Using Robot-Assisted Instruction to Teach Students with Intellectual Disabilities to Use Personal Narrative in Text Messages

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In the current investigation, we evaluated the effectiveness of a multi-component package (i.e., robot, simultaneous prompting, self-graphing) for teaching three students, ages 19–21, with intellectual disabilities (ID) to write text messages that included a greeting, personal narrative, and closing. Data suggest that the package was effective in increasing correct performance for all participants. In addition, participants demonstrated their newly acquired texting skills across different communicative partners.

The rapid development of the digital technologies for establishing and maintaining ones' social network has impacted societal expectations of what it means to be socially competent. Individuals not only must acquire and apply a broad and complex set of social skills to fully participate in their communities, but they also must learn to apply them in the context of electronic social media. This may present a unique challenge for students with intellectual disabilities (ID), as they may have difficulty meeting these increased response requirements for social inclusion that in turn may result in limited access to age appropriate venues for social exchange (Amado, Stancliffe, McCarron, & McCallion, 2013; Chadwick, Wesson, & Fullwood, 2013).

Few research teams have evaluated methods for teaching individuals with ID to use social media. The majority of the research has involved participants' use of microswitches in accessing messaging software. For example, Lancioni and colleagues (2010; 2011; 2013) taught adults with ID to select from prepared lists of communicative partners and/or messages to send texts. This growing but limited body of research reflects an important emphasis on providing access to text messaging tools, but access to these highways for communication is only one of the barriers to the proficient use of social media.

The effective use of social media also requires the application of skills in the area of written expression. Individuals must learn to compose messages that will evoke desirable responses from the reader. Unfortunately, data suggest that acquiring proficiency in written expression is a challenge for many students (U.S. Department of Education, 2011), but especially for students with ID (Bird, Cleave, White, Pike, & Helmkay, 2008; Joseph & Konrad, 2009). Furthermore, there is a paucity of research literature on methods for teaching written expression to this unique population. Much of the available research has addressed spelling skills (Kinney, Vedora, & Stromer, 2003; Purrazzella & Mechling, 2013; Schlosser & Blischak, 2004; Schlosser, Blischak, Before, Bartley, & Barnett, 1998; Stromer, MacKay, Howell, McVay, & Flusser, 1996; Sugasawara & Yamamoto, 2007). Additionally, only a few researchers have addressed skills related to the content of written messages, including writing a sentence to a picture (Yamamoto & Miya, 1999), story writing (Bedrosian, Lasker, Speidel, & Politsch, 2003; Pennington, Ault, Schuster, & Sanders, 2011; Pennington, Stenhoff, Gibson, & Ballou, 2012), and letter writing (Collins, Branson, Hall, & Rankin, 2001; Pennington, Delano, & Scott, 2014).

The majority of the research on teaching writing to students with ID has involved the use of technology (Pennington & Delano, 2012). This is not surprising, as technology offers many benefits to the developing writer. For example, response effort related to challenging motor requirements can be reduced through keyboard or switch use; poorly developed spelling skills can be augmented through word prediction software or by selecting whole words organized in an array; and organizational prompts (e.g., word or content order) may be inserted within visual displays to guide writers during writing. To date, most of the writing research for students with ID has involved technology in the form of desktop or laptop computers, or voice output communication aids (Pennington & Delano). In many cases, these devices were a part of an instructional package directed by a teacher or researcher in a one-to-one instructional arrangement (Pennington, 2010). This teacher-mediated use of technology requires that instructional staff be present during writing instruction and may limit students' opportunities to write throughout the day.

One strategy for increasing independence during writing instruction is to incorporate instructional technology that prompts and provides feedback to students as they write. Although several tools exist that provide support for writing (e.g., spell check, auditory feedback, speech to text), students with ID must first acquire the skills to use and navigate the software. One alternative may be to use technology that directly emulates teacher-student interaction, as students will likely have a history with this instructional format. Recently, there has been an increased interest by researchers in the use of robots as educational change agents (Diehl, Schmitt, Villano, & Crowell, 2012). For example, researchers have investigated the effects of small humanoid robots on the performance of a variety of responses for children with disabilities including interactions (Costa, Santos, Soares, Ferreira, & Moreira, 2010; Kim et al., 2012), play (Wainer, Dautenhahn, Robins, & Amirabdollahian, 2010; Yin & Tung, 2013), asking questions (Huskens, Verschuur, Gillesen, Didden, & Barakova, 2013), and the identification of body parts (Costa, Lehman, Robins, Dautenhahn, & Soares, 2013).

