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Perceived credibility of an AI instructor in online education: The role of social presence and voice features☆

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ABSTRACT

Technological advancements have made AI instructors, or more broadly machine teachers, a lived reality. However, limited information is available about how students will perceive an AI instructor that provides educational content. Thus, the present study examines the effects of an AI instructor's voice and expertise on the perceived credibility of an AI instructor through an online experiment with a 2 (voice: machinelike vs. humanlike) x 2 (expertise: novice vs. expert) between-subjects design. Findings indicate that students perceive greater credibility of an AI instructor with a humanlike voice than those with a machinelike voice. The study also finds that social presence mediates the relationship between the voice of an AI instructor and the perceived credibility of the AI instructor. Finally, the perceived credibility of an AI instructor positively influences students' intentions to enroll in future AI instructor-based online courses. These findings highlight the importance of developing AI instructors that are perceived as credible.

1. Introduction

The use of artificial intelligence (AI) in education has seen an increase in recent years. According to a Global Market Insights report, the AI in education market was only valued at roughly $400 million in 2017, but it is expected to grow to more than six billion dollars by 2024 (Bhutani & Wadhwani, 2018). Though it is a relatively new concept to education, AI is already prevalent in many learning contexts.

Currently, AI exists largely as online tools or applications that are developed to evaluate students' performance and provide feedback (Marr, 2018), such as Carniege Learning's MathiaU program. However, the possibilities for AI in education exist beyond simple online applications. In fact, one university in the U.S. already introduced an AI-powered virtual teaching assistant named Jill Watson in a college course (Georgia Institute of Technology, 2017). A recent systematic review also emphasizes the great potential of AI in the future of higher education (Zawacki-Richter, Marín, Bond, & Gouverneur, 2019), including the use of AI for tutoring students and teaching content.

As the adoption of AI in education increases, the role of human instructors may be slightly reimaged to allow AI instructors to participate in online education. To clarify, given that communication is a scripted endeavor (Kellerman, 1992), human instructors can focus on creating learning materials (e.g., content) while allowing AI instructors to assist in delivering lecture content. The adoption of AI instructors in this way would potentially create an effective learning environment, where human and AI instructors can collaborate in an efficient manner. Although the idea of AI instructors is in its infancy, there exists promising ways in which AI can promote educational experiences as an instructor that are likely to be widespread in the near future. In this regard, there is a need to understand how to create effective AI instructors that can be well-received and understood by students.

Credibility is one of the most crucial characteristics that instructors should establish to be perceived as effective instructors (Myers & Martin, 2018). An instructor's credibility is the extent to which students perceive information communicated by that instructor as reliable (Teven & Katt, 2016). Establishing credibility would be more critical when the instructor is powered by AI. Instructional communication research documents that several features contribute to establishing instructor credibility, such as speaking styles (Simonds, Meyer, Quinlan, & Hunt, 2006) and nonverbal immediacy behaviors (Klebig,

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Goldonowicz, Mendes, Miller, & Katt, 2016; Mazer & Graham, 2015; Mottet, Parker-Raley, Beebe, & Cunningham, 2007). Among those, the present study's particular interests are an AI instructor's voice and expertise in the subject matter. When students hear an AI instructor's lecture, one of the first distinctions they may notice is the instructor's voice because the instructor is a machine. Also, when students first learn that the lecture is delivered by an AI instructor, they might question the AI's expertise or knowledge regarding the subject matter. In this regard, an AI instructor's voice and expertise would become focal features for establishing credibility.

Considering the continued increase of using AI technology in education in creative and diverse ways (Bhutani & Wadhwani, 2018; Zawacki-Richter et al., 2019), the possibility of adapting an AI instructor in higher education, particularly in an online learning environment, may become a reality in the foreseeable future. Therefore, the present study investigates the credibility of AI instructors. In particular, the present study examines how an AI instructor's voice and expertise affect students' perceptions of credibility of the AI instructor.

2. Literature review

2.1. Instructor credibility

"Instructor credibility is one of the most important variables affecting the instructor-student relationship" (Myers & Martin, 2018, p. 38). Generally, *instructor credibility* is the believability of the instructor (Teven & Katt, 2016; Teven & McCroskey, 1997). In order for a student to deem an instructor to be credible, they must perceive that the instructor is conveying trustworthy information. As such, credibility is not the extent of the perceived expertise of the instructor, but rather the amount of faith a student can have that everything they learn from the instructor is accurate (Martin & Meyers, 2018). When students assess that their instructor is credible, they are more likely to be motivated to learn within the classroom (Moore & Richards, 2019), enjoy their classroom experience, and believe that they have learned once the class concludes (Martin & Meyers, 2018; Teven & Katt, 2016).

