I, teacher: using artificial intelligence (AI) and social robots in communication and instruction

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ANALYTIC REVIEWS

I, teacher: using artificial intelligence (AI) and social robots in communication and instruction*

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ABSTRACT

Human–machine communication has emerged as a new relational context of education and should become a priority for instructional scholarship in the coming years. With artificial intelligence and robots offering personalized instruction, teachers' roles may shift toward overseers who design and select machine-led instruction, monitor student progress, and provide support. In this essay, we argue that bringing the sensibilities of instructional researchers to bear on these issues involving machine agents, within and outside the traditional classroom walls, is vitally important.

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Reportedly, by the end of 2018, Japan will boast a robot news anchor named Erica, a highly human-like android designed by Hiroshi Ishiguro to resemble a 23-year-old woman (Tumboken, 2018). Because Erica can capably recite scripted news writing, ably converse with humans, and project charisma, Ishiguro and others believe she is well suited to a public information-sharing role. However, questions emerge regarding what is gained and lost when the communication traditionally occurring between human beings starts to involve machine partners. Will off-loading repetitive information-labor tasks to robots and artificial intelligence (AI) free humans to pursue more interpretive, creative, and high-value work associated with consciousness? Will people find the experience of receiving information and instruction from machine agents educational, fulfilling, and enjoyable? What are the social and ethical implications for replacing or offsetting human labor with machine agents? Which aspects of design, as well as which contexts of adoption and use, will enhance or diminish our shared values and desired outcomes for the process of communication? And, at the most basic level, to what extent is it even possible for humans and machines to communicate with (and thereby educate) one another?

Already, AI software and embodied social robots are being employed as teachers' aids, tutors, and peer learning specialists in classrooms around the world (e.g., Vasagar, 2017). Forecasts vary, with some educational specialists predicting machine agents will begin

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*This essay is a collaboration of the Communication and Social Robotics Labs. www.combotlabs.org replacing teachers in classrooms within the next 10 years as part of "a revolution in one-to-one learning" facilitated by intelligent machines' ability to adapt methods of communication to individual pupils' baseline levels of knowledge and their unique learning styles (Bodkin, 2017, para 1). With AI and robots offering personalized instruction, teachers' roles may shift toward overseers who design and select machine-led instruction, monitor student progress, and provide pastoral support.

Although there is a long history of using machines as educational tools, the introduction of machines that serve as the communication source or interaction partner is both a recent and rapidly developing reality. Human–machine communication (HMC) has emerged as a new relational context of education and should become a priority context for instructional scholarship in the coming years (Edwards & Edwards, 2017). Because HMC has the potential to disrupt some of our most basic assumptions and expectations about communication and education (e.g., that these processes necessarily occur between human actors) and to alter existing educational arrangements and outcomes dramatically, it is vitally important to bring the comprehensive sensibilities of scholars who study communication, teaching, and learning to bear on these issues at the earliest possible stages in design, policy-making, implementation, and evaluation. In the following sections, we discuss how communication can be scripted in the HMC instructional context and then highlight several ways that researchers could use existing teacher/learning variables to start exploring machine agents (AI and social robots) in the classroom.

Human-to-human interaction script for communication, instruction, and HMC

Much of communication is a scripted endeavor (Kellerman, 1992) and this can allow for machine agents to take a more significant role in the educational process as co-instructors. Machine agent teachers use Spoken Dialogue Systems (SDS), or more generally, scripted responses that can instruct and teach. SDS can be defined as "computer systems that use spoken language to interact with users to accomplish a task" (McTear, 2002, p. 91). SDS is used with both AI software (e.g., chatbots) and embodied social robots and aims to imitate human dialogue in a scripted process. The effectiveness of SDS can be rated on how "human-like" the interaction is perceived to be (Boyce, 2000, p. 29). The interpersonal impressions and perceptions of SDS will be a central focus of assessing the use of AI and social robots in an instructional context.

Consequently, it is important to understand how the characteristics and assumptions of human-to-human interactions are played out in HMC. Research demonstrates that people operate on the basis of a human-to-human interaction script when interacting with machine communicators. Generally, people expect their communication partners to be other humans and face greater uncertainty, and lower anticipated social presence and liking, when their partner is instead a machine (Edwards, Edwards, Spence, & Westerman, 2016; Spence, Westerman, Edwards, & Edwards, 2014). One aspect of this human-to-human interaction script is that communication is a heavily scripted process in which priming and prior experience play key roles in the process of selecting and modifying appropriate scripts for use in a given context. Identifying such scripts in an education setting can help to determine best practices for the design of machine agents that teach humans. For example, one common education script involves critiquing and coaching a student on the writing process. A machine agent could do much of this work with the proper scripting. Designing machine scripts would also afford scholars the ability to examine commonly used educational scripts for issues of gendered, sexist, or othering language. In other words, we might be able to "challenge sociocultural oppressions" that can occur in teaching (Fassett & Warren, 2007, p. 3). At the same time, there would need to be a greater understanding of what is lost in the teaching context when the human's role is potentially reduced and when human scripts are designed for machine teachers.

