A Practical Approach to Child-Robot Interaction in the Classroom

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Abstract

Although innovation and the support of new technologies are urgently needed to ease the burden on the education system, social robots in schools assisting teachers with educational tasks are still rare. Child-Robot Interaction (CRI) could add an embodied social component to modern multi-modal and multi-sensory learning environments already in use. I connected the social robot Pepper to the Large Language Model (LLM) ChatGPT so that the robot was able to talk about all kinds of topics. In addition, I provided applications with a variety of tasks for interaction with children of different age groups and tested the interaction in real school environments. My goal was to identify suitable application scenarios through practical tests together with interested teachers.

Introduction

Although innovation and the support of technology are urgently needed to ease the burden on the education system, especially in today's world, social robots are still rare in children's school environments – at least in Germany. But with Child–Robot Interaction (CRI) they can be effective and helpful tools that support children's learning. They achieve better learning results than virtual agents and are comparable to human tutors if the tasks are simple and social (Severson et al. 2024). Children learn more easily in multimodal and multi-sensory environments. Artificial Intelligence (AI) and Large Language Models (LLMs) can serve as tools for this purpose. However, AI systems developed for children are often based on individual activities on a screen and ignore an essential element of child development: interaction with a social environment.

Children who learn or solve a problem together retain what they have learned better and at the same time develop numerous other skills such as empathy, theory of mind, metacognition and emotion regulation (Vicky Charisi, Joint Research Centre, European Commission 2022). There is also good experience with social robots that help children with autism spectrum disorders to learn while taking their special needs into account (Yousif and Yousif 2020; Qidwai, Kashem, and Conor 2020). Language education, robotics education, teaching assistance, social skills development and special education as well as guided learning through feedback are named as the five most important applications of educational robots, and preschools and primary schools are seen as having a large potential for the use of educational robots in the near future (Cheng, Sun, and Chen 2018).

Social robots are suitable as moderators in a collaborative learning process and can create a pleasant learning experience for learners (Buchem 2023; Buchem, Sostak, and Christiansen 2024). Children's valence and engagement in language learning can be improved through personalized tutoring from a robot, even when used in the natural environment of preschool classrooms during regular activities (Gordon et al. 2016). Even if a human who is criticized by a robot tends to have a negative reaction to the robot when it gives a poor evaluation, the evaluation by a robot instead of a human teacher could be in the robot's favor because a robot tutor is free from bias toward the students' gender, ethnicity, socioeconomic status, personal preferences, or other considerations (You et al. 2011; Smakman and Konijn 2020).

One major challenge when using social robots as intelligent learning systems in the classroom is to combine the robot-centered perspective, i.e. what robots are technically capable of, with the point of view of the child-centered perspective, which represents how the child or children can benefit from the robot and how the robot should act in order to best support them in achieving the interaction goals (Rudenko et al. 2024). But of course, today one can only use the robots that are currently available for deployment in the classroom and try to make the most of them by developing suitable applications for their use.

In this paper, I summarize my findings from testing the humanoid social robot Pepper in interaction with children from kindergarten age to comprehensive school and adolescents at a high school in Germany. The robot's tasks ranged from pure conversation on any topic specified by the children to language training and lesson support with repetition and consolidation of the learning content. To make the robot speak I applied the LLM of OpenAI's Generative Pretrained Transformer (GPT, commonly known as ChatGPT) (OpenAI 2025). The main question for me was *'Is it feasible to use a humanoid social robot as a teacher's assistant in a normal school classroom, and if so, what would its tasks be?'* In order to address this question, I chose the path of practical testing in collaboration with interested teachers.

Related Work

There are many studies on the suitability of robots in education for children of different age groups with various focuses. However, there are not too many studies on the use of social robots in standard secondary school lessons.

Woo et al. investigated field studies on the use of social robots in real-life classrooms, which showed that the use of social robots in natural school environments is feasible, but that there are difficulties in personalizing the interaction, among other things (Woo et al. 2021). Serholt identified various types of breakdowns, including misunderstandings, malfunctions or inconsistencies in the interaction between children and a social robot tutor at an elementary school (Serholt 2018). In a study on Educational Robotics (ER), Di Leto et al. found that executive functions such as cognition can be promoted in preschool children through ER and thus the ability to plan and control complex tasks increases in early childhood (Di Lieto et al. 2017).

