Kim, Y., Bingham, E., Marx, S., Nguyen, T., & Pham, H. (2018). *Exploring robot-child interaction with linguistically and culturally diverse school children*. The Annual Conference of American Educational Research Association (AERA): New York. April 13 – April 17, 2018.

Exploring Robot-Child Interaction with Linguistically and Culturally Diverse School Children

Abstract: This study explored the viability of a robot to help provide inclusive contexts for children in public schools. We designed robot-mediated collaborative activities for kindergartners in the U.S., whose home language was either English or Spanish. Through ethnographic observation of twenty-four children paired cross-culturally, we examined children's participation patterns in the activities. We found that children were more engaged in the activities when mediated by a robot than by a human. When encouraged, children made observable efforts to work together even over occasional language barriers.

1. Purposes

Over the years, student population in public schools worldwide has been becoming more diverse due to various personal, social, and political reasons. This trend continuously spurs the need for inclusive curricula and constructive instructional contexts that support all learners from various cultural and linguistic backgrounds. Considering that many public schools are limited in resources and training to address student diversity, the authors have explored the use of advanced technology, a humanoid robot, to determine whether a robot can be a viable tool to create inclusive learning contexts. The effectiveness of technology integration is known to be higher when technology is used with early ages than later (Cheung & Slavin, 2013); young children are prone to attach to digital toys socially and emotionally (Turkle, 2011). In this study, therefore, the authors designed triadic collaborative activities for kindergarten-aged children, where a

mediator (either a human or a humanoid robot) encouraged two children to collaborate. To determine the effectiveness of this mediation, we ethnographically observed twenty-four children's participation patterns in human-mediated and robot-mediated interaction activities over the course of a school semester.

2. Theoretical Framework

2-1. Needs for Inclusive Contexts in Schools

Globally, many families move abroad to pursue economic and educational opportunities temporarily or permanently. Additionally, political and economic challenges worldwide have contributed to an increasing number of people displaced from their homeland (United Nations High Commissioner for Refugees, 2015). Gaining fluency in the language and culture of one's new community is a requirement for success, and schooling is an important resource enabling children to develop essential skills in the target language and culture.

In reality, however, schooling can be a challenging and even alienating experience for language and cultural minorities. Around the world, evidence shows that children not fluent in the target language and culture consistently fall behind in scholastic achievement (e.g., Kena, Musu-Gillette, Robinson, Wang, Rathbun, Zhang, & Dunlop Velez, 2015; Kigel, McElvany & Becker, 2015; Saunders & Marcelletti, 2013). More troubling is that this achievement gap persists even when second language learners become fluent in the target language (e.g., Kigel, McElvany & Becker, 2015; Saunders & Marcelletti, 2013). This phenomenon is often attributable to less favorable social and instructional climates in schools that marginalize and devalue language and cultural minorities (Valencia, 2010; Marx & Saavedra, 2014). This marginalization can lead to the development of negative self-concept, weak confidence in

academic success, and dis-identification with schooling. The provision of inclusive programs is necessary and urgent to support the growth of all children into confident and capable learners.

2-2. Children's Interactions with Humanoid Robots

It is well known in human computer interaction research that human computer interaction is similar to human to human interaction (Reeves & Nass, 1996). Particularly with young children, the distinction between digital and real beings seems minimal (Turkle, 2011). Many children treat digital toys much like they do real toys and humans, even developing social and emotional attachments to the digital toys. Especially, humanoid robots can afford social and affective benefits for children. Children develop social and affective relationships with a humanoid robot (Westlund & Breazeal, 2015; Robins et al., 2010), voluntarily sustaining engagement in the learning tasks that are mediated by a robot, regardless of their cultural and linguistic backgrounds (Kahn, & Shen, 2013; Kim & Smith, 2017). The humanoid robots in those studies seem to allow learners to confidently collaborate on tasks and interact freely without social embarrassment. From this, the authors inferred that the robot could be used as a supplemental tool. It might serve as a mediator to connect English learning children with other native English-speaking classmates and dominant classroom culture, who otherwise might feel isolated due to the cultural and linguistic differences between the home and school environments. This study was conducted to test this conjecture.

3. Method: Research Questions and Mode of Inquiry

For this exploratory research, we had one big question: *What interaction patterns emerge as native Spanish-speaking and native-English speaking children together collaborate with the robot?* To find answers, we used a design-based research approach, where data were collected

through ethnographic observation. Based on communication theories, we crafted utterances for a mediator to facilitate equitable collaboration among children. We implemented and observed children's interaction activities in a triad with two children and a mediator (human and robot in a separate session). We continuously refined mediation utterances as we observed children's interactions.

