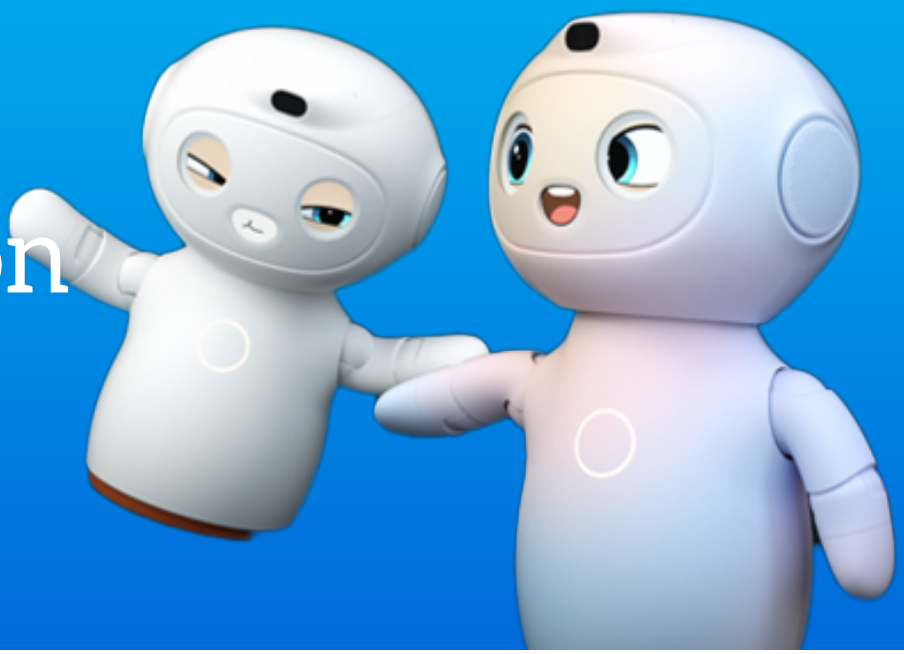
Education Companion Robot



Case Study

Name of initiative

Huawei's Education Companion Robot

Implementing organization

HUAWEI

Initiative type

Artificial Intelligence (AI) System

About the Initiative

The Education Companion Robot has been adjusted through a multiple-stage design process to better tailor its companion robot to the needs and rights of the main user demographic: children aged 3 to 12 years. The process involved teams of experts across diverse fields (AI, robotics, game and animation design, human factors design and engineering, data security, ethics, education, developmental and cognitive psychology). The use of iterative, child-centred design where inclusion of and for children has led to improved accessibility and transparency, fairness and non-discrimination. Upstream in the design process, a set of precautionary approaches have been built to help integrate privacy and safety mechanisms into its robot's design.

Alignment with UNICEF Policy Guidance on AI for children

The initiative has aimed to:

+ Support children's development and well-being
+ Prioritize fairness and non-discrimination for children
+ Ensure inclusion of and for children
+ Protect children's data and privacy
+ Ensure safety for children

Location

China and global

Launched

2021

unicef
for every child

ABOUT THE CASE STUDY

UNICEF published a Policy guidance on AI for children in 2020 and updated it in 2021, with the support of the Government of Finland, and encourages the business sector to pilot this guidance in their field and openly share their findings. This is one of the two case studies developed to document how the UNICEF Policy Guidance on AI for children was used and describes the resulting journey in the form of a case study. They were developed by the Communication University of China (CUC) with the guidance of China Federation of Internet Societies (CFIS) and support of UNICEF China. They were authored by Eleonore Pauwels. Each case study illustrates how the principles of the Guidance can be embedded in AI system, making the whole process of development, design and adoption more child centred.

The AI systems illustrated are produced and owned by the company. UNICEF was not involved in any stage of the process. The reference to a specific company as part of this project does not imply endorsement by UNICEF of the company's policies and practices.

UNICEF encourages the design, production and dissemination of open-source learning platforms.

OVERVIEW

New applications at the confluence of artificial intelligence (AI), robotics, education and cognitive psychology show promise in supporting children's capacity for learning and creativity, emotional and social development, logical thinking and problem-solving. Yet these innovations also have ethical implications relating to fairness and non-discrimination, inclusion and participation, as well as privacy and safety.