A second aspect of the human-to-human interaction script is that people have an anthropocentric expectancy bias for communication. In the instructional context, people assume teachers will be other humans and may experience positive or negative expectancy violations when an instructor is an AI or social robot. For example, if a student possesses a script for interacting with a human teacher but is told to interact with a social robot as a teacher, increased levels of uncertainty might occur. Levels of uncertainty should decrease after communicating with the machine agent in a learning context, but it is unclear whether human-to-human uncertainty reduction scripts will map to the human-to-robot interaction. Finally, a third aspect of the human-to-human interaction script is that humans nonetheless tend to treat and respond to machine agents as if they were people (Reeves & Nass, 1996). In the classroom, this might lead to both positive and negative outcomes. Does the perceived value of teachers increase or decrease when a classroom comprises both human and machine teachers? Would this change lead to dehumanization of other mentoring-type figures? With these assumptions in mind, many communication and instruction theories, variables, and processes that influence human interaction will likely also be useful for understanding the potential advantages and disadvantages of machine agents in educational contexts both within and beyond traditional classrooms.

Parallels in human–robot interaction (HRI) and instructional communication research

When machine agents play a role in teaching, it is important to consider students' impressions of their source characteristics, message behaviors, and relational skills and capabilities. Each class of factors has been demonstrated in instructional literature to contribute greatly to educational outcomes including learning, motivation, and affect toward teachers and material. A number of historic and contemporary communication variables (e.g., credibility, attraction, immediacy, humor) are already receiving attention in the HRI field, although they typically are addressed with different nomenclature and measurement techniques. As communication researchers, we have the vital opportunity to put our long-standing efforts to study the rhetorical, critical-cultural, and relational aspects of teaching/learning (linked to outcomes of varying desirability) into conversation with the efforts occurring in the HRI field. Ultimately, trans-/multidisciplinary engagement will benefit the effort to understand the implications of replacing/displacing humans in the instructional context and identifying best practices for employing human–machine configurations in the educational space. In the following sections, we sketch some areas of promising overlap in the research agendas of communication, instruction, and HRI fields.

Immediacy

The concept of immediacy, or psychological closeness, has been the focus of many studies (e.g., Allen, Witt, & Wheeless, 2006; Andersen, 1979; Gorham, 1988). Instructor immediacy has been linked to student affective learning (Witt, Wheeless, & Allen, 2004) and to instructor credibility (Schrodt & Witt, 2006). Importantly, instructional researchers have adopted a behavior-centered approach to the study of immediacy, focusing on students' perceptions of the frequency with which instructors display verbal and nonverbal closeness/approach-inducing cues (e.g., inclusive pronouns, smiling, nodding). In the fields of HMC and HRI, the related concept of social presence, conceptualized and referred to by scholars as a feeling that one's partner is real and close (referred to as a sense of *mediated immediacy*; Short, Williams, & Christie, 1976), has been identified as an important perceptual variable for understanding human–machine interactions. Instructional researchers are particularly well suited to examine how specific behaviors, whether performed by a person or a machine instructor, may either result in feelings of connectedness and the associated positive outcomes or produce negative emotions in the classroom environment. As AI and social robots are both in the classroom and increasingly at home acting as tutors (Han, Jo, Park, & Kim, 2005), the study of immediacy with machines is warranted.

Credibility

Whether an instructor is perceived as credible or not is an important consideration in the classroom. Credibility—comprising competence, goodwill, and trustworthiness—has been related to positive instructor and student behaviors in the classroom (McCroskey & Teven, 1999; Schrodt & Witt, 2006). Perceptions of AI and social robots as teaching partners will most likely rely heavily on student impressions of credibility. Edwards, Edwards, Spence, Harris, and Gambino (2016) demonstrated in an experiment that a social robot could be perceived as credible in a college classroom, albeit in a limited role of short-term lecturer. This finding makes sense given what we know of the machine heuristic: the idea that that people often prescribe credibility to a machine because it is viewed as unbiased or free from error (Sundar, 2008).