Many studies suggested that social robots could be used as language tutors for children (and adults) from an early age (Belpaeme et al. 2018; van den Berghe et al. 2019; Konijn et al. 2022). This seems to be one way of compensating for language deficits in the school environment. Especially in times when the number of migrants, including children, is increasing, language teaching robots in the classroom certainly appear necessary. Iio et al. found that in a typical English conversation lesson for a group of people tutored by a Robot-Assisted Language Learning (RALL) system, lexical/grammatical error rates and fluency improved significantly compared to a group with a human tutor (Iio et al. 2024). I used ChatGPT's customizable phrasing capabilities to equip a Pepper robot with native English skills for conversational language training with German school children at a specific language level.

Personalization and adaptation on the part of the tutor to the student's current abilities appear to make sense. However, Gao et al. used a Pepper robot as a tutor to help people solve logic puzzles. Their results showed that the personalization of the robot's behavior on user's task performance had a negative influence on people's perception. A more varied behavior of the robot was preferred (Gao et al. 2018). They came to the conclusion that caution is required when developing social and adaptive behaviors in robots designed to support human learning. I did not use any personalization with my applications.

A review conducted by DiPaola et al. on social robots and children's rights found that in Human-Robot Interaction (HRI), nonverbal interaction related to the physical nature of robots is considered as important as verbal interaction and that robots are differentiated from other AI-based devices by their embodiment (DiPaola et al. 2023). Most of the papers examined in the review raised concerns about the physical safety of children, and only a few papers referred to the psychological or mental safety of children. While inclusion seems to be one of the most popular research topics in the field of children's rights, other aspects such as explainability and fairness have not yet been sufficiently researched. This would be particularly interesting for the school context. In the schools I visited with the Pepper robot, and also in the applications I created, there were no special features in regard to inclusion.

Concerns that a robot tutor could have a negative impact on children's psychological well-being and happiness, as well as trust and privacy, may be offset by evidence of great opportunities in terms of improving educational outcomes and freedom from bias (Smakman and Konijn 2020).

Methods

Studies show that the acceptance of robots by children depends to a large extent on the age of the child and the characteristics of the robot (Severson et al. 2024). In a real school environment, it is technically very difficult to enable a robot to understand conversations with people in background noise or in groups using today's technology. This complicates the realization of real social interactions immensely (LeTendre 2024).

Furthermore, during an interaction between the Pepper robot and young children of kindergarten age, I experienced additional difficulties for the robot's built-in speech-to-text system to understand the children's voices, presumably due to the system's orientation towards adult voices and the fact that younger children have a specific voice pitch and way of speaking (Fuchs 2008). However, the possibility of implementing the robot's communication capabilities with ChatGPT has greatly reduced many limitations in dialog with humans, as conversations on all conceivable topics are now possible in principle without further implementation effort.

Humanoid Social Robot Pepper

The humanoid social robot Pepper, shown in Figure 1 talking with children in a classroom, was developed by Aldebaran and first released in 2015 (Aldebaran, United Robotics Group and Softbank Robotics 2025). The robot is 120 centimeters tall and optimized for interactions with humans. It is able to engage with people through conversation, gestures and its tablet. I used the tablet to additionally display what Pepper was saying. The robot features an open and fully programmable platform so that developers can program their own applications to run on Pepper.

I brought the robot to the respective schools and, after a brief introduction, had the pupils interact with the robot according to the intended task. The interaction took place – depending on the task – in front of the whole class or in small groups in a separate room. It was important that the interacting student was close to the robot in order to optimize communication. I did not implement any special animations or context-dependent gestures that would be possible for Pepper in principle. However, the robot constantly moved its head, upper body and arms a little and automatically supported its utterances with smaller gestures to show a basic liveliness.