Data-driven and AI technologies can reproduce and augment the patterns of discrimination and marginalisation in our societies. These patterns can come from biases in datasets or in the AI model's design. If not well designed, smart toys and robot companions could exhibit biased or discriminatory behaviours.

Protecting children's privacy is another complex challenge when designing smart toys. Cross-cultural and cross-discipline studies have emphasized how children may sometimes over-trust robots and confide in them, sharing private and sensitive information. A large amount of video and audio data can also be captured by companion robots as they interact with young users in the home and in the classroom. UNICEF's Policy Guidance on AI for children states that 'Without adequate data protections, this data can be sold to third parties, and could forever be linked to the child, potentially influencing future opportunities related to higher education or jobs'.

In this context, the Education Companion Robot was adapted for enhanced data protection and personalized, adaptive learning and play, by designing child-centric interfaces, experiences, contents and tools. Inspired by UNICEF's policy guidance on AI for children, several strategies were adopted for the development of socially intelligent robots:

In collaboration with interdisciplinary experts, a cognitive and psychological framework to qualify children's developmental needs by age has been developed.

This framework supports the AI system when it determines what types of conversations, games and learning scripts can be initiated with a child and best integrated into an appropriate routine or family life context. Efforts were made to include parents and caregivers into the learning and social activities proposed by the robot.

An iterative child-centred design has been implemented to improve safety, reliability, fairness and non-discrimination.

The robot integrates age-appropriate content, prohibits digital marketing, and limits access to trusted contacts. The datasets for training algorithms were built to ensure objectivity and impartiality, and avoid bias, stereotypes, and prejudice.

The R&D team collaborated across disciplines, including privacy protection, to understand, anticipate and prevent unintended consequences that could harm children at the convergence of AI and robotics.

In the design process, the R&D team built in robust privacy and safety mechanisms to the robots. Physical and online risks have been considered at every stage during the design and development phase.

CONTEXT AND PROJECT ORIGINS

Children interact with AI and robotics differently than adults. For instance, children may approach digital learning as an 'experiential journey' where interactions with a robot 'teacher' or 'playmate' are based on trust, sharing, and a multifaceted sensory and emotional experience. Research shows the potential of AI-led robots to play a substantial role in impacting children's behaviour and well-being.[1] Personalized learning with the support of AI-led robots could serve children's unique needs, preferences and interests, adapting to their sensitivity and personality. Such an education companion could empower them to shape their personal learning trajectories.

AI has the potential to transform learning, culture, leisure and play, but many digital products, including smart and assistive technologies, are not designed with and for children. They lack the precautionary design approaches required to empower and engage with children and to actively protect them from harm and exploitation. This is the diagnosis made by the R&D team through a collective, multidisciplinary effort in collaboration with experts across interdisciplinary fields, including, AI, and robotics, game and animation design, human factors design[2] and engineering, data security, ethics, education, developmental and cognitive psychology.

Designing child-centred AI products should be a cross-discipline, rigorous process, which analyzes children's cognitive abilities and psychological characteristics at different ages, so that there is a robust cognitive framework in place to guide AI-led interactions.

The R&D team recognizes that young children grow at different paces and some exhibit developmental maturity at early stages. This is why the team has designed the AI system in a way that the robot tries to adapt to each young user's learning progress and capabilities and provide tailored learning recommendations. The robot's multi-sensory model can also support rich and multifaceted interactions that may solicit and involve eye contact, touch and signs for toddlers and progressively verbalization, story-telling, and a sense of humour for older children.

The challenge of promoting fairness and non-discrimination while designing AI-enabled educational robots and smart companions is a complex, but critical research and design endeavour.

