The Future of Social Robots in Education, Healthcare and Engineering

Ioana Corina Bogdan[1], Horia Alexandru Modran[1], Simona Mihaela Bibic[2] and Emil Simion[3]

[1] Department of Electronics and Computers, Transilvania University of Brasov, Romania
corina.bogdan@unitbv.ro, horia.modran@unitbv.ro,
[2]Department of Applied Mathematics, National University of Science and Technology POLITEHNICA Bucharest, 060042, Bucharest, Romania, simona.bibic@upb.ro,
[3] Department of Department of Mathematical Methods and Models, National University of Science and Technology POLITEHNICA Bucharest, 060042, Bucharest, Romania,
emil.simion@upb.ro

Abstract. This paper proposes a study of social robots influence in education, medical field and engineering including benefits of the artificial intelligence (AI) in our society, level of acceptance and resulted behavior of humans of all ages, children and elderly persons. Three distinct cases are discussed and evaluated based on the psychological point of view, education, ethics, security of communication and interaction. Studies showed that facial recognition, interaction or voice analysis help robots to discern human emotions, offering in this way the appropriate personalized assistance and meaningful feedback. Moreover, through AI algorithms, social robots can ongoing learning and intensify their behavior to develop and improve the users or individual's needs respecting the security communication and ethical standards. Social robots can be perceived as an integrated platform that reunites the capabilities of various systems making easier by their presence and ability to comprehend both verbal and non-verbal communication cues, resulting in smoother and more intuitive interactions.

Keywords: Education, Social Robots, Human Robot Interaction, Artificial Intelligence (AI).

1 Introduction

Humanoid Social Robots (HSR) or Androids are a controversial topic in our days, with a remarkable influence on human psychological development, daily tasks' simplification, and individual education. When addressing humanoid social robots (SR), we specifically refer to the fact that the topic of this work is humanoid robots that look and act like human beings, including as examples the AMECA's robot, Jiajia, Kime, Sophia, Eve, Einstein, or the Phillip K. Dick Android [1-2]. Moreover, HRSs possess a physical form, contrasting with chatbots, which exist solely in digital form. Briefly, SR has the potential to become great companions for human beings [3] as

long as AI, security of communication (cybersecurity), ethics, standards, and human-robot interaction (HRI) are clearly defined and function appropriately for human well-being, accordingly with societal and environmental considerations [4-6].

For this study, we aim to evaluate the impact of the android when it takes several roles in charge during the interaction with a human being. These roles could include:

(1) A personal trainer for students, able to provide feedback on any related questions about the preparation of the topic exam,

(2) A personal assistant for a patient suffering after stroke, a trainer for speech therapy exercises, or any other special needs for patients suffering from Alzheimer or autism spectrum disorder (ASD),

(3) A supervisor for engineers and technicians on the automotive production lines, and not only being able to answer questions related to the programming aspects or manufacturing stages.

Given that, SRs need to provide reliable information respecting the certification standards [7], as well as the security measures required to be implemented at the system level for security evaluation purposes [8].

This paper is based on an extensive survey of related research papers from the engineering, education, and medical fields, taking into consideration studies based on: (a) observations of the interaction between the user and the social robot. (b) interviews and user surveys related to perception and experience, (c) analysis of human behavior; (d) usability testing to understand the efficiency of the HSR in the HRI; and finally, some (e) measures that should be considered for security evaluation purposes and safety issues. It is important to mention that the current work involves points of view and evaluations only from research papers, and it was not yet tested on any human participants, as a case research study.

The article is divided into five parts, including the introduction. Section 2 provides an overview of AI in our society related to the three main areas of this study: AI in education, AI in medicine, and AI in engineering. Section 3 discusses cybersecurity standards and highlights key ethical considerations. Before concluding, Section 4 addresses the evaluation of social robots, their impact, contributions to our society, and the advantages and drawbacks of interactions with children and the elderly in various contexts such as education, healthcare, and engineering.