Robots may offer several benefits as a part of an instructional package. First, particular features associated with a robot may serve to reinforce a range of behaviors. For example, Kim and colleagues (2013) found that students with autism spectrum disorders (ASD) produced more vocal interactions in the presence of a robot dinosaur than a human or touch screen computer game. Robots also can be programmed to deliver explicit instruction with high levels of fidelity. This is critical, in that researchers have established a relationship between instructor fidelity and student performance (Dib & Sturmey, 2007; Wilder, Atwell, & Wine, 2006). Finally, learners who may struggle to interpret the messages of others may benefit from the reduced variability in prosody, facial expression, and appearance that is characteristic of robot (i.e., digitized) instructional delivery (Schlosser & Blischak, 2001).

In the current investigation, the researchers evaluated the efficacy of a robot-assisted instructional package to teach students with ID to improve the quality of their text messages. These data contribute to the limited body of literature on the use of robots as change agents in educational programs for students with ID. To date, there are no available data on the use of robot technology for teaching writing or texting skills to students with ID. Furthermore, the researchers targeted the inclusion of meaningful content within the students' text messages. Despite recent emphasis on teaching core content to all students, there is a scarcity of research on interventions to address skills in written expression, especially for students in secondary settings. The current investigation contributes to the body of knowledge on how to teach students to include specific content within written narrative. It addressed the following research question: Is there a functional relation between robot-assisted instruction and an increase in the use of specific writing elements (i.e., greeting, personal narrative, closing) within the text messages of individuals with ID?

Method

Participants

Three students with ID, ages 19 to 21 years, participated in the study. All three attended a public school transition program housed on a university campus. The lead teacher approached the students for participation because they all had previously used the text features of their phones, were emerging Facebook users, and demonstrated an interest in the texting by peers that frequently occurred on campus. All three agreed to participate in the study.

Donald was a 21-year-old white male with Down syndrome. His intellectual functioning was in the mild moderate range as indicated by his full-scale score of 63 on the Wechsler Intelligence Scale for Children 3rd Edition (WISC-III; Wechsler, 1991). His educational records also indicated a score of 88 on the Oral Written Language Scales (Carrow-Woolfolk, 1996). David's teacher reported that he wrote simple personal narratives and persuasive pieces up to a page in length. Prior to intervention, his texting responses primarily consisted of questions to a communicative partner (e.g., What are you doing this weekend? When can you hang out with me?).

Emma was a 19-year-old white female with Down syndrome. Her intellectual functioning was in the moderate range as indicated by her IQ score of 52 on the Stanford-Binet. Emma's teacher reported that she had learned to write thank you letters consisting of three sentences, but generally produced list of words during other writing tasks. Prior to the investigation, her text messages primarily consisted of randomly organized lists of words (i.e., Good me as to sad food at you eat we).

Kendall was a 21-year-old female with ASD and moderate ID. She had an IQ of 40, as indicated by performance on the WISC-III (Wechsler). Kendall scored a 40 on the Oral Written Language Scales (Carrow-Woolfolk). Her teacher reported that she could write four- to five-word sentences with prompts for word order and spelling. Prior to the study, Kendall's texts consistently and almost exclusively contained the message, Hi, Watch up?

Settings

The researchers conducted all sessions in a transition classroom on the university campus. Students spent part of their day in the classroom, where they received academic and life skills programming. The rest of their day was spent in university courses and campus activities. All instructional sessions were conducted behind a 1.8m wooden divider in the back corner of the classroom. A white sheet was hung on the divider behind the participants' head. Each participant sat in a chair facing a robot that was placed on a small (1.8 x .81m) table.

Materials

During instructional sessions, a humanoid robot (see Figure 1) delivered response prompts. The robot (NAO model H25, Alderbaran Robotics) was 58cm in height and included two computers and a range of sensors, motors, and actuators that allowed it to simulate human mobility and detect movement in others. The robot was equipped with a voice synthesizer, voice recognition software, high-fidelity speakers, and microphones that allowed it to receive and respond to auditory input from a participant. Two cameras were located on face area of the robot and were used to interpret visual information in order to detect and recognize faces and complex objects. During all sessions, the participants typed and sent text messages using the iMessages application software on an iPhone 4. This texting software maintains conversations across devices, allowing for analysis from an Apple desktop computer. Finally, the teacher provided a paper bar graph on which

Figure 1

Humanoid Robot (NAO model H25).

the participants recorded the number of components they used during each response.