Research has shown that preschool-aged children can learn bias from verbal and non-verbal cues expressed by adults, and this form of social mimicking or learning can produce racial and other biases. Other research has explained how some conversational topics can be sensitive, for instance the indirect consideration of race when talking about hairstyles, sexual orientation when talking about families, and religious beliefs when talking about holidays. UNICEF's Policy Guidance highlights the serious and harmful impacts that exclusion and discrimination through AI bias may cause to children: 'Such exclusion can have long-lasting effects for children, impacting a range of key decisions throughout their lifetime.'[3]

ABOUT THE AI SYSTEM

The Education Companion Robot uses a multi-person interaction model so that children can interact with the robot together with caregivers and other children. The goal is to promote children's socio-emotional communication and development, as well as to provide parents with stimulating child-friendly resources (narratives/animations, conversation topics, picture books) and a comprehensive way to supervise young users' progress, interests and learning.

Teams of experts across diverse fields were involved through a multiple-stage design process to tailor the companion robot to the needs and rights of children aged 3 to 12 years. The educational companion was conceptualized from scratch to try to maximize rich social interactions with children, while aiming to uphold child rights and child protection principles. To better meet the needs of each child, from social to emotional and intellectual development, the AI companion robot provides personalized recommendations that help children learn, develop socio-emotional and imaginative capabilities, as well as develop critical and logical thinking in a trusted environment.

In the initial design phase, experts in human-robot interaction (HRI) developed a **multi-modal sensing and decision-making program** – the AI education engine – which guides the robot's behaviour and helps optimize its set of interactive activities with children. This design phase has been refined in collaboration with child psychologists, academics and educators. Together they developed a framework that analyses and qualifies children's cognitive, emotional and social capacities and needs by age categories.

For instance, younger children may have an interest in exploring and learning but can quickly feel frustrated if activities are too long or too demanding. From age 4 to 6 years, children start exhibiting increasingly complex patterns of behaviours and new capacities to connect brain and body functions. They become increasingly empathetic, able to understand other people's emotions and perspectives, and so they can be stimulated by story-telling activities and games based on increased social interactions.

A second critical design process revolves around **the capacity of the robot and its AI software to try to perceive, interpret and understand children's emotions, speech, movements and intentions as well as the surrounding home environment.** For instance, the robot is programmed with a capacity to operate around daily schedules that are part of a child's healthy routine (e.g., bedtime, schooltime, time for brushing teeth, time to exercise, time for leisure, time to get away from screens) and to integrate seamlessly with family life activities. The AI companion also provides games, conversations and reading activities that require the involvement of parents or other caregivers.

In the third collaborative effort, the research and development team worked with partners in academia, the education and business sectors to curate a large library of appropriate, child-centred content, including interactive games, puzzle games, reading and learning materials and curricula, as well as comprehensive sets of topics to be explored in conversations. External experts were consulted in the process, including education practitioners working in kindergartens and schools, experts in the adaptive learning and education sectors, as well as academic institutions, such as the Institute of Psychology of the Chinese Academy of Sciences, and Southeast University. Inspired by research in paediatrics and developmental psychology, emphasis has been placed on the 'power of play' to help children learn and communicate.

The team that developed the Education Companion Robot focused on a set of requirements in line with the UNICEF's Policy Guidance on AI for Children, with the following principles in mind: supporting children's development and well-being, ensuring inclusion, diversity, and participation among all children, and prioritizing fairness and non-discrimination for children.

Supporting Children's Development and Well-Being

While recognizing that companion robots cannot and should not replace the role of parents and caregivers, the focus of developing the Education Companion Robot has been to help parents support their children's development and well-being. This includes engaging in activities and scenarios that matter in children's everyday lives, from improving listening and communication skills in conversations, to encouraging activity at home that will create interactions between parents and toddlers.

The robot's learning and development framework has been devised and framed around a set of priorities, including physical development, cognitive development, and socio-emotional development. This framework is based on a comparative and systematic review of the set of priorities considered by the Early Childhood Learning and Development Standards in China, several representative states of the United States (including Illinois, District of Columbia, Wisconsin, Washington, Delaware), representative countries of the Commonwealth, and China's Hong Kong region.

Prioritizing Fairness and Non-Discrimination for Children

To help prevent potential discrimination caused by AI-based recommendations efforts were made to develop a robot that supports educational and leisure activities, as well as socio-emotional development for children of diverse socio-economic and cultural backgrounds. During data-curation and algorithmic model training, engineers have tried to integrate a large diversity of children's educational situations and behavioural learning strategies.