2 AI in our Society

Education, healthcare, and engineering are expansive disciplines strongly interconnected, playing an essential role in advancing and improving human knowledge and quality of life. Thanks to the evolution of medicine and engineering, humanity has also experienced advancements in education. Disciplines like science, mathematics, physics, psychology, and the humanistic sciences contributed significantly to the advancement and customization of our society. However, with the arrival of AI, it is essential for us to be prepared to accept being engaged in ethical and efficient communication and collaboration with SRs in various contexts. This paper examines several case studies to explore these themes: (1) The SR could be a personal trainer (in-

structor) for students capable to provide feedback on any related questions about the preparation of the exam topic, course lectures or general knowledge, (2) the SR could be a personal assistant for a patient suffering after stroke, trainer for speech therapy exercises or any other special needs for patients suffering for example of Alzheimer or autism spectrum disorder (ASD) or (3) the SR could be the supervisor for engineers and technicians on the automotive production lines and not only, being able to answer questions related to the programming aspects, manufacturing stages or assembly production lines.

2.1 Social Robots

A SR is a part of the autonomous robot class conceived to interact and communicate with human beings and other physical agents of socialization, following behaviors and social policies associated with its well-defined roles and responsibilities. This interaction is also called a "holistic interaction experience" [36], and robots are designed to be engaged in social contexts, realizing the bridge between technology and human interaction. In terms of their complexity, these tasks can be among the most diverse, such as protection, connection, well-being coaches, consulting, teaching, companionship, customer service, and so on. Unlike avatars or artificial on-screen characters, social bots are physically embodied.

Social robots are thought of and designed to interact with humans or other intelligent entities in various situations. They can have shapes and structures from the simplest to the most complicated and advanced (for example, they can look like humans [1-2], either partially or entirely, meaning that these robots are mostly humanoid). Designing an autonomous SR is a great challenge due to the fact that it must correctly interpret human actions and commands, and respond precisely to requirements [14-15].

2.2 Social Robots in Education

Social robots in education, also called educational robots (ER), are considered promising technologies conceived for improving learning experiences. These robots are useful to teach and assist children during the process of learning, including A-STEM subjects such as arts, science, technology, engineering, and mathematics. The triangle of learning in education traditionally represents the relationships between the three points: teaching (teacher to student), expertise (teacher to subject), and learning (student to subject), as illustrated in Fig. 1.

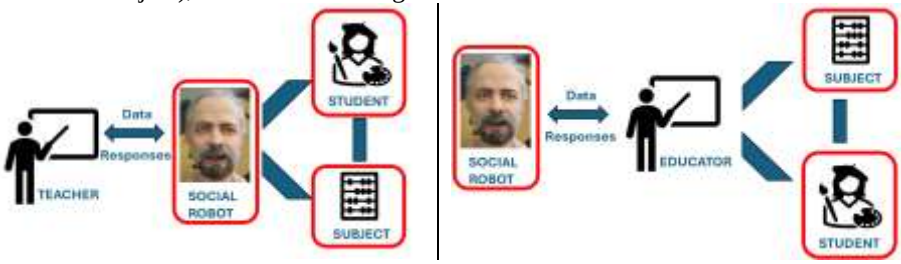

Fig. 1. Triangle symbol in education with SR as teaching assistant and educator.

In organizing A-STEM programs, it was found useful to consider the contribution of educational robots related to learning activities. SR represents a novel technology, adjusted with AI and robotics evolution, as the investigation theme and proof-of-concept experiments. These robots support teachers and instructors during the educational activity, including skill development, identifying weak points at the level of knowledge, and training to acquire the optimal base of information on the subjects of study.

2.3 Social Robots in Medical Field

Conventional methods of learning applied to psychological and social development can be improved by using technological innovations, mentioning the evolution of SR and AI.

SRs are used in the medical field to bring curiosity and inherent motivation to children's development, with the goal of enhancing learning and social interaction. Furthermore, SRs could be considered great companions that encourage communication among the elderly and improve their emotional experiences, including loneliness, ennui, anxiety, helplessness, and even stress [24-26]. Also, an AI companion could help an individual with object lifting, fall detection, or reminding him about medication leftovers [24]. In addition, children diagnosed with neurodevelopmental disorders such as ADHD, Autism Spectrum Disorder (ASD), or any other learning disabilities that significantly affect social, personal, or academic interaction could be compensated by the advancements of AI and SRs. This is the context in which a SR could be seen as a personal trainer, companion, or simply a medical device. SRs could serve as a way of communication, using symbols and speech output to facilitate intermediate interaction, visual displays, and wearable devices so that the individual is helped to accomplish and overcome social boundaries [25].

