Social Robots That Promote Soft Skills in Students

Social robots are coming to classrooms, but they can do more than teach new content. They can implement validated pedagogy to promote soft skills such as curiosity, growth mindset, and collaboration.

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Robots are on the rise, in warehouses, across campuses delivering pizza, and in various manufacturing industries. However, there are other robots that are slowly being integrated into our daily lives, which can have a more significant impact, especially for students. These are social robots, robots whose purpose is the social interaction between themselves and human beings, as opposed to physically manipulating their environment. One of the main fields into which social robots have been studied and slowly integrated is education, where social robots communicate verbally and nonverbally with students to help them learn better. Social robots, as opposed to screen-based characters, have embodiment, meaning they are physically present in the real world. They can point at physical objects, make eye contact, and draw the attention of a group of students, all focusing on one physical agent that educates and entertains them. Social robots can perceive social signals, such as facial expressions and poses, as well as understand speech. Moreover, they can communicate with their own social signals, such as projected facial expressions, moving their body, and answering questions verbally.

While robots have been widely used in educational institutes, most are educational robots, designed to teach STEM, including coding and robotics. These robots are used as the object of learning, not as companions/tutors. In contrast, social robots can teach anything. Besides science and engineering, social robots have been used to assist in teaching language, nutrition, and history courses. However, most of the uses of social robots in the educational domain have been focused on teaching new content. In other words, the pedagogy of teaching this new content has been programmed into the robot. It can now deliver it to the students it interacts with in a repeatable, tireless manner. While teaching a new language or new topics in math and science is truly important, there are other facets to education that have been recently brought to renewed focus, namely, the promotion of soft (or 21st century) skills.

THE CHALLENGE OF PROMOTING SOFT SKILLS

Soft skills refer to a combination of interpersonal skills, social skills, communication skills, character traits, and attitudes that allow individuals