Acknowledging the importance of instructor credibility, research documents several factors that influence instructor credibility. For instance, instructors who speak at a rapid or moderate pace are perceived to be more credible than instructors who speak slowly (Simonds et al., 2006). Thus, instructors who practice their speaking pace to be fluid are more likely to be perceived as credible. Instructors can also increase their credibility by skillfully making appropriate and relevant self-disclosures while they are teaching, demonstrating that not only do they understand the denotative meaning behind the material they are teaching, but that they also have lived experiences with the subject matter (Schrodt, 2013). Finally, displaying nonverbal immediate behaviors (e.g., smiling, making eye contact with students, having a relaxed body posture) increase students' perceptions of instructor credibility (Klebig et al., 2016; Mazer & Graham, 2015; Mottet et al., 2007). Notably, though researchers consistently find that refining these instructional behaviors increases students' perception that their instructor is credible, there is little explanation as to why changing these delivery styles changes perceived reliability of the information shared by the instructor.

Establishing credibility might be particularly important in a technology-mediated or online learning environment because cues are limited. Early work in distance learning (Jayasinghe, Morrison, & Ross, 1997) investigated how camera angles relative to the face of an instructor when recording lectures affect students' perception of instructor credibility. The study revealed that the highest credibility scores are given when videos are filmed at the instructor's eye-level. This finding was later explained by Bailenson, Yee, Blascovich, and Guadagno (2008), who found that simulating eye contact with a camera allows online instructors to enact augmented gaze, the illusion of simultaneously making eye contact with every viewer. Further, Ramlatchan and Watson (2020) found that video lectures showing equal parts of content and the instructor are rated most credible by students because the content videos help establish credibility and the videos of the instructor allow instructors to develop immediacy, which is believed to indirectly enhance credibility. From a student perspective, Vallade and Kaufmann (2020) found that the more credible online students perceive their instructor to be, the greater their liking of their instructor, liking of course content, and perceived learning.

Although many of those cues are unavailable in the online environment, which may sometimes create a unique challenge (Teven & Katt, 2016), instructors can still find a way to establish instructor credibility by utilizing various nonverbal cues that can be communicated online. Then, what if an online instructor is an AI not a human? Would an AI instructor be able to develop credibility in an online learning environment? To understand this unanswered question, the present study investigates students' perceived credibility of an AI instructor.

2.2. Machine teachers

Technological advances made the use of machines, such as robots and AI, in the classroom a lived reality. Though currently limited, these machines are likely to provide instruction to students in the near future. These types of machines are often referred to as machine teachers. Machine teachers are "a technology that plays a meaningful role during an interaction with humans in helping them engage in affective, cognitive, and behavioral learning through various ways" (Kim, Merrill Jr., Xu, & Sellnow, 2020, p. 1904).

As more machine agents are introduced in educational contexts, there appears a strong need to understand students' perceptions about machine teachers in their own learning. One study investigated how undergraduate students think of an AI teaching assistant (Kim, Merrill Jr., Xu, & Sellnow, 2020). The study found that perceptions about usefulness and ease of communication with an AI teaching assistant predict favorable attitudes about the AI teaching assistant. In return, more favorable attitudes are associated with greater intentions to enroll in an online AI teaching-assistant based course. In a follow-up study (Kim, Merrill Jr., Xu, & Sellnow, 2022), the researchers also found that students' strong social presence of their human instructors in their online classes lead students to perceive positive attitudes toward an AI teaching assistant, which leads to strong intentions to take an AI teaching assistant-based education.

Similarly, Edwards, Edwards, Stoll, Lin, and Massey (2019) compared perceptions of a robot evaluator to a human evaluator among undergraduate students. The study found that, although the human evaluator is rated more positively than the robot evaluator, the evaluation of the robot evaluator is above the midpoint of the scale. This finding suggests that although students may prefer the human evaluator over the robot evaluator, the robot evaluator still elicits generally positive responses from students. Taken together, these studies highlight the importance of machine teachers in higher education.

2.2.1. Credibility of machine teachers: voice and expertise

Although limited, some research highlights that credibility is an important concept to consider regarding machines agents in the classroom (Edwards & Edwards, 2017; Edwards, Edwards, Spence, & Lin, 2018). Edwards, Edwards, Spence, Harris, and Gambino (2016) investigated differences in credibility between a robot as a teacher and a teacher as a robot among undergraduate students. Though the students perceived the teacher as a robot to be more credible, both received credibility ratings were higher than the midpoint of the scale. This finding suggests that students find robots in the classroom to be credible enough to provide instruction.

Research documents that voice of a machine agent plays an important role in influencing humans' perceptions about the agent (McGinn & Torre, 2019). In fact, the voice of a robot is likely to predict how a human will perceive the entire interaction with the robot (Niculescu,

vanDijk, Nijholt, Li, & See, 2013). Walters et al. (2008) investigated differences in approachability among four mechanical robots that varied in voice. The four robots included a robot voiced by a man, a robot voiced by a woman, a robot with a robotic or highly synthesized voice, and a robot with no voice. The authors found that humans are less likely to approach a robot with a robotic or highly synthesized voice than the other robots.