SRs can be included in rehabilitation programs and care for patients who have suffered a stroke, brain trauma, or other neurological conditions. The technological features of SRs can provide physical, emotional, and cognitive support, thereby significantly contributing to improving the quality of life of patients. It can be mentioned that there are a few ways in which social robots can intervene: emotional and social support, speech therapy, occupational and cognitive therapy, and health management by following treatment and monitoring vital parameters [35]. Another context in which SRs can serve in the medical field is when they are used for personalized therapies. Human beings facing anxiety, depression, or special needs and often confronting behaviors or adjustment problems in a particular environment or within a group could benefit from personalized therapies. In this case, robots can have a double role: communicator (the liaison between the therapist and the patient), or simply a personal assistant. For example, with the help of robots, aspects related to the patient's emotional or personality states can be identified, and based on the information collected, personalized, adapted, and optimized communication solutions can be made available through chromotherapy, melotherapy, play therapy, and others.

The issue that could be encountered is the acceptance of the SRs around us [27]. For example, among older adults with dementia, acceptance is defined in terms of

both functional use and social interaction, resulting in a low score of acceptance, highlighting the need for improved usability and user experience designed to increase their effectiveness and adaptation. According to [26], there is a lack of information about the usability and user experience of such robots in the care of elderly individuals. For children, such robots represent toys, gadgets, or outstanding play buddies, helping them to improve their learning style, problem-solving skills, and social interaction. In other words, SRs are beneficial partners in children's development and learning journey.

2.4 AI in Engineering

Investigating SR's involvement in engineering is also essential. AI and SR could be beneficial for people with certain disabilities to be included in workplace environments. The brain-machine interface associated with smart social robots could contribute to the quality of life. There are observed significant interactions and collaborations between humans and robots, not only from the programming point of view [38], but also from the point of view of AI capabilities and SR constraints related to security and privacy problems [28]. Engineers have designed SRs to understand information and react to human social cues, such as hand gestures, facial expressions, or voice tone or volume, or to optimize processes or improve processing time [37]. These capabilities enable SRs to communicate with human beings, assisting them to solve complex tasks and facilitating efficient cooperation and interaction between human beings and machines or robots. Therefore, SRs in engineering represent an emerging technology that has the ability to innovate the concept of how human-machine interactions are understood, developed, and accomplished securely.

3 Cybersecurity, Ethics and Standards

Social robots are increasingly popular and integrated into various activities, as discussed thus far in this article. Human beings are beginning to trust robots (SRs, industrial robots, flying robots, etc.), which simplify their daily tasks. However, this trust must be considered with caution, as communication services must be associated with cybersecurity measures [28]. Reference [30] presents several cases where SR cyber communication is compromised, potentially compromising user activity. In other words, SRs need to be developed in a manner that ensures that sensitive information is not shared with individuals unrelated to the owner's account or leads the user to improper actions. Additionally, SRs need to integrate facial recognition capabilities and include ethical considerations, such as providing information to maintain confidentiality between human beings.

In [6], the authors bring to the attention of the reader of the reader the significant gap in existing safety standards for robots, highlighting the need for a re-evaluation extended to social robots retrieved in public spaces. The complexity of public spaces should not be seen as a barrier; rather, SRs find their utility in gathering and analyzing information similar to social media platforms and smartphone digital assistants. However, it should be considered in several aspects with regard to threats, attacks, and

solutions to prevent the malicious behavior of the social robot [10-11], [13]. The most vulnerable aspects that can compromise a robot's behavior are related to its data, software, network, and hardware. As a solution, [11] proposes implementing encryption, authorization/authentication, and physical security measures. This approach allows for the analysis of the security level of robotic systems in different areas to find out if additional updates or corrections are necessary.

Through SRs, personal data is collected and processed. Data and results privacy and security must be ensured for the long term. At the international level, the cyber threat is primarily represented by three categories of attackers: 1) individuals and entities associated with state actors; 2) individuals and groups engaged in cybercriminal activities; 3) individuals and groups of hackers with ideological, political, or extremist terrorist motivations [39]. To ensure security, it is necessary to consider the factors that potentiate cyber-attacks: 1) the existence of technological, procedural, and human vulnerabilities affecting information systems, 2) the availability and accessibility of hacking resources; 3) the low level of security culture and hygiene in cyberspace; 4) insufficient training and specialization in cybersecurity among employees and managers; 5) normative and procedural deficiencies; the expansion of the range of devices; 6) the lack of a regulatory framework and risk management policies for the cyber nature of the supply chain [7-9], [34].