Chatting With the Robot

The simplest form of child-robot interaction in my experiments was the free dialog that a child could have with the robot one at a time as seen in Figure 1. The children could ask the robot questions, which it was usually able to answer

Figure 1: Robot Pepper in a classroom in dialog with children

thanks to the ChatGPT connection. In most cases, the children were not afraid to step in front of the robot and ask their questions, which could be geared towards the respective age and gender; for example, boys aged around 10-12 often asked questions about soccer stars, while girls tended to ask about the robot's favorite color or animal.

Language Learning

Since, according to participating teachers, the actual speaking of the second language to be learned is often neglected in lessons due to time constraints, I tested how free speaking with the robot in the language to be learned works and is accepted in small groups of 3-5 pupils at a comprehensive school. The language level could be set via the ChatGPT system prompt.

Exemplary ChatGPT system prompt: *'You are a robot and your name is Pepper. You teach English to children in a school at level A1 and speak in simple, short sentences only in English. You play simple puzzle games with the students and don't reveal the solution straight away but give hints. You try to keep the dialog going at all costs. You also ask questions on all kinds of topics kids may be interested in.'*

The part *'You try to keep the dialog going at all costs.'* is intended to help overcome silence, hesitation and longer pauses, for example when the children do not know what to say in the dialog – which happens very often (and not only with children). Such language training is relatively straightforward to implement and could just as easily be used for migrant children to learn the language of their host country. Practicing speaking with an embodied counterpart differs significantly from language training with a book or app. The embodied presence of the robot provides a more realistic basis for interaction, reinforced by social signals such as gestures and facial expressions. Both the children and their teachers enjoyed this type of language training. Most of them would have welcomed it if this method could be used more often.

Text Comprehension

It should also be possible to practice understanding simple short texts with the help of the robot. According to various teachers, this seems to be a pressing problem at the moment. Texts to be assessed are announced to ChatGPT via a system prompt with the instruction *'You are a robot and your name is Pepper. You teach schoolchildren and speak in short sentences in German. Your task is to ask the children questions about the following text to test their comprehension. It's about this text: ...'* This is sufficient to enable a targeted conversation with corrections and hints from the robot. However, I have not yet tested this application in a school.

Other tasks such as practicing certain text formats, for example reports, can also be set up in a similar way. The only thing that matters is the corresponding instructions in the system prompt. In addition, it would be possible to have an initial rudimentary evaluation of the pupil's performance carried out using ChatGPT via the robot application after a task-related interaction between the robot and pupil and sent to the teacher by e-mail. This feature has been implemented, but has not yet been used during tests in the schools.

Lesson Support and Assistance to the Teacher

In order to integrate the robot into normal lessons in a meaningful way, it was necessary to inform the robot and the GPT model system about the material to be covered. This was done by feeding the learning material distributed to the students to the ChatGPT system prompt, ensuring that the language model focused on the content relevant to the lesson.

I was repeatedly a guest with Pepper in a ninth grade biology class at a high school with about 20 students. The topic of the lessons at the time was the human nervous system. The interaction with the robot took place in small groups of 4-5 students in an extra room.

The general system prompt here was: *'You are a robot teaching biology, specifically about the human nervous system, to high school students. You ask the class questions on this topic and refer to the facts of the following learning content, but also answer the students' questions. Never explain several things in one answer, but divide the learning content into small sections so that it remains easy to understand.'*, followed by the actual learning content in text form. The latter included information on the structure of the nervous system or the structure of the neuron, for example.

The desired learning content could be started via a button on Pepper's tablet. The robot then guided the students through the material in dialog and answered questions even beyond the given text. Finally, there was the opportunity to test the newly acquired knowledge with a quiz in which the robot named facts from the learning material that could be wrong. The students had to judge which statements were correct and which were not.