Response Measurement

Data were collected on the occurrence of three components within each text message. Prior to intervention, the first author met with a class of undergraduate students enrolled in a special education course to identify age-appropriate components to targets within participants' text messages. Following an informal discussion, the group identified three acceptable components that included (a) a greeting, (b) a statement about an activity or event they engaged in (personal narrative), and (c) a closing.

Each day, the teacher presented an opportunity to text a communicative partner and scored the occurrence of three targeted components within the text. An occurrence for Component A was scored if it occurred prior to the other two components and included a greeting (e.g., Hi, Hello) or a nonspecific question (e.g., What's up). An occurrence for Component B was scored if the participant included a sentence or phrase related to a personal activity or event (e.g., Played flag football). Finally, an occurrence for Component C was included if the participant included a closing (e.g., Bye, Later, See ya). Data were reported and graphed as the number of unprompted components included during each daily probe.

Reliability. The researchers collected both dependent and independent variable reliability data. Both the lead teacher and a member of the research team independently scored the text messages for the number of components. The texts were printed along with their corresponding date and sent to the scorers. We used the point-by-point method to calculate dependent variable reliability by dividing the number of agreements by the sum of agreements and disagreements and then multiplying by 100. During the investigation, the researchers collected interobserver agreement data for 94% percent of total sessions across all three participants. Agreement across all participants averaged 91.8% (i.e., 90.9%, 84.6%, 100%).

The researchers also collected independent variable reliability (implementation fidelity) data for each participant weekly and across all conditions (83% of sessions). During daily probes, the teacher was scored on (a) the delivery of a prompt to text, (b) the provision of help for only spelling, and (c) a prompt to wait for a command to read the response from the communicative partner (if needed). During instruction, data were collected on the occurrence of a response from the communicative partner only. This was primarily because we observed no malfunctions of the robot during treatment. Independent variable reliability was 100% across all participants.

Experimental Design and Procedures

The researchers used a concurrent multiple baseline across participants design to evaluate the effectiveness of instruction on the participants' use of text components. Baseline data were collected for a minimum of 5 days across all participants. Subsequently, intervention was introduced to the first participant and continued until the participant met criterion (i.e., 3 consecutive sessions at 100%). Intervention conditions for the second and then the third participant were introduced following 4 days of performance above baseline levels for the previous participant. In addition, the researchers conducted generalization probes to assess each participant's performance when texting a different communicative partner.

Daily probe sessions. During baseline and intervention conditions, each participant sent a text message to the same communicative partner. The partner, a member of the research team, had prior history interacting with the participants through community and university activities. At the beginning of each daily probe, the teacher prompted the participant to send a text to the partner. The teacher informed the participant that she would be available to help with spelling but could offer no other assistance. Upon receipt of the text, the researcher responded with general feedback (e.g., Cool, OK).

The researchers added a graphing instructional component to the daily probe session for two of the participants following several days of intervention. The addition was proposed to address variability in Emma's responding, but the classroom teacher recommended adopting the graphing component for both Emma and Kendall based on her prior knowledge of the students. Upon completion of each text, the teacher asked the participant if he or she had included each step. If the participant incorrectly identified the occurrence or omission of a component, the teacher provided the correct response. The teacher then asked the participant to shade the number of squares on a bar graph corresponding to the number of components present in the text message.

Generalization probe sessions. During the generalization probe, the teacher used procedures identical to daily probes, with the exception that the participant was asked to send a text message to a different communicative partner. The same paraprofessional with prior experience working with the participants served as the communicative partner during all generalization probes.