More germane to credibility, Edwards et al. (2019) investigated whether students would perceive an AI instructor differently based on their voice. The study found that older college students perceive an AI instructor that is presented as older as more credible than younger college students. Similarly, Xu (2019) found that a robot with a more humanlike voice induces greater perceived trustworthiness than a robot with a synthetic voice.

In addition to the voice, the perceived expertise of a machine agent is also an important aspect to consider. Although the contexts are somewhat different, people generally report favorable responses to a technology that is deemed as an "expert." For instance, Nass and Moon (2000) examined how people respond to two different types of television, which vary in the level of expertise as "specialist" or "generalist." The study found that people perceive the specialist television to be more informative, serious, and have better quality than the generalist television. Andrist et al. (2013) found that people are more likely to respond to suggestions made by robots that have greater levels of expertise than those with lower levels of expertise. On a similar vein, another research revealed that people generally report greater levels of trust after interacting with an expert agent than a nonexpert agent (Pan & Steed, 2016).

Overall, the extant literature highlights how different features of machine agents, particularly voice and expertise, influence the way people perceive the agent. Regarding voice features, while synthetic or mechanical voices are usually perceived as unnatural (Gong & Lai, 2003), human or humanlike voices are considered as powerful and delicate (Nass & Brave, 2005). With regard to expertise, research suggests that people respond favorably to a machine agent that appears to have some level of expertise (e.g., Andrist et al., 2013).

Since machines are highly customizable, one can create a machine teacher that will elicit the greatest positive responses from students. Further, one could customize a machine to specifically fit the needs of the students it serves. To better understand this unique and important matter, the present study examines the effect of the voice and expertise of a machine teacher on the way students perceive the machine teacher, particularly credibility. Of various types of machine teachers, the study focuses on an AI instructor that can be effectively incorporated in an online learning environment. Given the influence of conversational cadence on instructor credibility (Simonds et al., 2006), the study proposes the following hypotheses.

H1. An AI instructor with a more humanlike voice will induce greater credibility than an AI instructor with a more mechanical voice.

H2. An expert AI instructor will induce stronger credibility than a novice AI instructor.

2.2.2. Credibility and intention to take a course

Instructor credibility is a critical variable affecting student learning experiences (Myers & Martin, 2018). In particular, students' perceptions of instructor credibility are positively correlated to their own affective learning, which indicates that students are more likely to want to take a future course with instructors that they perceive to be credible (Pogue & Ahyun, 2006; Vallade & Kaufmann, 2020). Considering the Computers are Social Actors (CASA) paradigm that suggests that humans treat machines as if they were humans (Reeves & Nass, 1996), the present study predicts that the credibility of an AI instructor will also play an important role in student perceptions, such as intentions to enroll in a course that is taught by an AI instructor.

In all, credibility is an important instructional concept whether the instructor is a human or machine (Edwards & Edwards, 2017). Thus, it is likely that the credibility of an AI instructor will influence students' intentions to enroll in a course that is taught by an AI instructor. Taken together, the following hypothesis is proposed.

H3. Greater credibility of an AI instructor will lead to greater intentions to take an AI instructor-based online course.

2.3. Social presence

In understanding a human's interaction with a machine agent, social presence plays a vital role for an effective interaction experience. Of diverse approaches to social presence, Lee (2004) defines it as "a psychological state in which virtual (para-authentic or artificial) social actors are experienced as actual social actors in either sensory or nonsensory ways." (p. 45). Essentially, social presence evokes when individuals do not realize the para-authenticity of humans in a mediated environment or the artificiality of nonhuman social actors (e.g., AI, robots, etc.).

Theory-driven research documents that social presence (or presence) is induced by various factors, such as technology-related factors (e.g., modality, content, vividness), user factors (e.g., personality), and social factors (Lee & Nass, 2005; Lombard & Ditton, 1997). Research also documents that social presence (or presence) has a diverse range of effects on users such as persuasion and perceptions (Lee, 2004; Lombard & Ditton, 1997).

Social presence is not a mere outcome or dependent variable that users experience regarding a media or technology experiences (Lee, 2004). Social presence can function as a mediating variable between social presence-inducing variables (independent variables) and social presence-producing variables (outcome variables) by linking this relationship, which ultimately fosters psychological and/or social responses toward the technological experiences, such as attitudes and intentions. That is, as a mediating variable, social presence explains that the reason why individuals perceive the technology socially is because they experience social presence of the technology they interact with.

A considerable amount of research documents the mediating role of social presence in diverse contexts (e.g., Kim, Kim, & Collins, 2021; Kim & Merrill Jr., 2022; Kim, Merrill Jr., & Yang, 2019; Kim & Timmerman, 2018; Kim, Yang, & Kim, 2020) including in education contexts (e.g., Kim, Merrill Jr., Xu, & Sellnow, 2020; 2021; Song, Kim, & Park, 2019). Lee and Nass (2004) tested the role of social presence by examining the impact of synthetic voices on people's perceptions about the voice. The study found that multiple synthetic voices are more persuasive in influencing people's perceptions than a single voice. Notably, the reason why multiple voices have more persuasive influences on people is because of social presence.