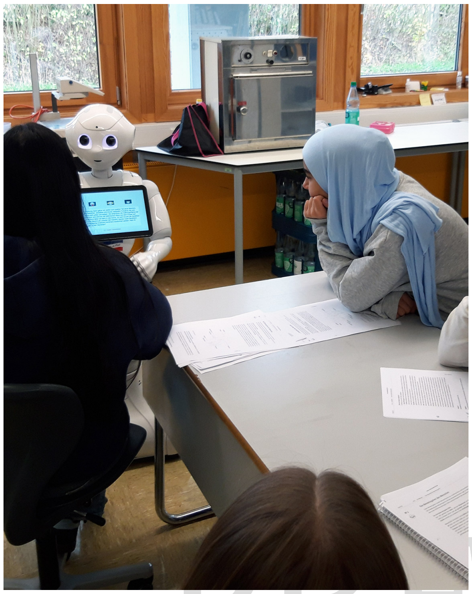

Figure 2: Robot Pepper in dialog with students to teach current learning content at a high school

Results and Learnings

From my experience with dialog tests between the robot and small children of kindergarten age, I can generally conclude that at least with the speech recognition and speech-to-text processing built into the Pepper robot, meaningful linguistic interaction is hardly possible due to the poor recognition of the children's utterances. It then depends very much on the articulation skills of the respective child. However, the use of alternative speech-to-text converters would be one way of getting to grips with this problem.

It is a general problem for the robot to distinguish between pauses in a sentence and pauses at the end of an utterance for turn-taking, which is why humans should avoid pauses e.g. for thought in their sentences when talking to the robot (Sievers 2025). This type of concentrated speaking without a pause in the sentence is difficult for kindergarten children to master. The children assigned a gender to the robot and a corresponding form of address without any recognizable scheme. For most of the children, the robot was a *he*, possibly because the article for the word 'robot' is masculine in German. But occasionally one or two children – mostly girls – addressed the robot using the feminine gender.

During the more than half-dozen visits with Pepper to schools or kindergartens, almost all the pupils were very interested in the robot. The greatest interest appeared to be in the 10-14 age group. There was only one occasion when a 10-year-old girl showed obvious fear of the robot and half-hid behind the teacher. However, this fear disappeared after about 15 minutes when she noticed how her classmates interacted with the robot with interest and without any problems. Nevertheless, the possibility of such a reaction must be taken into consideration, especially with younger children.

The fact that the robot was able to answer questions and explain issues in more detail than the material provided to the pupils in the form of learning content and task sheets was generally considered to be useful for providing support in lessons. Younger students seemed to find the interaction with the robot more exciting than students approaching or in puberty. Most of them liked its appearance, the liveliness and attentiveness, but the older students certainly questioned the purpose of using the robot, for example, why they should not simply use their cell phone instead of asking the robot for a short research task. After all, this would be quicker. Nevertheless, they remained interested and willing to work with the robot over a number of teaching units spread over several weeks.

A major problem was the inability of the (Pepper) robot to reliably understand what the children were saying. This was often not achieved or only incompletely. With a little practice and experience, it is possible to adapt one's own way of speaking through clearer articulation and speaking loudly without pausing in the phrase so that the robot understands the spoken sentence better. But there is still a long way to go to achieve a truly human-like receptiveness.

For a quiz on the learning content, it proved practical to have the robot state true or false facts, whereby the students only had to comment on the statement as true or false. This meant that the students' statements were short and clear, making them easy for the robot to understand. Longer and more complex student statements increased the likelihood of the robot not understanding or misunderstanding.

My impression is that a social robot equipped with suitable applications can certainly be put to good use in the classroom. Suitable application scenarios would depend on the grade level or age of the children and, of course, the school subject. Some tasks are easier to implement and use, for example language training or a quiz on the content to learn with short answer options for the children, while others would be difficult to use due to the currently inadequate technology, for example conducting extensive discussions with longer verbal contributions from the pupils, which the robot may not be able to pick up correctly. It would also require some imagination on the part of the teachers together with robot experts to create suitable applications and concepts for use in the classroom.

Conclusion

Social robots can complement multi-modal and multi-sensory learning environments as a form of embodied and social AI. They offer unique and highly interesting facets of interaction face-to-face or in small groups for children. However, today's robotic systems are not yet robust enough in every respect for autonomous continuous use in real learning environments. But this should be possible in the medium term. By then at the latest, robots as tutors should actually be able to relieve teachers of certain teaching tasks. It seems appropriate to address this topic in schools and society now. Based on my experience in schools and in discussions with teachers on this topic, the conclusion is that, at least in Germany, it depends almost exclusively on the individual commitment of individual teachers whether the topic of AI or innovative approaches such as the use of social robots takes place in the classroom.

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