Efforts were made to ensure that datasets used to train the robot's algorithms are collected, cleaned, and annotated in a way that helps eliminate potential biases during model training. Testing methods as well as external collaborations were employed to assess and audit the algorithmic model before its release. For instance, the engineers built a completely independent dataset strictly for iterative testing and for determining and preventing the potential occurrence of biases. Through the full cycle of the design process, engineers have stressed the need to employ high-quality data sets to ensure data availability, reliability and integrity. While engineers receive specific training related to data and algorithmic fairness, human oversight and manual intervention during data curation are also part of the robot's design process to mitigate the occurrence of potential biases.

Ensuring Inclusion of and for Children

The R&D team partnered with experts in pedagogy, development, cognitive psychology, human factors design, animation and game design to create an inclusive companion.

The robot's capacity to use multi-modal interactions (through vocal, visual, touch-enabled signals, gestures and expression of emotions) has been chosen so that visually impaired children (or guardians) can rely on voice guidance and touch to initiate and participate in activities and, for instance, ask the robot to read a book or tell a story out loud. Engaging with the robot mostly does not require advanced digital literacy; this can be done through touch, vocal and visual signals so that it can be used by guardians who are less digitally savvy.

Children's spontaneous use of language differs considerably from that of adults in terms of pronunciation, emotional expression, speech logic, usage of repetitive syllables, and word segmentation. In response to these challenges testing was done with a large number of children and a child speech recognition framework attuned to the development, pronunciation, speech logic, and emotions of children was introduced. The process has substantially improved AI processes to recognize speech and pursue dialogue with children. A set of voice assistant standards inclusive of children of different ages, was developed to help the robots try to carry conversations varied in length, in Chinese or English.

In total, testing sessions included over 3,500 young users aged 3-12 in multiple cities and regions of China using different methods, from collective experiential sessions in private and public primary schools and kindergartens to focus groups and surveys. Testing has included young users and families from low-income to middle-class groups located in China's capital, in first-tier and second-tier cities, as well as users from urban and suburban areas.