More germane to the present study's context, social presence is expected to function as a mediator between behaviors of instructors and student responses to the instructional behaviors (c.f., Kelly & Westerman, 2016). For instance, Song, Kim, and Choi (2019) examined instructor's self-disclosure in online learning experiences and found that social presence mediates the relationship between an instructor's self-disclosure and student learning experiences. Further, Kim, Merrill Jr., Xu, and Sellnow (2021) examined the role of social presence of an AI instructor in an online education context. The study found that social presence of an AI instructor mediates the relationship between an AI instructor's communication style (functional vs. relational) and favorable responses towards AI-based education, such as attitudes and intentions. In all, extant research highlights that the social presence of instructors, whether humans or AI, is related to students' psychological response to how their online instructors communicate. As such, instructor behaviors become the indirect influence of classroom outcomes such affective learning, cognitive learning, and their perceptions of the instructor (e.g., credibility).

Based on the aforementioned argument, the present study predicts the mediating role of social presence of an AI instructor. That is, the

reason why the voice and expertise of an AI instructor influences perceptions of the credibility of an AI instructor (H1 & H2) is because of the social presence of the AI instructor. Thus, the study proposes the following hypotheses.

H4. Social presence will mediate the relationship between the type of voice (machinelike vs. humanlike) and the credibility of an AI instructor.

H5. Social presence will mediate the relationship between the level of expertise (novice vs. expert) and the credibility of an AI instructor.

3. Methods

An online experiment was conducted to test the proposed hypotheses. Specifically, the study employed a 2 (voice: machinelike vs. humanlike) x 2 (expertise: novice vs. expert) between-subjects design. For the present study, voice-based lecture clips were created.

3.1. Participants

The sample of the study was obtained from a large, southeastern university in the United States. Initially, 290 people responded to the research. To ensure the quality of the data, the study performed screening processes. First, twenty-four individuals did not complete over 50% of the study questionnaire; thus, they were removed. Second, forty individuals indicated they have already participated in this study for another class; thus, they were removed. Third, an attention check was performed while participants were completing the questionnaire to ensure they were paying attention to the questions. Three individuals failed the attention check; thus, they were removed from the data.

After a series of screening processes, the final dataset included 223 individuals. Majority of the sample identified as females (n = 160: 71.7%), and the average age was 22.13 years (SD = 4.48). The sample consisted of various ethnic groups, such as White/Caucasian (n = 130: 58.3%), Latino/a/x or Hispanic (n = 44: 19.7%), Black/African American (n = 30: 13.5%), and other racial and ethnic groups (n = 19: 8.5%). Participants were randomly assigned to one of four AI instructor conditions: a novice with a machinelike voice (n = 58), a novice with a humanlike voice (n = 58), an expert with a machinelike voice (n = 53) or an expert with a humanlike voice (n = 54).

3.2. Procedure

Following the university's IRB approval, an initial recruitment message was sent to several undergraduate classes. Individuals were invited to click on the link to participate in the research study. Before participating in the study, they were asked to acknowledge the informed consent message.

The present research included three sections. The first section evaluated participants' preexisting attitudes toward new technologies. The second section included one of the four voice-based lectures by an AI instructor and a series of questions that assessed participants perceptions about the lecture. Following the lecture, a series of questions were asked regarding the lecture and the AI instructor. The last section of the study included demographic questions. Participation was voluntary, and confidentiality was guaranteed. All participants were rewarded with course credit or extra credit.

3.3. Materials

First, to simulate the lecture by an AI instructor, lecture content was created. Specifically, the content was selected from a biology course that focused on basic information about cells, which is typically taught in an introductory biology course. To create a similar class environment that most students may experience, the lecture content included three sections: 1) a brief opening conversation with the students, 2) the course content, and 3) a transitioning/closing conversation before moving on to the next topic. This lecture script was used for all four experimental conditions.

To simulate an AI-facilitated online lecture, a voice-based lecture was developed. Specifically, the text-to-speech (TTS) software on the OSX system "SayIt" was used to convert lecture scripts to audio clips. Each clip was approximately 100 seconds long with speed of 160 words per minute.

Voice and expertise of the AI instructor were manipulated for each condition. With regard to voice, several machine voices available in the software were assessed in order to create a humanlike voice and a machinelike voice. After comparing several options, a female voice "Samantha" was selected for the humanlike voice conditions, and another female voice "Victoria" was selected for the machinelike voice conditions. Regarding expertise, a written script that provides a brief introduction of the AI instructor was presented prior to the lecture clip. For the novice conditions, the AI instructor was introduced as "a prototype" that is currently being developed and tested for potential implementation in the future. For the expertise conditions, the AI instructor was introduced as a "state-of-the-art AI" which was developed by an internationally recognized team and has been used in various universities.