4 Discussions on Social Robots, AI and Humans

4.1 Humans and Social Robots

Based on recent research, it has been shown that the potential of SRs comes first of all from their ability to provide individual training, adapted to different human typologies, as well as a physical presence, which replaces traditional computer-based learning [14-15], [18-21], [26], [30]. Studies also indicate that their physical nature and non-virtual presence in real-world interactions with students provide increased benefits during the learning process, leading to improved learning outcomes [23], [27], [30-31].

From the point of view of efficiency, social robots are an optimal and easily accessible resource in teaching (or tutoring) - guidance activities for small groups of students, respectively for students with special needs. For example, the mean effect size values for different teaching types are presented by comparison in the table below [14-17].

Table 1. Effect size values for different teaching methods.

Teaching methods	**Effect size index *d***
Human tutoring vs. class-based teaching	d = 0.79
Intelligent Tutoring Systems (ITS) vs. Computer Aided Instruction (CAI)	d = 0.76
Robot prototypes	d = 0.70

Thanks to AI, SRs are able to communicate with humans and create well-informed and well-adjusted learners [16]. On this matter, robots can use face detection to recognise humans and objects and have the ability to understand speech sounds to extract and generate words from spoken interaction, dialogue models, or any conversation [14], [18-19]. Furthermore, the natural interface makes robots adequate for a wide spectrum of tutoring activities. This includes tutoring pre-literate children, teaching foreign languages through natural interaction, performing in-depth assessments, and delivering individualized training programs for specific tasks.

In comparison to software-based learning methods such as Intelligent Tutoring Systems, which offer solely one-on-one and personalized teaching, a social educational robot brings social and physical presence [20-21].

As a result of these evaluations, the HRI process proves that attention and motivation are well defined and understood. However, some interactions with social robots could generate a certain form of connection that is different from interactions with other people [22]. In this matter, social robots can be used both as teachers and as teaching assistants [14-15]. It can be distinguished in several cases: (a) the robot can interact and communicate with a group of students instead of one single student; (b) the robot can solve administrative tasks (e.g., student registration) and assume specific teaching duties (e.g. check prior knowledge, assign multiple-choice questions, summarize answers, and provide feedback), offering the possibility for the teacher to pay attention to each individual student. One significant outcome of this role is that the robot inspires great confidence in students, leading to progress even among those who struggle the most [23]. Besides their educational role, robots can also serve as counsellors, providing socio-emotional support in a non-judgmental and neutral manner. Robots have now become indispensable in society, and their integration into education is paramount. However, there is genuine apprehension regarding the digital divide in education and the unequal access to educational technology.

Table 2. Pros & Cons aspects of implementing SRs in educational and social activities.

PROS	**CONS**
Supporting teaching activities in A-STEM	Considerable technical, economic, and logistical challenges
Availability and versatility	Limited capacity of data storage
Improving social skills (by understanding and carrying out certain social interactions) or languages (e.g., robot-assisted language learning domain RALL)	Interrupting or slowing down classroom activities
Assisting children with special needs	Increase the workload of teaching staff
Personalized Intelligent Tutoring Systems (PITS)	Negatively impact interpersonal relationships
Preventing and reducing school dropout	Risk of increasing social isolation
Well-being and comfort	Developing a "robotic" style of interaction in the classroom environment (which includes some important char-

	acteristics, such as: precision, consistency, task-oriented, repetition, etc.)

4.2 Resulting outcome: AI and SR Interaction with Humans

In the following paragraphs, several outcomes of human interactions with social robots will be presented. These outcomes serve as a guide for researchers, indicating areas for innovation, development, and implementation in social robots. Additionally, they help individuals understand the impact and benefits of new technologies and AI on human well-being, as well as the constraints involved in interacting with these technologies.