Training sessions. We conducted history training prior to intervention to reduce the adoption threats resulting from the novel exposure to the robot, whose name was NAO. First, NAO was programmed to introduce himself to the entire class. During this session, NAO stood at the front of the class, introduced himself and then performed a dance routine. Additionally, we conducted a single training session with each participant prior to baseline sessions. During this session, we reintroduced each participant to NAO, provided an opportunity to touch NAO, and conducted a practice training sequence. During this sequence, we explained that NAO would provide directions and the participant was to respond via text message. We directed the participant to wait for NAO to finish talking before responding. Next, NAO asked the participant to type a word unrelated to the study (i.e., name, colors). Subsequently, NAO responded with positive verbal feedback. Finally, NAO performed a Thai dance that came standard in its programming. This session lasted approximately 10 minutes.

Intervention Sessions. At the beginning of each session, one of the researchers reminded the participant to speak clearly and ask for spelling assistance if needed. During each session, NAO instructed participants to use specific components in their text messages. First, NAO stated, "Today we are going to work on writing cool text messages. Are you ready?" and waited 5s for the participant to look at it and respond by saying, "Ready" or "Yes." If the participant did not respond, NAO repeated the cue. Subsequently, NAO asked the participant if his or her phone was ready and waited 5s for a response. Again, if the participant did not respond, NAO repeated the question. For both steps, all students responded with no more than one repeat of the question. Next, NAO directed the participant to type a greeting (i.e., "First, you will need a greeting. You might say, Hi or what's up."), and waited for the participant to type the message and indicate completion. If the participant did not say that he or she was finished within 20s, NAO asked the participant if he or she was finished and waited 5s for the participant to respond. If the participant said "No," NAO provided approximately 20 additional seconds. If the participant indicated completion, NAO delivered a praise statement and prompted the participant to a type brief personal narrative (i.e., "Write about something you did recently."). Again, NAO waited, asked the participant if he or she was finished (if necessary), and delivered a praise statement. Finally, NAO prompted the participant to include a closing (i.e., "Now you need a closing. You might say bye or see you later."). Again, NAO provided the response interval and contingent praise. After the participant completed the final step of the task, NAO reminded him or her to send the message. Upon receipt of the message, the researcher responded with praise and a related response for messages containing all three components. If a component was missing, the researcher added a feedback statement (e.g., "Don't forget your closing."). At the end of each session, NAO offered to sing a preferred song and dance for the participant. A day prior to each session, we asked participants to identify one of their favorite songs. A member of the research team (i.e., the second author) programmed the song for play the next day.

Results

Donald

During baseline sessions, Donald consistently texted questions to his communicative partner (i.e., "What are you doing this weekend? When is the best time for you hang out with me? What is the date in two weeks from yesterday?"). Following the introduction of intervention, he met criterion within 4 sessions. At 2 weeks following instruction he used all three components, but at 4 weeks he included only two elements and an additional question (i.e., "Do you want to hang out with me sometime soon?"). During the generalization probe, he used of all three components when asked to text a different communicative partner. Finally, following the introduction of intervention, David described five different events within his text messages (e.g., "Went to trampoline park, won 45 bucks in the Derby").

Emma

During the baseline condition, Emma consistently included no components in her text messages. Her messages included lists of words that could not be interpreted by the teacher or the researcher. After the introduction of intervention, Emma increased her use of targeted components but demonstrated variability in responding. On day 12 of intervention, the team decided to make a change that required Emma to graph the number of components that she included in her text messages during daily probe sessions. Subsequently, Emma continued to display variability but ultimately met criterion on the 21st day of intervention. During her generalization probe, Emma used all three components when texting to a different communicative partner. Maintenance probes were not conducted due to the termination of the study at the end of the school year. Following the introduction of intervention, Emma described five different events within her text messages (e.g., dance team practice, going to baseball).

Kendall

During the baseline condition, Kendall used one component (i.e., "Hi, watch up") across all probes. During intervention, she continued to use the single element. One Day 6 of intervention, we added the graphing requirement to daily probes. Kendall met criterion on the 10th day of instruction. In addition, she maintained the use of three components at 1 and 2 weeks following instruction and used all three components during the generalization probe. Following the introduction of intervention, Kendall described six different events within her text messages (e.g., "Went to Walgreens, Got my haircut, Planted flowers").