3.4. Measures

Attitudes toward new technologies (α = 0.75) were evaluated with three items (Nass, Moon, Fogg, Reeves, & Dryer, 1995), such as "How comfortable would you be with new technologies (e.g., robots, AI) taking interpretive roles (e.g., editorial writers, newspaper reporters, novelists)" and "… taking routinized roles (e.g., accountants, auto mechanics, bank tellers)." A 6-point scale (1 = *Very Uncomfortable*, 6 = *Very Comfortable*) was used to record the responses.

After the stimulus, the study asked a few questions to ensure the manipulations were successful. *Perceived expertise* (α = 0.89) was assessed with five items (e.g., "unknowledgeable – knowledgeable" and "unqualified – qualified"). Responses were recorded on a 7-point semantic differential scale. *Perceived machine voice* (α = 0.78) was evaluated with three items (e.g., "mechanical" and "humanlike" – reversed item). A 7-point scale (1 = *Not at all*, 7 = *Very*) was used to record the responses.

Next, the study assessed perceptions of an AI instructor. *Perceived credibility of an AI instructor* (α = 0.75) was assessed with six items (e.g., "distrustful – trustful" and "unreliable – reliable") adopted from Gong and Nass (2007). A 7-point semantic differential scale was used to obtain the responses.

Intentions to enroll in an AI instructor-based online course (α = 0.95) were evaluated with three items (e.g., If an AI-based online class is available … "I would be interested in taking the class" and "I might take the class"). Items were slightly modified from Choi and Ji (2015) to fit for the present study's context. Responses were recorded on a 7-point Likert-type scale (1 = *Strongly Disagree*, 7 = *Strongly Agree*).

Social presence (α = 0.90) was assessed with four items (e.g., When I was hearing the AI's lecture, I felt like … "the AI was around me" and "the AI and I were together in the same place"). Items were adopted from Lee, Jung, Kim, and Kim (2006). Responses were recorded on a 7-point Likert-type scale (1 = *Strongly Disagree*, 7 = *Strongly Agree*). The reported Cronbach's alphas (α) in this study ranged from 0.75 to 0.95. Considering that the recommended cut-off value of α is 0.60 (e.g., Griethuijsen et al., 2014), all of the measures in this study are considered to be reliable.

4. Results

The study used SPSS (Statistical Package for the Social Sciences, version: 26) to conduct the analyses. First, the study performed manipulation checks to ensure that the manipulations of the stimuli were successful in the intended direction. Then, a series of analyses were

conducted to test the proposed hypotheses.

4.1. Manipulation check

A set of independent *t*-tests were performed to ensure that the manipulations were successful. For the voice of the AI instructor, participants in the machinelike voice condition ($M = 6.36$, $SD = 0.93$) perceived the AI to sound more like a machine than participants in the humanlike voice condition ($M = 5.91$, $SD = 1.22$), $t(221) = 3.09$, $p < .01$. Regarding the perceived expertise of an AI instructor, participants in the expert condition ($M = 5.30$, $SD = 1.20$) perceived the AI to be greater in expertise than participants in the novice condition ($M = 4.85$, $SD = 1.50$), $t(221) = -2.48$, $p < .05$. Thus, the manipulations were successful.

4.2. Primary hypotheses testing

The study included a control variable when conducting the main analyses. Acknowledging that an AI instructor is a forward-thinking notion of technology, the preexisting attitudes toward new technologies might affect the way participants perceive an AI instructor. Thus, the hypotheses were examined while controlling for preexisting attitudes toward new technologies, which were assessed before listening to the lecture.

H1 and H2 predicted the effects of voice (H1) and expertise (H2) of the AI instructor on the credibility of the AI instructor. To test H1 and H2, a two-way ANCOVA was conducted. Regarding the effect of voice (H1), the results suggested that the humanlike voice ($M = 4.47$, $SD = 1.06$) evoked greater perceived credibility of the AI instructor than the machinelike voice [($M = 4.20$, $SD = 0.98$), $F(1, 218) = 4.42$, $p = .038$, $\eta_p^2 = 0.020$]. With regard to expertise (H2), there was no significant difference on the credibility of an AI instructor between the expert AI instructor ($M = 4.37$, $SD = 1.01$) and the novice AI instructor [($M = 4.31$, $SD = 1.05$), $F(1, 218) = 0.21$, $p = .65$, $\eta_p^2 = 0.001$]. No interaction effect was found between the types of voice and the levels of expertise [$F(1, 218) = 0.05$, $p = .83$, $\eta_p^2 = 0.00$]. In all, H1 was supported, but H2 was not supported (see Table 1).