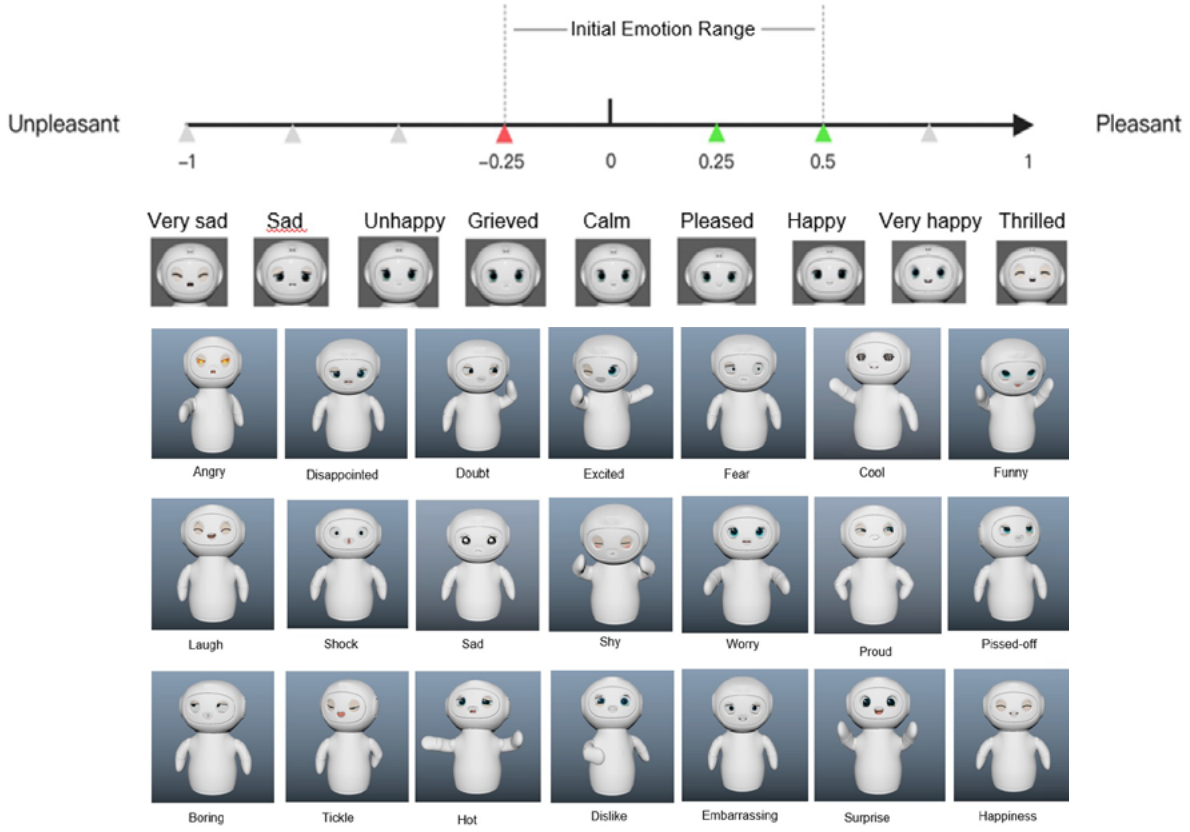
Testing a range of timbre design

To ensure that the voice of robots is well received by children, a survey was conducted with over 300 children and bilingual sounds in Chinese and English for children of different ages were developed, based on the survey results.

Testing a range of emotions & expressions

As children grow older, they acquire diverse and complex emotions. However, they tend to lack the ability to fully manage how they express their emotions and may be prone to impulsive reactions. Companion robots have proven capable of sensing and expressing emotions, as well as showing sympathy to children. They can express up to seven emotions of their own. Currently, more than 2,000 facial expressions are available. For instance, they can provide over 16 happy expressions, such as smiling, laughing, excitement, and exuberance (see Figures 1 and 2).

Figure 1 and 2: Large Display of Emotions Exhibited by Huawei Companion Robot



Protecting Children's Data and Privacy

The Education Companion Robot's privacy protection policy for children was developed in accordance with China's Personal Information Protection Law, the Cybersecurity Law, and the Law on the Protection of Minors. Due diligence on children's privacy and data protection underpins the following efforts, among others:

- **Transparency, consent and parental control:**

  Before initiating interactions with the robot, parents have to read and consent to the product's privacy policy, which presents the privacy protection features of the AI companion. When it comes to privacy protection's features, parents learn that all data-capture capacities (video and audio capture) are visible by light signals on the robot and can be activated and disabled both by touch and remotely through a secure mobile phone access for parents or guardians. The robot does not need to record personal information to be able to interact with a child (the robot can even recognize a child's age-range by visual algorithmic analysis). Yet, to provide a more personalized experience, during the first 'greeting phase,' caregivers can help young users provide some information such as a nickname and preferences in topics, conversations and activities. The robot functions as a closed system where external applications or programs cannot be automatically downloaded. Parents can manage their child's robot use on their mobile phone, for example, they can check incoming and outgoing calls and set a trusted contact list for the robot to answer or make calls. While parents can check the types of activities that take place between the robot and the young user, they can also clean up and delete past chats and games using their mobile phone.

Data security:

According to Huawei, users' data, including personal information, is managed by relying on certified data-security techniques, including anonymization and encryption. Huawei classifies users' personal information according to its importance and sensitivity and in compliance with China's Information Security Technology—Personal Information Security Specification. Huawei states that its data security mechanisms have passed relevant international certification programmes.

Third-party sharing:

Huawei states that it restricts sharing or transferring of user information to only a few affiliates that mostly provide age-appropriate content for interactions (for instance, picture books and games). The company also adds that parents are informed via phone notification and can choose to consent or refuse such data transfers. Huawei performs a security assessment to vet affiliates that might receive data, and signs agreements to help support the security of users' personal information. Huawei states it uses specific techniques to anonymize and pseudonymize sensitive information.

Ad- and marketing-free content:

Personalized ads and direct marketing are prohibited by Huawei for services designed for children, and parents or guardians are required to consent to any use of their child's personal information for the purpose of providing personalized experiences or improving Huawei's educational services.