(a) Observations on the interaction: user vs. robot

According to [24], three important factors must be taken into consideration in the development of SRs, including assistive social robots. These factors are related to functionality, usability, and user experience. Additionally, the appearance of the SR must also be considered, including the robot shape and the materials used, as these can significantly affect the user. Furthermore, [24] describes that users of social robots are interested in the social, cognitive, and emotional aspects of their interactions, which can lead to feelings of pleasure, aesthetic appreciation, or the desire to repeat the interaction. While children perceive social robots as toys, older adults are impressed by their physical attractiveness and social friendliness. This indicates a significant increase in positive efforts to assist elderly individuals in their physical and social activities.

However, according to [30], a SR does not always yield the best results and is not always the key to success. This is due to the fact that if the robot appears too friendly or addresses children by their first names, they may perceive it more as a friend than a teacher. Additionally, the robot's appearance, eye contact, and friendly interactions can distract children. This issue needs to be addressed by researchers and communicated with the medical team to find the appropriate solution.

Another aspect related to social robots is speech recognition. For effective speech recognition, robots must understand what people say and distinguish between verbal and non-verbal dialogue, such as gestures, body posture, and movements [29], [40]. This distinction is achieved through AI and machine learning techniques. Several engines, still in progress to be improved, could be mentioned: Alexa, Bixby, Watson, or Google Assistant [41].

(b) Interviews and user surveys vs. perception and experience

Often, surveys and interviews help to obtain a point of view on the perception, respectively, of the experience of a new technology appearing on the market. The researchers did the same thing on SRs and robotic platforms in order to find out the requirements and expectations of people, with the aim of improving the functionalities, design, and usability of the robots. According to [31] perception and human behavior are generated by expectation. In [31]-[32] there are given examples of interviews between humans and robotic platforms in the context of sequences of job inter-

views. Such evidence provides decisive influence over a technology or behavior. All recorded data from interviewed individuals demonstrated that they enjoyed this experience, acquiring trust, comfort, and engagement.

(c) Human behavior analysis in interaction with social robots

Generally, when humans interact with new technologies, they express interest, curiosity, and a behavior of exploration. All these characteristics are essential for human intellectual development, which leads to learning new skills, fact-solving abilities, creativity, environmental discovery, and more [28-32].

Analyzing human behavior, social robots need to meet different characteristics and performances in their design and implementation, depending on the age of the individual. For children, social robots serve as an educational tool not only at school but also at home as a tool for entertainment and developmental support. Moreover, SRs could be a great tool for children with special needs, perceiving them as companions that play an important role in emotional recognition, therapeutic support, communication, and social development skills [42]. For adults, SRs are developed for professional use (healthcare, customer service, education) and dedicated to specific tasks. For elderly people, social robots overcome the feeling of loneliness by avoiding social isolation, and offering dialogues with emotional support [43-44].

(d) Usability testing understand the efficiency of the HSR in the HRI,

HSR are robots developed to resemble and interact with humans, with facial expressions similar to humans, gestures, and bending capacity that make them capable of intuitive interactions for users [1-2]. Among the most advanced humanoid robots, we can mention the PKD Android or the Ameca robot [2]. In the meantime, HRI focuses on the dynamics between humans and robots, providing information necessary for the evaluation, improvement, and development of HSRs. Usability testing is an important step used in the context of evaluating and understanding SRs from the perspective of efficiency, effectiveness, quality of interaction, and user satisfaction.

First, the dialogue between the SR and the humans needs to be viewed as a common conversation between two individuals. Like a human, the robot can gather information during this dialogue, with the distinction that it can retain significantly more information than a human. Additionally, the robot has the ability to continuously contribute to the discussion by accessing areas of knowledge through AI that may not be available to the humans. The SR possesses information that could be further enhanced through the integration of emotion recognition techniques [28]. The same authors from [28] found that for emotion recognition had an accuracy of 74.38% for the fusion of biometric features, voice versus face, and a tolerance of 5 bpm for heart rate estimation.

(e) Measures for security evaluation purpose

Individuals demonstrate social skills such as trust, empathy, and verbal and nonverbal communication. Similarly, SRs, thanks to the AI, acquire and refine these human-like social skills. However, there is a potential risk that humanoid robots in HRI or in interactions with other robots may misinterpret or misuse these skills, develop-

ing social engineering attacks [33–34]. To prevent such issues and follow the cybersecurity rules, there are available solutions [45] to be included in the development of social robots. Several key methods are enumerated below: (i) develop a safe communication protocol that ensures prevention against any interception of data; (ii) include access restrictions to the operating system and software used for controlling the social robot; (iii) update software and firmware to avoid vulnerabilities; (iii) develop monitoring threads to detect unexpected behavior in the social robot's functioning; (iv) include authentication methods based on biometric or digital certificates; (v) social robot data protection; (vi) social robots need to meet ethical guidelines and standards.