H3 proposed that the credibility of an AI instructor predicts intentions to enroll in an AI instructor-based online course. To test H3, a regression analysis was conducted. Participants' attitudes toward new technologies and the credibility of AI instructors were entered in the same block. Overall, the model accounted for 9.7% of the variance of users' intentions to take an AI instructor-based online course [$F(2, 220) = 11.81$, $R^2 = 0.10$, $p < .001$]. After controlling for participants' attitudes toward new technologies, the credibility of the AI instructor further predicted participants' intentions to take an AI instructor-based online course ($B = 0.30$, $SE = 0.10$, $p = .004$). H3 was supported.

H4 and H5 predicted a mediation effect of social presence between voice (H4) and expertise (H5) and the credibility of an AI instructor. The PROCESS macro (Hayes, 2017) was employed to test the hypotheses based on 10,000 bootstrap samples. Specifically, voice and expertise were separately set as independent variables. The dependent variable was perceived credibility of an AI instructor, and social presence was set as the mediator. Model 4 was used to test the direct, indirect, and total effects of independent variables. The results were assessed based on a 95% Confidence Interval (CI). Voice (machinelike = 0; humanlike = 1) and expertise (novice = 0; expert = 1) were dummy coded.

Regarding voice (H4), the results revealed a significant mediation effect of social presence between voice and the credibility of an AI instructor ($B = 0.07$, $SE = 0.04$, CI = [0.01, 0.15]). Participants in the humanlike condition, compared to the machinelike condition, experienced stronger social presence (a = 0.46), which led to greater perceived credibility (b = 0.14). H4 was supported.

With regard to expertise (H5), no significant mediation effect of social presence was found between expertise and the credibility of an AI instructor ($B = 0.01$, $SE = 0.03$, CI = [-0.05, 0.08]). The level of expertise (novice vs. expertise) did not have any significant impact on social presence (a = 0.08), but social presence led to greater perceived credibility (b = 0.16). H5 was not supported (see Table 2). See Fig. 1 for the overall directions of the hypothesis testing.

Table 1
Main effects of voice and expertise levels on credibility of an AI instructor (H1 & H2).

IV	Condition	*M*	*SD*	*F*	η_p^2
Voice	Machinelike	4.20	0.98	4.37*	.02
	Humanlike	4.48	1.06		
Expertise	Novice	4.31	1.05	0.21	.001
	Expert	4.37	1.01		

Note. *$p < .05$.

5. Discussion

The present research investigated the effects of an AI instructor's voice and level of expertise on students' perceived credibility of the AI instructor. The primary findings indicate that students perceive an AI instructor with a humanlike voice to be more credible than an AI instructor with a machinelike voice. Further, social presence mediates the relationship between voice and credibility. The study also finds that the credibility of an AI instructor leads to greater intentions to enroll in an AI instructor-based online course. Unlike the prediction, however, the study does not notice any significant role of an AI instructor's expertise. The following section elaborates on primary findings along with contributions and implications of the study. Then, the study proposes future research directions based on limitations identified in this investigation.

5.1. Primary findings

The present research reports meaningful findings. First, the study finds that a humanlike, naturally voiced AI instructor induces greater credibility of the AI instructor compared to a machinelike, mechanically voiced AI instructor. This finding is aligned with existing research that reveals that people develop more positive perceptions when interacting with robots with natural voices than robots with robotic, synthetic, or mechanical voices (Walters et al., 2008; Xu, 2019). This result is likely due to the machine agent being perceived to be more similar to the human, as extant research found that people develop more positive perceptions of robots that are similar to them (Eyssel et al., 2012). In the present study's context, an AI instructor with a more humanlike voice may have been perceived as more similar to the students than an AI instructor with a more machinelike voice. Research also documents that the voice of a machine agent is an important indicator of how people perceive the interaction with the machine agent (Niculescu et al., 2013). Therefore, the study's finding that an AI instructor with a humanlike voice leads to greater levels of credibility is important and meaningful.

Table 2
Mediation effects of social presence (H4 & H5).

	95% Confidence Interval		
	B (SE)	*ULCI*	*LLCI*
Voice on credibility via social presence			
Total Effect	.28(.13)	.02	.55
Indirect Effect	.07(.04)	.01	.15
Direct Effect	.21(.13)	−.05	.48
Expertise level on credibility via social presence			
Total Effect	.05(.13)	−.21	.31
Indirect Effect	.01(.03)	−.05	.08
Direct Effect	.05(.13)	−.21	.31

Note: B: unstandardized effect; SE: standard error; ULCI: Upper level confidence interval; LLCI: Lower level confidence interval.

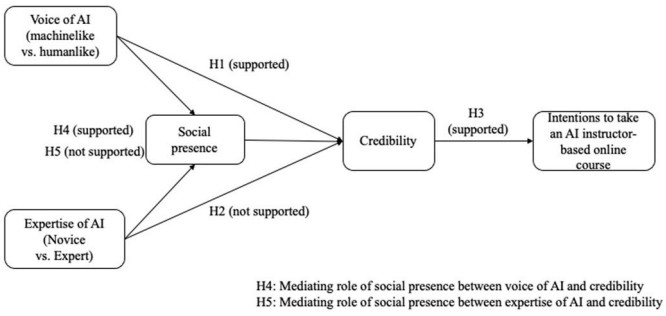

Fig. 1. Overall model.