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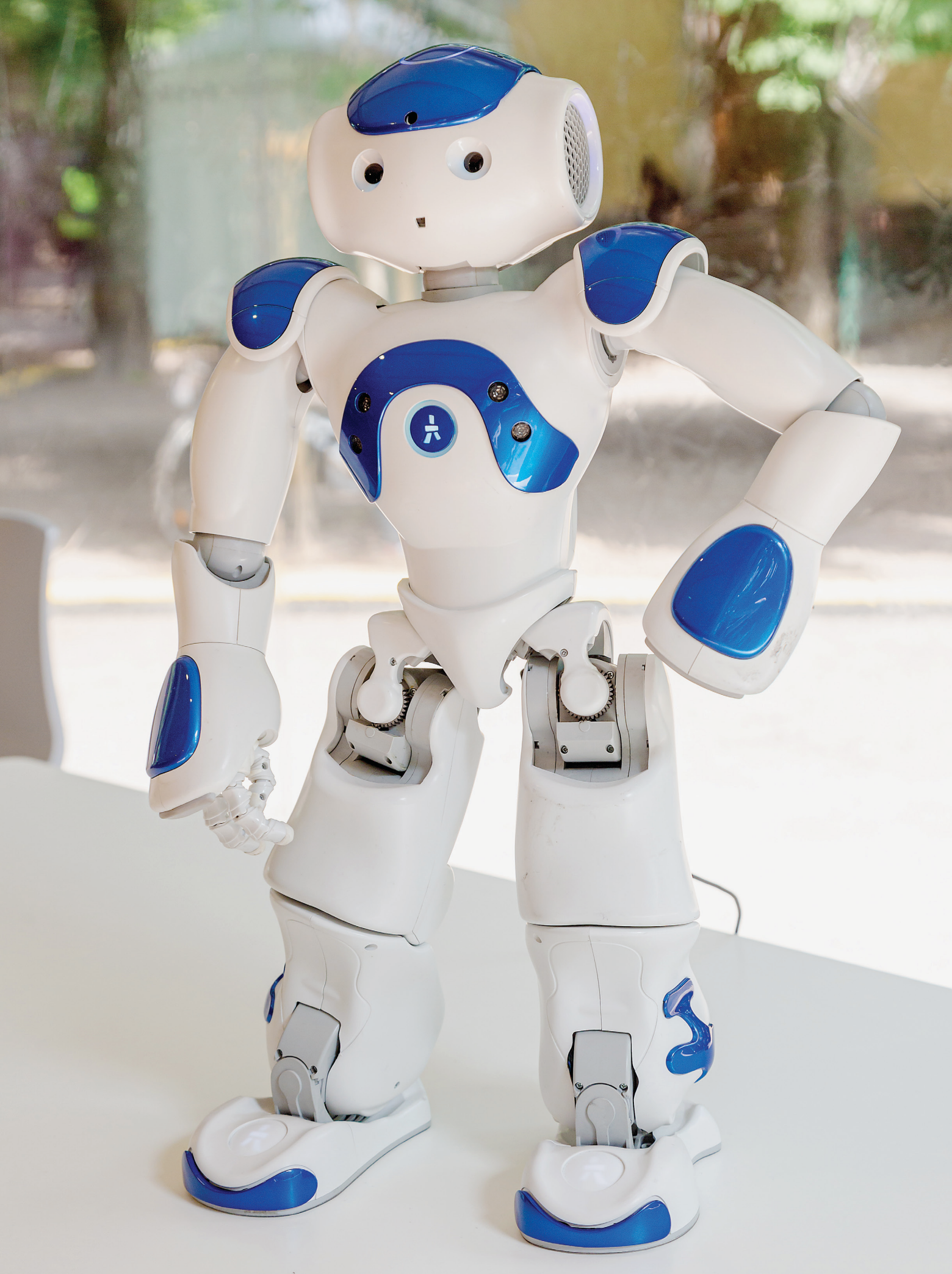
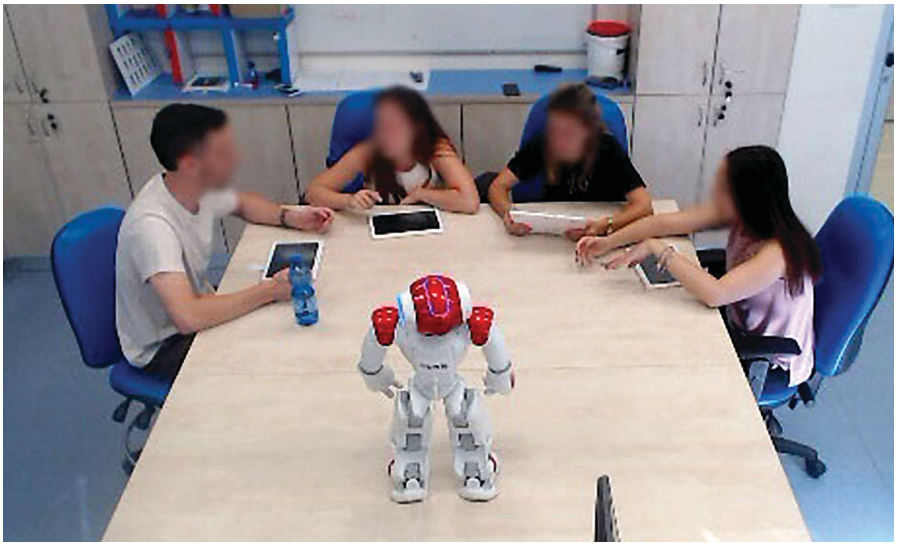


Figure 1. A social robot promoting group collaboration [2].



to navigate their environment, work well with others, perform well, and achieve their goals. There are several "lists" of soft skills, such as the 4Cs "superskills" (critical thinking, communication, collaboration, and creativity). If soft skills can be promoted by an educator, then it is natural to ask: Can these skills be promoted by a social robot? To thoroughly answer this question, one must first define a soft skill, then be able to measure it. Without proper measurement of the skill, one cannot show an increase (or promotion) of a skill under particular context. Finally, a protocol of promotion intervention must be developed and then tested. Luckily, for most soft skills, years of study (with human interactions) have provided many of these interventions and thus are relatively easy to be implemented for a social robot companion or tutor.

It is important to note other research directions aim at equipping the social robots themselves with these traits, or soft skills. In the current context, we are interested in something else: Having a social robot that promotes these skills in humans. In the following sections, we will discuss several soft skills, including the 4Cs, that have been promoted by social robots in detail.

CRITICAL THINKING

Critical thinking is the ability to analyze, evaluate, and form judgments on the basis of information, without allowing biases or preconceptions to influence the outcome. It involves applying logical and rational processes to understand and solve problems, make decisions, and develop well-supported points of view. In today's fake-news-ridden world, it is an imperative skill to have, to manage the influx of information from various sources. It is not an easy skill to measure, where only self-report questionnaires or dedicated assessments can give indications of a person's critical thinking skills.

In the context of social robots, interesting new challenges arise, namely, how should people interacting with social robots view the information the robot supplies. For example, it has been shown that gaze highly affects the trustworthiness of a social robot, namely, if the robot does not look at you, you trust it less. Other exciting studies have shown how social robots can manipulate their trustworthiness. Yet, in the current context, we are interested not necessarily in how people's critical thinking is applied towards the robot in front of them, but rather can a social robot teach and promote general critical thinking skills toward robots, AI, and other things in general?

