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Robots in the classroom: Differences in students' perceptions of credibility and learning between "teacher as robot" and "robot as teacher"

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ABSTRACT

Advancements in technology are bringing robotics into interpersonal communication contexts, including the college classroom. This study was one of the first to examine college students' communication-related perceptions of robots being used in an instructional capacity. Student participants rated both a human instructor using a telepresence robot and an autonomous social robot delivering the same lesson as credible. However, students gave higher credibility ratings to the *teacher as robot*, which led to differences between the two instructional agents in their learning outcomes. Students reported more affective learning from the *teacher as robot* than the *robot as teacher*, despite controlled instructional performances. Instructional agent type had both direct and indirect effects on behavioral learning. The direct effect suggests a potential machine heuristic in which students are more likely to follow behavioral suggestions offered by an autonomous social robot. The findings generally support the MAIN model and the Computers are Social Actors paradigm, but suggest that future work needs to be done in this area.

1. Introduction

Advancements in technology are bringing robotics into interpersonal aspects of life. No longer are robots confined to factories, laboratories, or battlefields. Robotic technologies are moving towards interpersonal relationships in everyday life, and as such, into higher education (Heo & Kim, 2013; Li, Kizilcec, Bailenson, & Ju, 2016). In addition to robotics, computer software and networks have advanced to a point where displacing technology (e.g., Skype) is a feasible option for instruction (Allen & Seaman, 2010; Garner & Buckner, 2013). The benefits of displacing technologies are convenience for students and instructors, as well as cost and time effectiveness. For example, Borup, West, and Graham (2012) demonstrated that students in displaced instruction situations felt more connected when video was used than when video was not used. Li et al. (2016) argued that social robots and virtual agents might "improve the accessibility of pedagogical content" (p. 1223). The use of robots for displacing technologies is relatively new.

A robot is a machine that can do the work of a person and that works automatically or is controlled by a computer (Merriam-Webster.com). There are several ways robots can be used in the classroom. Uses are dependent on the capabilities of the robot technology, as well as the pedagogical needs of the instructional situation. Currently, robots in the classroom are being used in four basic ways: (a) robot as classroom teacher, (b) robot as companion and peer, (c) robot as care-eliciting companion, and (d) telepresence robot teacher (Sharkey, 2016). The present study focuses on the first and last scenarios, as they pertain directly to the use of robots in the role of instructor.

Robots can be used to enable computer-mediated communication (CMC) between an instructor and students. For instance, a physically remote instructor can operate a telepresence robot (videoconferencing on a mobile platform) to interact with the class.

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Alternatively, robots can be used to enable human-machine communication (HMC) between students and a robot instructor. For example, an autonomous social robot can be placed in the position of information source and provide direct instruction to students. The two scenarios may be considered *teacher as robot* and *robot as teacher*, respectively. The former uses "displacing" technologies by enabling mediation of a distant human instructor through a robot. The latter involves "replacing" technologies by substituting a robot instructor for a human.

An important difference between the two types of classroom robots is agency. Is the source of instruction a human or a machine? The source of instruction with a telepresence robot is a human operator who uses the robot as a medium through which to interact with students. On the other hand, a social robot is autonomous, meaning it can act within bounds to achieve goals without any explicit human control. Therefore, a social robot is an agent, or source of instruction in its own right. The question that arises is whether students find these technologies credible and effective in the classroom. And, in a direct comparison, do students perceive the human or the machine robot agent more favorably?

The current study will compare differences in perceptions of credibility and learning between a human instructor using a telepresence robot (teacher as robot) and a social robot acting as a teacher (robot as teacher). Because robot technology is already being used in teaching-learning contexts, it is important to identify and understand students' reactions and educational experiences. Ultimately, studies like this may help develop best practices for integrating robots into higher education classrooms. The following sections will discuss telepresence robots and social robots in the classroom, using the MAIN model (Sundar, 2008) and Computers are Social Actors paradigm (Reeves & Nass, 1996) to frame the research questions.