Second, the study reveals the mediation effect of social presence. Specifically, a humanlike voice, compared to a machinelike voice, of an AI instructor fosters greater social presence of an AI instructor, and greater social presence leads to a greater perceived credibility of the AI instructor. Thus, the study finds that social presence functions as a mediator. Baron and Kenny (1986) note that a mediator explains why and how such relationship occurs. Therefore, the study's finding highlights that the reason why the relationship between the voice of an AI instructor and the perceived credibility of an AI instructor occurs is due to the perceived social presence of an AI instructor. In fact, a mediation effect of social presence is well documented in online education. A considerable amount of research highlights the mediation effect of social presence that ultimately facilitates positive online learning experiences (e.g., Song, Kim, & Choi, 2019) because it is a learner's psychological response to their interactions with their instructor that directly influences their learning outcomes (Kelly & Westerman, 2016). Beyond the context of online education, research documents the mediation effect of social presence in a variety of contexts, such as digital games (e.g., Kim & Timmerman, 2018), social media (e.g., Kim, Kim, & Collins, 2021), social TV (e.g., Kim & Merrill Jr., 2022; Song, Kim, & Choi., 2019), and radio listening (e.g., Kim & Yang, 2019).

Further, the present investigation finds that stronger credibility of an AI instructor is associated with greater intentions to enroll in an AI instructor-based online course. Edwards and Edwards (2017) highlight credibility as an important factor for education and instruction. Therefore, if students perceive a machine teacher to be more credible, they will be more likely to take a course provided by a machine teacher. Further, from a general perspective, this finding supports previous research findings (Kim, Merrill Jr., Xu, & Sellnow, 2020; Kim, Merrill Jr., Xu, & Sellnow, 2022) that finds that more positive attitudes about an AI teaching assistant are associated with greater intentions to take an online course that features an AI teaching assistant. Therefore, the present study's finding is well supported by extant research.

Although statistically significant findings might receive most of the attention, it is also important to acknowledge and discuss predictions or argument that are not supported by the data. Unlike the proposed hypothesis, the present study does not observe a significant association between the expertise of an AI instructor and students' perceived credibility of the AI instructor. Though unexpected, prior research provides some evidence to better understand this nonsignificant result. The machine heuristic states that people perceive machines as more favorable than humans in some contexts, such as more secure and trustworthy (Sundar & Kim, 2019). Thus, it is possible that, regardless of the expertise level, people perceive machines to be credible and capable. Another possibility might be due to the lecture content employed in this investigation. The lecture content was created based on typical content taught in an introductory biology course, which covers a basic level of knowledge. Thus, it is likely that participants may have already learned this information previously at a high school or at a college. In this regard, the level of expertise of the AI instructor may be irrelevant, as students may perceive this information as easy to understand and the content itself may not require an extensive level of experiences in the subject matter.

5.2. Implications and contributions

The present research's findings provide meaningful implications and contributions. First, the study provides implications for social presence research in the context of online education. In particular, the study highlights that the importance of social presence in online learning extends to a context where an instructor is an AI agent, not a human. Considering that most of the research on social presence in online education is examined in the context of a human instructor, the finding of the study contributes to advancing social presence research in this context. This finding ultimately sheds light on the possibility of adopting diverse forms of AI instructors (e.g., voice AI, text AI, virtually embodied AI) in online education.

As often emphasized in the literature on social presence and learning, students respond to their perceptions of their instructor's behaviors, rather than their instructor's behavior itself (e.g., Kelly, Rice, Wyatt, Ducking, & Denton, 2015; Kelly, Romero, Morrow, Denton, & Ducking, 2020). That psychological response is perceived social presence (Kelly & Westerman, 2016). As such, teaching is a complex and difficult endeavor because although instructors may have the best intentions on any day of teaching well, fatigue or sorrow can prevent the instructional behaviors they intend to use from being presented to students as intended (Kelly et al., 2015). These issues are not limitations of AI instructors as AI instructors can be manipulated to be their most instructionally optimal version. Studies such as this present research lay the groundwork for producing optimal social presence between AI and learners, so that cognitive and affective learning can be optimized.

Next, the present research contributes to advancing our understanding of credibility in online education. A substantial amount of research documents important factors that contribute to effective instructors and online learning experiences (e.g., Kim, Song, & Luo, 2016; Song, Kim, & Luo, 2016; Song, Kim, & Park, 2019). Yet, most of the literature about instructor credibility is somewhat outdated and does not provide sufficient information for the understanding of instructor credibility in online education. In particular, much of the credibility research in the extant literature is from samples of Gen X and Xennial students. Thus, the scholarly community might be making some assumptions about instructor credibility that may not hold now as current students are part of Gen Z and they are very different learners. Therefore, the present study's approach to understanding instructor credibility in this technologically advanced era among technology-savvy students, particularly with the idea of an AI instructor, provides meaningful perspectives.

