Playful learning and development
Young children’s embodied interactions with a social robot

Social robots are a popular choice for supporting learning and development of children intellectually, physically, and socioculturally. Yet, there has been little research examining social robots from the perspectives of student diversity and embodied cognition and learning design. Professor Yanghee Kim and her research team have designed a humanoid sociable robot, a new tool to facilitate children’s learning experiences more naturally and holistically. They have also developed a selection of child–robot interaction activities, including some that foster equitable collaborative interactions among culturally and linguistically diverse children.

The coordination of intellectual, emotional, sociocultural, and sensorimotor development integrally is a key characteristic of childhood development, and proficiency in early sensorimotor skills has an influential impact on developing the part of the brain that enables proficiency in learning of mathematics and science later. Also, students who speak English as a second language tend to struggle both academically and socially at school. These learners have a dual burden: learning English as a language as well as learning through English. Low expectations, negative stereotypes, and racialised learning pathways can negatively affect their learning and identity. If they are to succeed academically, children from diverse backgrounds should be integrated in schooling, both socially and culturally. However, many children attending public schools lack access to resources to support their cultural and social integration.

The research team is addressing these challenges. Kim describes how the CREATE researchers have designed a humanoid sociable robot — a new tool to facilitate embodied learning experiences and mediate collaborative interactions among culturally and linguistically diverse children.

**PHYSICALLY EMBODIED ROBOTS**
Social robots are physically embodied, life-like robots that interact in a human-like way. Much of the research and development on social robotics has been directed at their social and emotional behaviours. Researchers have found that both young and old users respond socially to the robots. Also, physically embodied robots can act as playmates for young children, supporting more highly developed social and emotional relationships than other mobile devices.

**DESIGNING A SOCIAL ROBOT**
The toy-like robot, Skusie, is made up of four components: the robot, robot controller, main controller, and server. The theories of child development, embodied cognition, intercultural communication, and culturally sustaining pedagogy underpin the work of the CREATE researchers. This research addresses the developmental characteristics of children when designing the robot-mediated interactions for culturally and linguistically diverse young children. The playful learning activities centred on Skusie, a robot from another planet.

**RESEARCH ON DESIGN CHALLENGES AND SOLUTIONS**
To design, test, and improve the robot’s interactions with children, the researchers combined design research with ethnographic observations over a ten-week period in a real-world classroom setting. In this study, 24 kindergarten children were divided into pairs, forming cross-cultural, cross-linguistic English and Spanish partnerships. The children moved around with Skusie, performing various activities while Skusie asked each pair of children about their personal experiences, prompting them to tell their own expanded stories.

As both Skusie’s skills and the activity sessions improved, the children’s engagement grew. Towards the end of the study, the children would excitedly inquire about Skusie and often said that they loved the robot. They wanted to know more about Skusie’s friends and home planet and often came up with their own imaginative answers.

The researchers recorded the sessions, transforming them into verbatim transcripts which were coded and analysed together with the researchers’ journals and field notes from all classroom interaction and weakly researchers’ meetings. Multimodal data analytics revealed four main themes characterising the challenges and solutions involved in designing interactions for children.

**Anticipating children’s communication styles with flexible design**
The language and behaviour of 5- and 6-year-old children are still developing, and their word order often differs from that of adults. When this study was conducted, automatic speech recognition software that understands and responds to kindergarten language did not exist. Furthermore, the children frequently deviated from the conversation track that the researchers expected. As a result, the researchers modified the robot so that it listened more than it spoke, thus encouraging the children to share their stories.

**Inviting children to participate with personalised, friend-like communication**
Their second challenge was engaging children equally in the sessions so they would have positive collaborative experiences. Adapting Skusie to call the children by name invited even shy children to participate equally in activities. Using phrases that kept the children’s attention on the activity made the human–robot interaction more natural, with the children talking to Skusie like a friend.

The robot’s bilingual feature was essential in integrating Spanish and English speakers equally within the learning environment.

The researchers anchored activities on the children’s prior knowledge and familiar experiences, drawing on their everyday experiences and knowledge about their school, family, and other topics. This boosted their confidence; Kim says, ‘their enthusiasm for this activity was a clear indicator of its success.’