Discussion

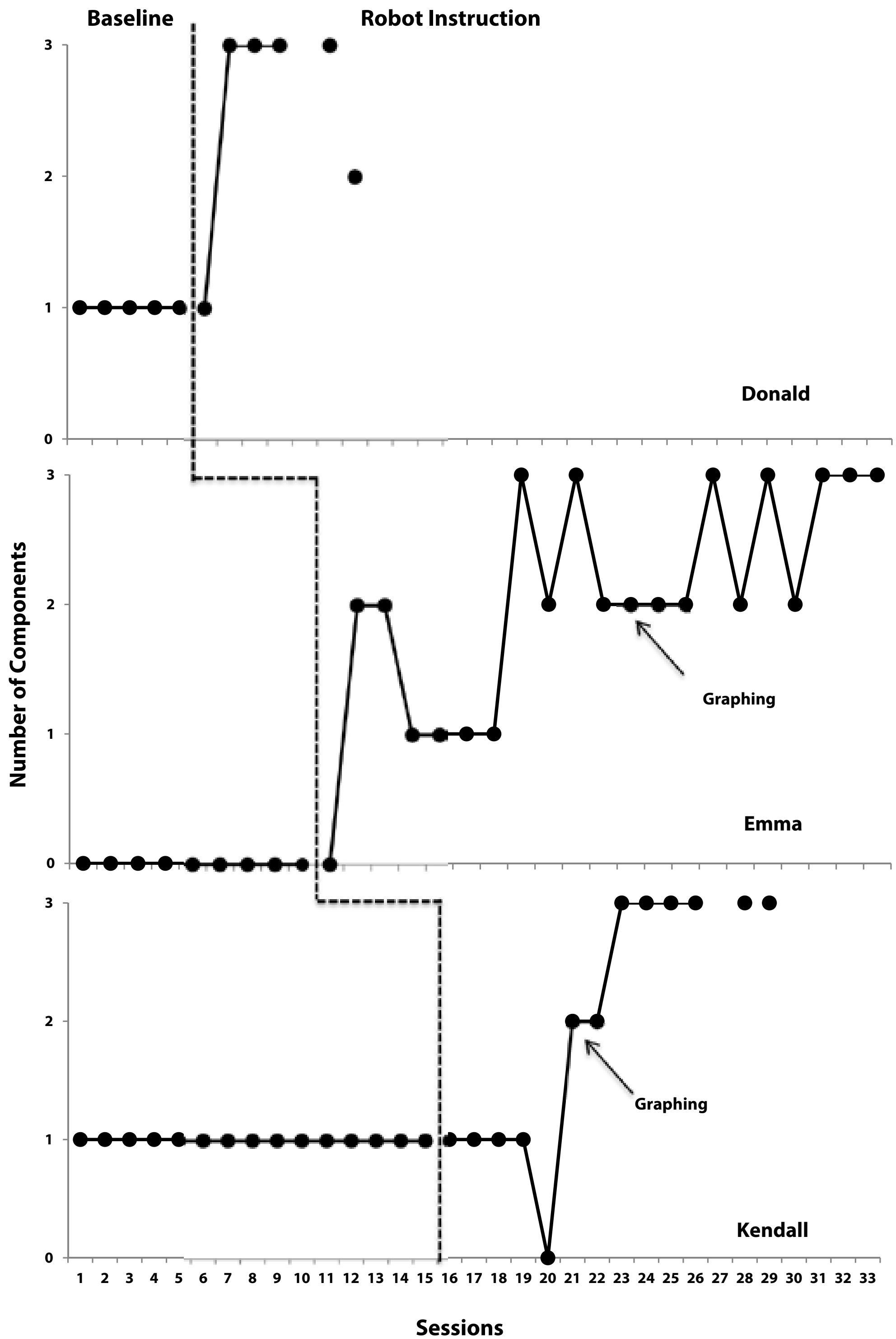
In the current investigation, we evaluated an instructional package (i.e., robot, prompting, feedback, self-graphing) to teach participants with ID to improve the quality of their text messages. All of the participants increased the use of targeted components during instruction and generalized skills to a different communicative partner (Figure 2). Two participants demonstrated maintenance after the intervention was terminated. Interestingly, all of the participants' data reflect some latency in response to intervention. We believe that these patterns are not atypical for many learners with ID (e.g., Parrott, Schuster, Collins & Gassaway, 2000; Pennington et al., 2012, Pennington et al., 2014). Additionally, since the participants' first responses during intervention were often similar to those during baseline conditions, it may have been that those particular responses had been established firmly through a history of reinforcement. Our overall findings are consistent with previous research demonstrating that participants with ID can acquire the use of a variety of predictable writing elements (Collins et al., 2001; Pennington et al., 2012; 2014) and are not surprising, as the instruction of predictable routines has been recommended for struggling writers without disabilities (Graham & Harris, 2009).