Further, the study's findings provide implications for human-machine communication research. In particular, the present investigation highlights the importance of the voice of a machine agent. The study reveals that individuals respond more favorably when the machine agent features a humanlike voice. This finding is especially important for fields that hope to introduce machine agents that will interact with humans in diverse contexts and perhaps throughout our daily life. For example, machine agents in healthcare may be perceived more positively if they feature a more humanlike voice. Overall, this study's findings provide promising ways to advance and incorporate the use of machine agents in a variety of contexts and provide effective ways to help people develop the credibility of machine agents.

Lastly, the current study provides practical implications for the consideration of voice when designing machine agents for education. As supported by social agency theory (Mayer, Sobko, & Mautone, 2003; Moreno, Mayer, Spires, & Lester, 2001), the voice used for a machine agent can influence how individuals perceive that agent (McGinn & Torre, 2019; Niculescu et al., 2013). The study's core finding that students perceive an AI instructor with a humanlike voice as more credible than an AI instructor with a machinelike voice highlights the importance of choosing a humanlike voice type when designing a machine

teacher-based educational technology (e.g., AI instructor, AI teaching assistant) and/or multimedia presentations. In addition, noting the tendency that presenters receive higher social and performance ratings when they use an enthusiastic voice compared to a calm voice (Liew, Tan, Tan, & Kew, 2020), creating a machine teacher or multimedia presenter with an enthusiastic, humanlike voice would be ideal. In all, the present study suggests that various characteristics of the voice should be considered when developing machine teachers or machine teacher-based technologies.

5.3. Limitations and future research directions

Although the present study reports important findings, the study acknowledges some limitations identified in this study, which requires more investigations in future research. First, the study only employed a female voice as the AI instructor. It is possible that students may perceive female instructors and male instructors differently in terms of perceived immediacy, which could potentially influence perceived credibility of an instructor. In this regard, it would be interesting to test the effect of female vs. male voices to see whether a different gendered voice has any effect on the way student perceive an AI instructor. It would be a unique opportunity to test how machine simulated sex, which differs by gendered voices in this line of AI research context, affects student perceptions about the instructor without any verbal immediacy.

Second, because the study used preexisting voices from a software, customization of the voice features was limited. There are a wide range of voice features, such as tone, pitch, accent, and volume, which can naturally create different levels of humanlike voices (or machinelike voices). Especially, as suggested by Craig and Schroeder (2019), dialect would be a meaningful aspect to examine as dialect of the voice can potentially impact student learning experiences. To better understand which aspects of an AI instructor's voice would have impacts on students' perceptions of the AI instructor, the study calls for follow-up research in this realm.

Next, the present study only assessed an individual's perceptions of a disembodied machine teacher. However, there are likely other cues that are important in understanding how an individual will perceive a machine teacher. A research study found that social presence of a disembodied AI robot fosters perceived usefulness of the robot, but this pattern does not appear when the robot is embodied (Merrill Jr., Kim, & Collins, 2022). Although the context is different Merrill Jr. et al.'s study raises a question of how students might perceive an embodied machine teacher (e.g., robots) with more humanlike cues compared to a disembodied machine teacher (e.g., voice AI). Students may also have varying perceptions of the machine teacher depending on its degree of anthropomorphism, or the degree it resembles a human. As observed with human instructors (Simonds et al., 2006), rate of speech may also influence students' perceptions of AI instructor credibility. Thus, future research should manipulate these various cues to see whether students perceive the machine teachers differently.

Finally, the study encourages future research to investigate how students would respond to an AI instructor with a humanlike machine voice compared to an actual human voice. The present study compared two machine voices that vary on the spectrum of human likeness; thus, it is not clear how students would react to an AI instructor that has an actual human voice. Craig and Schroeder (2019) found that a classic machine voice and a modern machine voice do not create substantial differences in the perceived credibility of a machine agent used in the multimedia presentation lecture. However, an actual human voice induces stronger credibility than both types of machine voices. To better understand whether differences emerge when examining humanlike machine voice vs. actual human voice of an AI instructor, the study calls for more research endeavors.

5.4. Conclusion

The present research investigated the effects of voice and expertise of an AI instructor on the perceived credibility of an AI instructor. Primary findings indicate that students perceive greater credibility of an AI instructor with a humanlike voice than those with a machinelike voice. Importantly, the study finds that the reason why the voice of an AI instructor matters is due to social presence. The study also finds that the perceived credibility of an AI instructor positively influences students' intentions to take an AI instructor-based online course. To advance our understanding in this area, the present study calls for more research to examine this important and emerging area of research.

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Declaration of competing interest

None.

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