 2, EduPrompt features a video without the chat room or the agent, but with a pop-up quiz question that appears at the center of the video frame at the end of each video chapter. EduPrompt logs participants' behavioral data (e.g., timestamps, chat history).

Analysis and result

We conducted a two-way ANOVA to compare the effects caused by the learning companion agent's (Alex's) different personas and message types when initiating conversations (Round 1 data). Participants perceived a significantly stronger rapport with the agent when it roleplayed a peer to initiate conversations (F [1, 39] = 5.04, $p < .05$; agent as a teacher: $M = 3.7$, $SD = 1.78$; agent as a peer: $M = 4.9$, $SD = 1.59$). Participants also reported the agent to have a higher level of anthropomorphism when it simulates a peer instead of a teacher (F [1, 39] = 6.36, $p < .05$; agent as a teacher: $M = 2.44$, $SD = 1.13$; agent as a peer: $M = 3.43$, $SD = 1.34$). The agent was perceived as more intelligent when it roleplayed a peer, with borderline significance observed (F [1, 39] = 3.92, $p = .05$; agent as a teacher: $M = 3.60$, $SD = 1.00$; agent as a peer: $M = 4.20$, $SD = 0.92$). The persona has no main effect on participants' self-rated emotional and cognitive engagement, self-efficacy, distraction, cognitive load, and the agent's likeability (all $p > .05$). Participants' responses to conversation initiations suggest that message type may affect their reactions. Participants who received questions replied with significantly longer messages than those who received statements (in number of words: F [1, 39] = 9.30, $p < .01$; when messages are questions: $M = 29.17$, $SD = 21.97$; when messages are statements: $M = 12.80$, $SD = 9.94$).

We compared self-reported measures from Round 1 participants who received questions from Alex (either as a teacher or a peer) with those from Round 2 participants who received quiz questions. Participants who received questions as in-video quizzes reported significantly higher cognitive load than those who received questions as conversation initiations (F [1, 42] = 5.09, $p < .05$; questions as initiation messages: $M = 2.79$, $SD = 1.12$; questions as quizzes: $M = 3.67$, $SD = 1.45$). While participants' question response rates did not differ, those who answered quiz questions self-rated significantly higher frequency of engagement than those who replied to message (F [1, 42] = 4.17, $p < .05$; questions as initiation messages: $M = 5.0$, $SD = 1.8$; questions as quizzes: $M = 6.0$, $SD = 1.25$), which aligns with the observed difference in cognitive load. ANOVA showed no differences in participants' emotional or cognitive engagement, or in their perceived helpfulness of EduPrompt (all $p > .05$).

Thematic analysis of Round 1 participants' open-ended responses revealed that most participants perceived proactive conversation initiations as beneficial to their learning experiences. Participants mentioned that the learning companion agent helped them to stay focused on the video and recognize the important information, triggered in-depth thinking and reflection, improved learning retention, and made their learning experiences more interactive and fun. While participants watched only one short video in our study, many felt the benefits of enhanced interactivity would be more apparent in longer learning sessions. However, several participants were concerned that the agent's frequent interruptions may cause distraction.

Discussion and conclusion

Learning companion agents that proactively send conversation initiation messages could enrich video-based learning experiences (*RQ1*). Agents interrupt learners' mindless video-watching and encourage learners to deeply engage through reflective thinking, making learning experiences livelier without adding excessive cognitive demands (compared to in-video quiz questions). It implies that learning with companion agents may be pedagogically beneficial according to the *ICAP framework* (Chi & Wylie, 2014), which indicates that active, constructive, and interactive learning may lead to deeper understanding and better knowledge retention than passive learning. An agent's persona and message type can significantly impact learners' learning experiences (*RQ2*). When an agent roleplays a peer instead of a teacher, learners perceive higher levels of anthropomorphism, intelligence, and rapport, highly desired characteristics in human-agent interaction (Wang et al., 2021). Learners wrote longer messages in response to questions than statements; they described these messages as useful materials for future use. We suggest that designers of learning companion agents adjust the agent's message type based on learners' expected outcomes or goals for interaction. For example, if learners are expected to construct comprehensive and reflective notes, an agent that asks questions could better help learners to achieve this goal.

Endnotes

(1) Appendices can be accessed at https://osf.io/v8m4d/overview?view_only=0f8fbc55ea4443d68ccf674e7ca5e101.

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