Good pedagogy, which was developed for human teachers, can be relatively easily integrated into a social robot companion for positive effects.

This is still an open question, as relatively few (if any) studies have been done to address this important issue. The few studies that indirectly looked at critical thinking used deception in robots to elicit some form of a critical mindset. It is an interesting intersection between AI that promotes critical thinking toward AI.

COMMUNICATION

Communication skills encompass the ability to convey and receive information effectively and clearly, whether it is verbally or non-verbally. These skills involve listening, expressing oneself, understanding different perspectives, managing one's tone and body language, and adjusting one's communication style to suit the audience and context. Communication is an important skill that can influence how one is perceived and perceives others yet is rarely taught in school or encouraged actively. Measuring the outcomes of an improved communication intervention is often not simple and involves mostly subjective measures, such as the perceptions of an audience and self-report questionnaires.

Social robots have been, from their emergence, designed, and programmed with built-in communication skills. Facial expression, body language (depending on their morphology), and voice characteristics have all been developed and refined over the years to create a highly communicative social agent. Moreover, personalizing the communication channels to suit specific individuals has also been demonstrated, using machine learning algorithms. However, in the current context, the question is whether a social robot can promote human-human communication skills.

Few studies have shown how social robots can improve the interaction between two or more humans. One way to approach this is using a social robot as a focal point for group activity and engagement [1]. Having a social robot can bring people together—wherein it can serve as an "ice-breaker" or conversation starter that then continues between the human participants. Furthermore, social robots of various forms have been used in groups to encourage people to participate in a group discussion, share their thoughts and listen to others. By using an appropriate, validated intervention scheme, a programmed social robot can react to the social situation and encourage members of a group of human participants to communicate better and can even teach them improved ways of communicating.

Promoting soft skills such as collaboration, communication, and critical thinking can make humans better citizens and enrich our society.

COLLABORATION

Collaboration involves two or more people working together to achieve a shared goal. It involves cooperation, communication, and coordination, where all participants contribute with their skills and knowledge, and decisions are made collectively. Collaboration is a unique soft skill that is highly sought-after in many situations in real life, both for personal well-being and in the workplace. Collaboration can be separated into distinct aspects, namely, the outcome of the collaborative effort and the perception of the collaborative experience. Thus, objective performance measures and subjective perceptual measures are both indications of improved collaboration.

The field of study called collaborative-robotics (co-bots) is highly developed and commercialized, with several companies selling and/or using co-bots in their workplace. These co-bots improve human-robot collaboration, by using perceptual cues, timing, and sophisticated machine-learning algorithms, such as reinforcement learning. In our context, we are interested in promoting human-human collaboration by interacting with social robots.

The pedagogy of how to improve collaboration is well-studied, where equal contribution to the activity, learning how to listen to other group members, and improved relationships between all participants are important factors. Several studies have shown a social robot that works with groups of human participants can, depending on its social intervention, improve collaborative performance and collaborative perceptions [2]. Thus, social robots that facilitate group dynamics during a collaborative task can create an improved social atmosphere as well as improve performance. To achieve this amazing outcome, these robots need to be able to perceive the dynamics of the group using visual and auditory cues, including facial expressions and speech recognition, as well as using pedagogy-based algorithms to manage and guide the group dynamics, such as addressing the participant who engages least and handle resistances within the group.

CREATIVITY

Creativity usually refers to the ability to generate, develop, and express unique and original ideas, solutions, or artistic expressions. It involves thinking outside the box, challenging norms, and applying imagination, innovation, and inventiveness to various tasks or problems. In today's world, being creative in the workplace is becoming an essential skill, as well as being subjectively rewarding. There are different tasks that measure people's curiosity, usually by asking them to supply a variety of ideas, e.g., titles to abstract drawings, arranging squares in meaningful ways. Creativity is then measured by the number of different ideas and their originality (compared to a known or well-defined repertoire).

Several robots have been designed to be creative. There are painting robots, jazz robots, and dancing robots. Moreover, the field of computational creativity has bloomed, with generative AI leading to renewed interest in what is human creativity and how it is unique or different from AI creativity. However, in the current context, we are interested in how social robots can promote the creativity of humans they interact with.

Several studies have shown interacting with a creative robot, a robot that has been designed and programmed to follow the definitions of creativity, promotes creative expressions in students. One study showed how a social robot that generates more creative titles to abstract drawings resulted in children doing the same, compared to a social robot that generated fewer creative titles [3]. Another study showed a social robot that primes children to be in a promotional, positive state, results in more creative storytelling than a robot that primes them for prevention, secure state. These studies show that social robots can influence the creative process of children by both being role models and manipulating their internal states.