3-1. Data Collection

We visited a kindergarten classroom over the course of a fourteen-week semester. Cross-linguistic pairs of children met for fifteen minute sessions, twice a week, for a total of 45 transcribed sessions. To continually improve robot utterances, a bilingual research assistant acted as the robot for the first several weeks, interacting with the pairs at a separate table in the classroom. This assistant was able to spontaneously react to children's questions in English and Spanish, provide clarification, and modify strategies when necessary. The research team video-taped these interactions and studied the children's and research assistant's communications each week, compiling a long list of utterances that could be programmed into a robot, allowing the robot to eventually replace the human assistant. After several weeks, the robot replaced the human. The robot interacted with the cross-linguistic pairs of children in a separate room, so as to not distract other children in the classroom. Robot-mediated sessions included the pair of children, the robot, and a human moderator to assist with child-robot interactions only if necessary. In this Wizard of Oz setting (Riek, 2012), a researcher hidden from the scene remotely controlled the robot while watching and hearing the children's interactions. The research team continued to collect video data and refine the communication utterances.

3-2. Data Analysis

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We video recorded and transcribed each session and, using the qualitative data analysis program MAXQDA, coded emerging themes in the children and mediator interactions. To ensure accuracy, each video clip was transcribed by a research assistant and then verified independently by another student researcher. A senior researcher finally verified the transcript once more. The transcripts were then analyzed twice using the coding feature of MAXQDA. During the first analysis, codes were established based on the three key research questions. This helped identify broad trends and themes. All transcripts were then analyzed again to examine individual aspects of the key themes.

4. Material and Participants

4-1. Intervention: Children's Interaction Sessions

From an extensive review of communication literature, we derived a set of communication strategies that seemed optimal for engaging children in intercultural communication: 1) building common ground between all interactants (robot and children; children and children), 2) Developing coordinated meaning so children can understand one another, 3) Building an equitable partnership between all interactants, and 4) Building a co-cultural schema where students create ideas together (Gudykunst, 2005; Littlejohn & Foss, 2009). From these strategies, we crafted utterances a robot might use to initiate and then extend productive, respectful, and engaging conversations between native-English-speaking and native-Spanish-speaking kindergarteners. Instead of acting as a teacher that teaches the students, we designed the mediator to ask for help in four topic-based episodes, where children had to work together to help the mediator to learn the topic. The topics dealt with

animals, birthday parties, school, and family.

4-2. Participants

Participants were twenty-four kindergarten children in a public elementary school in a mountain-west state of the United States. The school has a high rate of families living near or below the poverty line. The kindergarteners included in the study were part of a supplemental hour of instruction for children needing additional review of class material. The children were divided into twelve pairs, with an intent to form cross-cultural, cross-linguistic (English and Spanish) partnerships. While all children participated, culturally diverse pairs consisting of both English and Spanish speakers were studied by the research team.

5. Results: Observation and Discovery

Two main themes emerged: 1) children were more engaged with the robot mediator than they were with the human mediator and 2) the children were affectionate with the robot, asking about it and giving it physical hugs. We will discuss these two major themes below.

5-1. Children More Engaged with Robot Mediator than Human Mediator

A clear difference was observed in children's interactions with a human mediator compared to a robot mediator. First, children stayed much more engaged with the robot than the human over the course of the study. Over the course of the 45 transcribed sessions, the children got distracted or changed the topic of the conversation 79 times. 66 of the interruptions occurred during a human-mediated session, while only 13 occurred during a robot mediated session. Furthermore, when a distraction did occur during a robot-mediated session, it was quickly corrected when the robot asked clarifying questions, called on a child by name, or presented an

image on the affixed phone, prompting children to come closer and give the robot their full attention.

This kind of engagement was quite different than with the human mediator. Several times, we observed the human mediator deviate from the prepared conversations, digress from the topic at hand, become flummoxed from a child's unanticipated behavior, or indicate lack of preparation for the session. The human also occasionally dominated the discussion, talking more with one child than another. Examinations of the data showed that children were twice as likely to not follow directions, even to the extent of clearly refusing to do as asked, while working with the human mediator as compared to the robot mediator (32 instances occurred with the human mediator, while 16 occurred with the robot). In six instances, the children even tried to trick the human moderator. See Table 1 for an example of this difference in engagement.