Visual and audio data capture:

Huawei states that children's data captured through visual technologies are processed locally on the robot's digital system, without being uploaded to the cloud. Voice commands (such as when waking up the robot) need to be recognized through the cloud, but Huawei confirms such audio data is not stored for an extended period.

Ensure Safety for Children

In addition to the data and privacy measures above, other efforts to prevent safety and physical risks include the use of environmentally friendly materials that have passed relevant electrical certifications. The soft robot design, its weight, and algorithmic techniques for collision detection and motion control, have also been tested to ensure very limited exposure to physical risks such as toppling, or clamping of the hand mechanism.

FUTURE CHALLENGES

The R&D team has identified further challenges that could benefit from being explored and tackled more thoroughly, and one of them particularly concerns UNICEF's requirement to provide transparency, explainability and accountability for children. The collaborative design across multi-disciplines has raised awareness of ethical considerations that are emerging at the confluence of AI, autonomy and child rights. While such considerations do not necessarily apply to Huawei's AI educational robot because it functions today in a closed-loop system, they are nonetheless interesting considerations to discuss in cross-field and cross-sector settings.

As different types of anthropomorphic robots and devices learn to engage with children in daily activities, questions remain as to what constitutes an ethical AI system, particularly when it is designed as a companion for collaborative activities. Children may sometimes over-trust or attribute human emotions to robots. Special care must therefore be taken when designing social and educational robots to safeguard children's rights. An important emerging challenge for companies in the field of child-robot interaction is the duty to protect and report. As mentioned by UC Berkeley Human Rights Center Research Team in their 2019 Memorandum on Artificial Intelligence and Child Rights[4]: where does corporate responsibility stand when it comes to reporting situations such as children sharing suicidal thoughts with a smart toy or expressing signs of self-harming behaviour, or confiding that they are being abused? What are a company's obligations to report such information to relevant authorities and under what precautions and protections? Another challenge to the R&D team is to create an easy-to-understand privacy policy and consent form for parents, ensuring simplicity and clarity.

Overall, while giving robots permissions and autonomy, Huawei's R&D team sees the need to embed ethical ideas into robot design and establish a set of professional ethical guidance through open business dialogue, and aim to provide proactive solutions for its users, to try to anticipate, prevent and mitigate future challenges around transparency, explainability and accountability.

ENDNOTES

1 For information on children's neurological and cognitive development, see Dion-Dosti E, Paquet N, Lasund M, et al. Multisensory integration and neurodevelopment in children[J]. Brain Science, 2015, 5(1): 32-57. See also, P. Simoens, C. Mahieu, F. Ongenae, F. De Backere, S. De Pestel, J. Nelis, et al., "Internet of robotic things: Context-aware and personalized interventions of assistive social robots (short paper)", IEEE, pp. 204-207, October. 2016. For methodological and ethical perspectives, see Tolksdorf NF, Siebert S, Zorn I, Horwath I, Rohlfing KJ (2020) Ethical considerations of applying robots in kindergarten settings: towards an approach from a macro perspective. Int J Soc Robot 13: 1–12. See also Serholt S, Pareto L, Ekström S, Ljungblad S (2020) Trouble and repair in child-robot interaction: a study of complex interactions with a robot tutee in a primary school classroom. Front Robot AI 7 :46. See also Belpaeme T, Kennedy J, Ramachandran A, Scassellati B, Tanaka F (2018) Social robots for education: A review. Science robotics 3(21). See also Belpaeme T, Vogt P, Van den Berghe R, Bergmann K, Göksun T, De Haas M, Kanero J, Kennedy J, Küntay AC, Oudgenoeg-Paz O et al (2018) Guidelines for designing social robots as second language tutors. Int J Social Robot 10(3):325–341.

2 The application of human factors and needs to the design and development of systems and services

3 (p 22), UNICEF, Office of Global Insights and Policy, "Policy Guidance on AI for Children V2.0," 2021.

4 (p 55), UC Berkeley Human Rights Center Research Team, Memorandum on Artificial Intelligence and Child Rights, April 30, 2019.