**Embracing language diversity with a bilingual robot**
The fourth challenge involved making the activities equitable and culturally sustaining for all children. Skusie was designed to be bilingual in Spanish and English. While most of the participants were English speakers, a few Spanish speakers were included in the classroom. The opportunity for him to engage with Skusie in Spanish allowed him to be a fully integrated member of the classroom community. The robot’s bilinguality was essential in integrating Spanish and English speakers equally within the learning environment.

**RESEARCH ON EMBODIMENT IN CHILD–ROBOT INTERACTION**
Over the past decade, social robots have grown in popularity for supporting young children’s learning and
Behind the Research
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Research Objectives
Yanghee Kim aims to design advanced technologies to help address educational challenges. Her research has focused on positive learning experiences for those from culturally and linguistically diverse backgrounds.

Detail
Bio
Yanghee Kim, PhD is the LD & Ruth G Morgridge Endowed Chair, Professor of Educational Technology, and Director of the Center for Cross-disciplinary Research on Equitable Advanced Technology for Education (CREATE) at Northern Illinois University. Her research deals with human–computer interaction design, with an emphasis on virtual agents and humanoid robots, learner affect, multimodal behavioural analytics, and cultural and linguistic diversity.

Funding
• The US National Science Foundation

References

Personal Response
Do you have any plans to expand Skusie’s language skills to include other languages in addition to English and Spanish?

Definitely. The robot system for our research is compatible with the Android multilingual API. The robot’s language skills can be expanded to as many languages as the API affords, with relatively minor enhancements.

Social robots can facilitate the embodied interactions of young children while they learn foundational academic skills and concepts.

Fluid learning space
The robot’s movements appeared to trigger the children to change their postures and locations around the robot. The children often made sure that Skusie could see what they were doing as they voluntarily re-positioned themselves within the robot’s visual field. Analysis confirmed that the children’s learning space was fluid, and their engagement was mobile in the learning activities with the robot. Furthermore, the children demonstrated extended attention and embodied explanations with gestures accompanied their verbal answers.

Appropriation of physical space
The children often accompanied their verbal descriptions with physical drawings in the air or on the floor. These drawings were usually larger than the children, so they had to use their hands, arms, and whole body at the same time.

A viable tool to facilitate learning
Kim concludes that an embodied robot can serve as a catalyst for children to use their bodies for thinking and communication. Its presence provides a space for interaction, influencing embodiments and permitting children to regulate their own learning and engagement. ‘A physically embodied, humanoid robot is a viable tool to support children’s natural and holistic development, thereby facilitating their learning in a developmentally appropriate way.’

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Development. While much research demonstrates the robots’ potential for children’s intellectual and social development, there has been little research examining social robots from the perspective of embodied cognition and embodied learning design. Embodied cognition postulates that our cognition is based on our bodily interactions with social, cultural, and physical environments.

Kim’s research team hypothesises that social robots ‘can facilitate the embodied interactions of young children while the child learn foundational academic skills and concepts.’ This led them to examine the interaction behaviour of children in robot-mediated activities and investigate the affordances of the robot for enabling young children’s embodied learning experiences. The researchers carried out two studies to explore Skusie’s affordances in engaging children in play and learning from an embodied cognition perspective. This line of inquiry was unprecedented, so the researchers employed a grounded-theory approach, collecting data and employing learning analytics to locate emerging patterns in children’s interaction behaviours repeatedly across the robotic activity sessions.

1. Robot facilitation for embodied engagement
For the first study, the researchers designed one-on-one child–robot interaction activities. They observed how the robot’s embodiment prompted embodied reactions of the children while they played and learned with the robot one-on-one. Analysing the data revealed two distinct patterns.

Rich multimodal interaction
Unlike interactions with other digital media, the children’s interactions with the robot were not restricted to only a stationary screen. Instead of holding the device with their hands or using a mouse or keyboards to respond, Skusie moved its head down to present the touch screen at an appropriate angle for the child to select items according to the robot’s cues. This created opportunities for diverse interaction modalities between Skusie and the children.

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