5-2. Children Showing Excitement and Affection for the Robot Mediator

Others signs that the children were engaged with the robot and eager to participate in activities with it were the excitement and affection they eagerly showed it. When a researcher entered the classroom, looking for participants, several children would jump up to volunteer to meet with the robot. Several examples from our researcher journal highlight the children's excitement; these are presented in Table 2. Children's names are replaced with xxx. As the weeks passed with the robot mediator, Skusie, children's affection toward it grew. Researchers observed children sitting closer to Skusie and frequently touching it. The research team had to add utterances to the robot that asked children to "Put me down!" The team also added commands that would move Skusie toward quiet children or move it away from children who could not stop touching it. Several children warmly hugged Skusie when the activities finished.

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Because children were so affectionate with Skusie, the team added emotional utterances to Skusie, including, "I want a hug," "I'll miss you," and "I love you." Figure 2 shares some images of the children showing their affection to the robot.

6. Significance

Aligned with the theme of the AERA meeting in 2018, this study took advantage of a state of the art technology (humanoid robots) to address an urgent challenge that public education worldwide faces these days: the provision of equitable opportunities for all children to learn regardless of their backgrounds. When encouraged by the robot, children from the mainstream culture and from Hispanic/Latino families practiced to work together, sometimes over the language barrier. Our findings overall confirm the viability of educational robots as a helpful tool to provide inclusive instructional contexts for minority children to exercise their full capacity and for children from the mainstream culture to understand diversity as meritorious. As children continue to do this kind of collaborative practice and learn to accommodate and adjust to differences, very likely, the children can broaden and deepen their frameworks of mind, as well as being able to think with empathy.

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Table 1

Human Mediator with Unengaged Child	Robot Mediator with Unengaged Child
Mediator: Well we're going to play a new game today. **Child 1:** Nyaaahhh! **Mediator:** And remember- **Child 2:** No. The same game. **Mediator**: No a new game. I'm in charge and I say new game. **Child 2:** The same game as the new game? **Mediator**: No, different game. Because it's a new game. (Child 1 touches the mic) K, leave that there. Um, so, remember that I don't come from this planet, right? And that I need help learning a lot of things, right? **Child 2:** You doooo! **Mediator:** Well we're just pretending for today. Can we play? **Child 1:** Yeah. **Mediator**: Ok. **Child 2:** Noooo. (unintelligible)	**Robot:** Huh? I don't get it. Can you help me [decide what to plan for a birthday party, Child 1]? **Child 1**: No. **Robot**: Why not? **Child 2**: Go! **Child 1**: Go! **Robot:** Could we do this on my friend's birthday? [shows image of laundry] [Both children come close to robot, studying phone] **Child 1:** No. **Child 2:** No. **Robot:** Why not? **Child 1:** [It's] folding laundry. **Robot:** (Child 1), do we do the laundry for a birthday? **Child 1:** No. **Robot:** Why not? **Child 1:** (takes off his shoes) I'm scratching my toes. **Robot:** Huh? Huh? Can you say that again? **Child 1:** Ha. (imitating the robot) **Child 2**: (Laughs) **Child 1:** Ha. Ha. Ha. **Robot:** Huh? **Child 2:** (Whispers something to Child 1) **Robot:** I don't understand. **Child 1**: Chocolate weezeberry. (Laughs) **Robot**: What is this? [Again flashing image] **Child 1**: Laundry. Laundry. **Robot:** Terrific. Thank you. Can we do this on my friend's birthday? **Child 1**: No!

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Table 2
Examples of Children's Excitement To Work with the Robot

• As soon as xxx and xxx entered the room, xxx yelled, "Skusie!" xxx was overjoyed to see Skusie again.
• Almost every day we have gone to the school, children have asked Skusie questions. Today, xxx asked, "Do you love Sam?" [another robot we have discussed] This adds to what we have already seen- we need to have more options for emotion in Skusie because the robot is so real to the children.
• Like xxx, xxx was super excited to meet with Skusie. She told the researcher, "I love Skusie!" when she left the kindergarten room to meet Skusie.
• When the researcher picked up xxx & xxx they were both really excited to talk with Skusie. While xxx was hesitant last Thursday, he was very excited to drop everything today and talk with Skusie today. "What are we going to talk about today?" he asked excitedly.
• Xxx was super excited to talk with Skusie. She told the researcher, "I love talking with Skusie!" several times.