In the field of HRI, credibility is sometimes referred to as *trust* or *machine trust* (Sanders, Oleson, Billings, Chen, & Hancock, 2011). Manipulating various agent characteristics (e.g., levels of interactivity, social presence, and message behaviors) is a good first step in determining how students will perceive the levels of credibility of their machine instructors. The machine heuristic (Sundar, 2008) is a powerful part of this process. In fact, research suggests that even if the machine agent makes some mistakes, those mistakes might not be enough to reduce trust (Salem, Lakatos, Amirabdollahian, & Dautenhahn, 2015). Factor into these complexities the issues of power and privilege that characterize human-to-human interactions, and there is even more to explore. What role does power and privilege play in terms of establishing and negotiating machine trust? Do machine agents change teacher–student power dynamics (as discussed by Golsan & Rudick, 2018)? Can machine agents avoid giving dominant voices more credibility because of status markers like race or gender? And how do these issues emerge in nontraditional instructional contexts like journalism, where social robots, such as Erica the journalist, will teach and inform audiences about issues of the day? These interactions will occur in a wide variety of contexts outside of the classroom (e.g., journalistic, organizational, and family contexts), hence the study of machine credibility will become important to examine.

Teacher clarity

For students to learn, teachers must demonstrate some degree of clarity in communicating information. Teacher clarity is defined as being "concerned with the fidelity of instructional messages" through the use of instructor behaviors (Powell & Harville, 1990, p. 372) and has a strong relationship with learning (Titsworth, Mazer, Goodboy, Bolkan, & Myers, 2015). Instructor vocalic cues, for instance, are an important part of being clear. With SDS, machine agents can have unique voices, pitches, and accents which may offer distinct advantages (or disadvantages) compared with human instructors with a few clicks of a button. Higher pitched social robots have been rated as more attractive (Niculescu, van Dijk, Nijholt, Li, & See, 2013) and the use of less than robotic voices with more local accents has positively impacted user perceptions (Tamagawa, Watson, Kuo, MacDonald, & Broadbent, 2011).

While altering a human instructor's voice for clarity is practically impossible, this is an instructor behavior that can be changed in HMC (Goble & Edwards, 2018). What role will the perception of a machine agent's SDS have on actual learning, perceived comprehension, and ratings of teacher effectiveness? Does the use of an SDS take anything away from instruction or change how identity shapes the teacher/learner experience? Do issues of technological capabilities make a difference if the AI or social robot is in a small classroom environment or being viewed at home in a tutorial setting? Instructional scholars can address many of these issues being discussed about the nature and quality of SDS voices occurring in HRI with regard to enhancing teacher clarity.

Humor

Humor has long been examined as having a positive impact on the classroom when used appropriately and has been correlated with many positive outcomes (Booth-Butterfield & Wanzer, 2010). The study of humor in HRI is relatively new (Mirnig et al., 2017) but is an important variable to consider (Tay, Low, Ko, & Park, 2016). Based on the limited research, we know that perceived social robot humor has been related to perceived task enjoyment (e.g., task attraction in instructional communication research) by a participant (Niculescu et al., 2013). Additionally, participants give higher likability ratings (a construct similar to social attraction) to social robots that demonstrate perceived positive humorous behaviors (Mirnig et al., 2017). Because humor can be an important part of teaching and learning in a variety of contexts, researchers should examine the ways machine agents can use humor to be effective as co-instructors.

Conceptualization of HMC in the context of communication and instruction

Issues related to communication and instruction can be divided into three categories: learning outcomes, student behaviors and characteristics, and instructor behaviors and characteristics (Mazer & Graham, 2015). In addition to immediacy, credibility, clarity, and humor, many other traditional communication variables can be adapted for use with machine agent instructors using SDS: communication satisfaction (Goodboy, Martin, & Bolkan, 2009), instructional feedback (King, Schrodt, & Weisel, 2009), student engagement (Mazer, 2012), and classroom climate (Myers & Claus, 2012). Also, traditional communication theories—such as speech acts (Searle, 1965) or conversational maxims (Grice, 1975)—might shed light on the crucial interactions between machine teacher and student, both in the traditional classroom and outside in a variety of learning environments. Additionally (and as previously mentioned), critical approaches to communication and instruction may also unveil both positive and negative implications of the use of machine agents in classrooms; deconstructing issues such as access, bias, identity, and displacement of human labor could be important avenues for exploration. In addition to these human factors, scholars could also benefit from examining the unique machine affordances and the impacts of the user interface of machine agents on the teaching and learning setting. Negative attitudes toward robots (Nomura, Suzuki, Kanda, & Kato, 2006) could be a factor in the classroom and might merit exploration as well.

The need to study HMC in instructional contexts will continue to grow as AI and social robot instructors find their way into a variety of teaching and learning contexts—within and outside traditional classroom walls—as co-instructors. HMC can unsettle our basic assumptions and expectations about communication and instruction by adding a new type of teacher, perhaps being perceived more as a threat than an opportunity. Yet scholars invested in communication and instruction have much to add to the conversations about possible design, implementation, and evaluation of these new machine agents in the classroom environment. Much like how Erica, the Japanese robot news anchor, will change how people learn about the news, AI and social robot instructors will change the way people learn our content—within and outside the classroom. While the immediate reaction might be to dismiss this new technology in any instructional context, it is essential for scholars of communication to engage in programmatic and rigorous research that will help guide industry and educators toward best practices.

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