1.1. Telepresence robots in the classroom

Although many definitions exist for the term *telepresence*, this concept can be conceptualized as "a sense of transportation to a space created by technology" that "occurs when a user perceives that he or she is physically present in a remote environment" (Lee, 2004, p. 29). Whereas one can communicate *to* and *with* a social robot, one communicates *through* a telepresence robot. A telepresence robot is a device that allows a person to videoconference on a moveable platform from a remote location. The user has remote control of the robot's movement and can interact through the screen. Factors such as distance learning and the attempt to keep students engaged in the classroom have led to a push for the incorporation of telepresence robotic forms of instruction (Smith & Mader, 2016). Although few studies have examined telepresence robots in the classroom, empirical work surrounding the use of other forms of telepresence and CMC in education is more plentiful.

Earlier work on telepresence examined the medium of television and how it impacted student-teacher interaction (Hackman & Walker, 1990). Students viewed real-time televised lectures and had access to phones so they could call-in to the lecture with questions or comments if they chose. The researchers found positive correlations among instructor immediacy behaviors (e.g., instructors who prompted student participation, engaged in feedback by taking student phone calls, and portrayed nonverbal behaviors such as smiling, speaking in an engaged voice, and having an open body posture) and overall student satisfaction and learning. In addition, aspects of the chosen system such as the clarity of audio and video transmission were also positively related to satisfaction and learning.

Other research has found interesting, but somewhat conflicting, results. Two meta-analyses conducted by Allen et al. (2002, 2004) found that overall, distance learners (i.e., students who were not physically present with an instructor and engaged in various forms of mediated learning) were less satisfied than their traditional student counterparts, but scored higher on exams and course grades. As Allen et al. (2004) noted, "the use of any means of communication in an educational setting may have a differential impact that favors or disadvantages different persons" (p. 404). Further, the type of telepresence (e.g., television, online-only) may also have an impact on factors such as student satisfaction and learning. Li et al. (2016) demonstrated that a human instructor could be effective in a MOOC (Massive Open Online Course) context using video presence.

Although research investigating the effects of telepresence robots in the classroom is limited, some studies have indicated positive learning experiences and outcomes. For example, researchers at Carnegie Mellon developed a telepresence robot that allowed a user to virtually attend meetings, classes, and lectures at a distance (Clark & Root, 2011). Based on their case studies, Clark and Root observed that although the interaction was unfamiliar for both parties, participants were able to overcome the unique situation and focus on the tasks at hand. Yun et al. (2011) examined the deployment of EngKey telepresence robots in South Korea. Teachers in the Philippines provided English instruction to elementary students, whose performance was found to improve. Although initial research has indicated there may be potential benefits in regards to telepresence in the classroom (in terms of enabling instruction that would otherwise be prohibited by interactional distance), further research is needed to better identify the possible effects it has on student learning and perceptions of instructor credibility.

1.2. Social robots in the classroom

A *social robot* is an autonomous, physically embodied robot that interacts and communicates with humans by following social behaviors and rules attached to its role. Social robots overlap in form and function with human beings to the extent that their locally controlled performances occupy social roles and fulfill relationships that are traditionally held by other humans. In the context of education, social robots have chiefly been used to provide or supplement instruction in three content areas: (a) language development and acquisition, (b) science education, and (c) technology and computer programming (Mubin, Stevens, Shahid, Al Mahmud, & Dong, 2013).

Several studies have demonstrated the benefits of social robot use in the classroom. For example, children have performed better in math when tutored by a robot (Brown, Kerwin, & Howard, 2013). Social robots have been used to reinforce social behaviors in children with autism (Kim et al., 2013) and to improve student retention rates by incorporating gestures and increasing vocal volume (Szafir & Mutlu, 2012). Park, Kim, and del Pobil (2011) found that robot instructors were perceived as more socially attractive when delivering positive feedback instead of negative feedback to college students.

In the context of robotics, virtual agents have been used in conjunction with mechanical bodies to produce social robots capable of performing tasks. A virtual agent is an animated computer-generated character that can utilize text-to-speech capabilities. Al Moubayed, Beskow, Skantze, and Granström (2012) argued that robots with human-like faces could better display complex information. Baxter, a 'collaborative robot' employed in industrial and manufacturing fields, combines two arms with an animated screen for a face. Baxter's abilities to express emotion and signal intention while simultaneously loading, lifting, and packaging enhance social interaction and workplace safety (see

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