One advantage to teaching predictable writing routines is that they may serve to mediate generalization (Stokes & Baer, 1977). Once established, these routines (i.e., required elements) may serve as a common bridge to new audiences and across different content. Future investigators should evaluate the extent to which these routines can be used to facilitate broader generalized responses across media (e.g., emails, computer messaging); across communicative partners (e.g., familiar vs. nonfamiliar peers); and across response topographies (e.g., verbal communication, handwritten notes). Furthermore, it may be important to assess whether these routines may in some cases restrict participants' performance as they may limit their responses through strict adherence to the targeted routine.

In the current investigation, a robot presented instructional components traditionally delivered by a human instructor. This is critical in that robots may be used increasingly to supplement teacher-delivered instruction within educational settings. Several issues concerning our inclusion of NAO warrant further discussion. First, although all three participants appeared to enjoy working with the robot (i.e., positive student comments, request to work with NAO), it is not clear that NAO contributed to the facilitative effects of the instructional package. It might have been the case that a peer or novel instructor may have produced similar outcomes. Although the use of robot technology may occasion visions of futuristic classrooms filled with automated instructional technologies, it will be important to carefully establish the most efficient and effective models through rigorous efficacy and comparative studies. These analyses must include comparisons of human- and robot-delivered instruction across a range of instructional settings and content. In addition, researchers will need to evaluate the relative effectiveness of different features of robot hardware and software. For example, in the current study, we programmed NAO to use human gestures (e.g., moving arms and hands) while talking, but it may be the case that these motions were distracting and may have inhibited performance.

Figure 2

Increased use of targeted components by participants during instruction and generalized skills to a different communicative partner.



Second, although NAO provided prompts and delivered praise, it was unable to provide specific feedback on the quality of participant responses. Following prompts, NAO praised participants after they indicated they were finished, but it did not analyze the participants' actual texts. NAO potentially could have delivered praise for an incorrect response. In the current study, we addressed this issue by requiring the communicative partner to inform the participant of an error by simply stating that the element was not included. Fortunately, this was not required for two of the participants and was only required once for Emma. Future investigations should include direct assessment of individuals' texted responses via automatic text mining technology.

Third, it is important note that, following a pilot test with a participant not included in the current study, several modifications were made to improve NAO's voice recognition capability. First, NAO was sensitive to background noise, so in addition to conducting sessions behind a wooden divider, we asked the students not participating in the study to talk quietly. This increased the intrusiveness of the intervention, as it required changes in the routine of nonparticipants. In future investigations, instruction may be delivered in a separate room, during naturally occurring quiet times, or with the use of microphones with greater filtering capability. Second, we programmed NAO to confirm participant responses (e.g., "I heard, Yes. Did you say, Yes?"). This decreased errors in voice recognition resulting from loud background noises or the participants' level of speech intelligibility.

Finally, the cost of robot technology is likely prohibitive for most educational settings. In the current investigation, the researchers purchased the NAO robot model H25, for $13,750. The H25's body resembled the human body, with articulated arms, fingers, and legs versus the truck-like bases of other robots. Therefore, NAO could mimic human representations for behavior, modeling that might have been more accepted as an instructor or peer. Pared down versions are available. For example the NAO T2, which is a torso version of the robot, costs $4,000. Although robot technologies currently are too expensive for use in most local school settings, they will likely become more affordable and accessible in the future. This delay may be advantageous, as it will provide researchers opportunities to work through iterative refinements of the technologies and investigate their potential utility.

In this preliminary investigation, we employed a robot to deliver response prompts while teaching students to compose text messages including target components. Although our instructional goals may have been deemed socially valid through normative comparison (Wolfe, 1978) to a set of same-aged peers, we acknowledge that proficient text messaging requires a broader writing repertoire. Future research must address establishing texting repertoires that include writing for multiple purposes (e.g., manding for information, commenting on popular media). These data will add to the paucity of research available on writing instruction for participants with ID. Perhaps more importantly, they will demonstrate how targeting academic skills within meaningful contexts potentially can result in increased access by traditionally marginalized individuals to an expanded world of social reinforcers.

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