CURIOSITY

Curiosity has been the topic of research and interest for millennia. While there are many definitions of curiosity, we present this one: An intrinsic drive to learn as much as possible and the accompanying behavior. Once it is defined, one can operationalize it and build mathematical models to accurately describe the behavior. One promising line of research is to imbue robots with curiosity, program them to seek out new information and explore their environment for pure learning's sake. Here we are interested in the question: Can a social robot promote curiosity in students?

First, before attempting to promote curiosity, one must be able to measure it. Even here, social robots have come to the rescue. While curiosity has been around for some time in the research community, there was a lack of a quantitative, model-based

tool for it. In a couple of studies, social robots were used as both experimenters, objects of interest and curiosity, and measurement tools of curiosity. They have enabled the elucidation of the dynamics of information gathering behavior of humans [4].

How can a social robot promote curiosity? By behaving as a curious agent. In a ground-breaking study, a social robot behaving as a curious child makes children express more curiosity than children interacting with a non-curious social robot. For example, the robot expresses enthusiasm for learning by saying: "I love to learn" or "I wonder what would happen if …". In another, more recent study, a social robot was programmed with curiosity, i.e., it selected its actions to learn most, and explained its decisions to a child with both verbal and non-verbal cues [5]. In this unique study, the same algorithm that dictated the robot's decision making was "inverted" to give a curiosity score to the child, based on its behaviors. This study showed playing with a non-curious robot makes children express less curiosity, whereas playing with a curious social robot maintains children's curiosity.

To summarize, curiosity can be promoted by simply having a curious social robot playing with a curious student. However, programming a curious robot can be done either by hard-coding the behaviors, or by applying curiosity-based machine-learning algorithms, to make the robot truly curious.

GROWTH MINDSET

A growth mindset is a belief that one's abilities and intelligence can be developed through dedication, hard work, and persistence, and viewed challenges and failures as opportunities to learn and grow. Contrary to a fixed mindset, which assumes our intelligence and talents are static, a growth mindset embraces the idea that we can improve through effort and practice. Growth mindset has been shown to be one of the best predictors of children's well-being and has been correlated with many positive aspects throughout life. Measuring growth mindset can be performed either behaviorally, by measuring how students cope with failure and challenges, or subjectively, by administering validated self-report questionnaires. Furthermore, intervention schemes of how to promote the growth mindset have been studied extensively, with the most prominent aspect being the emphasis on the process and not the state, for example, saying "you succeeded because you worked hard" and not "you succeeded because you are smart."

Social robots can influence the creative process of children by both being role models and manipulating their internal states.

Since measuring and interventions have been proven so successful, can they be performed by a social robot? Indeed, a study showed children playing with a social robot that promotes and congratulates the process, while playing tangram spatial puzzles, increases the growth mindset, compared to children playing with a neutral mindset [6]. This has been shown both behaviorally, where children who played with the growth-mindset robot tried harder after failure, as well as subjectively, where children agreed with growth-mindset statements more. This is another example of how good pedagogy, which was developed for human teachers, can be relatively easily integrated into a social robot companion for positive effects.

CONCLUSIONS

We have briefly discussed how social robots can promote soft skills in humans. There is obviously great potential in using social robots as teaching assistants, tutors, and companions, where children and adults can benefit from the interaction more than mere companionship or learning content. Promotion of soft skills, such as curiosity, growth mindset, and creativity can enrich people's lives and make them strive and reach new heights. Promoting soft skills such as collaboration, communication, and critical thinking can make humans better citizens and enrich our society.

While using social robots to promote soft skills may trigger some uneasiness—since it is thought of as the role of educators, parents, and generally, other humans—using technology for self-growth has been around for more than a decade. Social robots bring a new aspect, namely, of social interaction via verbal and non-verbal channels.

The potential for the educational system is too great to ignore and many initiatives are blooming worldwide to bring social robots to everyone. We only hope that social robots will be used to make us better humans.

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Biography

Prof. Goren Gordon has six academic degrees, a B.A., M.Sc., and Ph.D. in quantum physics; as well as a B.MSc., an MBA, and a Ph.D. in neurobiology. He did his postdoc in MIT Media Lab's Personal Robots Group. Gordon is the head of the Curiosity Lab in Tel-Aviv University and studies mathematical models of curiosity, implementing them in curious social robots and using them to assess and promote curiosity and other 21st century skills in children. He is also the co-founder and Chief Science Officer of Curiosity Robotics, Ltd.

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