5 Conclusions

Social robots are designed to communicate with human beings using natural language, nonverbal gestures, or voice recognition. This kind of interaction contains tremendous information to evaluate the importance of AI and SRs in various domains (education, healthcare, or engineering) that provide intellectual and physical support to humans. Using facial recognition and voice analysis, robots could identify human emotions, provide corresponding feedback, and also offer personal assistance. Thanks to AI, algorithms, and programming software strategies, SRs could learn and improve their behavior according to the needs of the user or person. However, it is important to consider that the high level of information related to confidentiality and security is crucial for such interactions, and at this point, cybersecurity needs to be involved to solve issues of loss of information or corruptly acquired or processed data; therefore, cybersecurity brings the measures that should be taken into account.

References

1. A. Habib et al., "Learning human-like facial expressions for Android Phillip K. Dick.", CASE 2014*:* 1159-1165.
2. https://builtin.com/robotics/humanoid-robots
3. www.liebertpub.com/doi/full/10.1089/cyber.2020.0181
4. www.oecd-ilibrary.org/sites/1c3b1d56en/index.html?itemId=/content/component/1c3b1d56-en
5. Puglisi A et al., "Social Humanoid Robots for Children with Autism Spectrum Disorders: A Review of Modalities, Indications, and Pitfalls. Children (Basel)", 2022 Jun 25;9(7):953. PMID: 35883937; PMCID: PMC9316169, doi: 10.3390/children9070953.
6. S.O. Oruma et al.., "Security Aspects of Social Robots in Public Spaces: A Systematic Mapping Study.", *Sensors* 2023, *23*, 8056. https://doi.org/10.3390/s23198056.
7. Certification of processes for AI, https://www.lne.fr/en/service/certification/certification-processes-ai.
8. The European Cybersecurity Scheme on Common Criteria (EUCC).
9. https://www.enisa.europa.eu/publications/cybersecurity-certification-eucc-candidate-scheme
10. A. Botta et al., "Cyber security of robots: A comprehensive survey", Intelligent Systems with Applications", Vol. 18, 2023, 200237, ISSN 2667-3053.

11. D. Pascuali et al., “That's not a Good Idea: A Robot Changes Your Behavior Against Social Engineering”, HAI '23: Proceedings of the 11th International Conference on Human-Agent InteractionDecember 2023Pages 63–71https://doi.org/10.1145/3623809.3623879.
12. whitepaper-benefits-of-social-robots.pdf (furhatrobotics.com)
13. J.P.A. Yaacoub et al., “Robotics cyber security: vulnerabilities, attacks, countermeasures, and recommendations”, Int. Journal of Information Security (2022) 21:115–158 https://doi.org/10.1007/s10207-021-00545-8.
14. T. Belpaeme et al., “Social robots as educators”, OECD Digital Education Outlook 2021 Pushing the Frontiers with Artificial Intelligence, Blockchain and Robots: Pushing the Frontiers with Artificial Intelligence, Blockchain and Robots, 143-158, Paris: OECD Publishing, 2021.
15. R.Y. Pai et al., “Effectiveness of social robots as a tutoring and learning companion: a bibliometric analysis”, Cogent Business & Management, 11(1), 1-17, 2024, https://doi.org/10.1080/23311975.2023.2299075.
16. K. Vanehn, “The relative effectiveness of human tutoring, intelligent tutoring systems, and other tutoring systems”, Educational psychologist, *46*(4), 197-221, 2011, https://doi.org/10.1080/00461520.2011.611369.
17. T. Belpaeme, et al., “Social robots for education: A review”, Science Robotics, 3(21), 1-9, 2018, https://doi.org/10.1126/scirobotics.aat5954.
18. C. Bartneck et al., Human-Robot Interaction, Cambridge University Press, 2020, https://doi.org/10.1017/9781108676649.
19. C. Bartneck et al., “Expressing uncertainty in Human-Robot interaction”, Plos one, 15(7), 1-20, 2020, https://doi.org/10.1371/journal.pone.0235361.
20. W. Bainbridge et al., “The Benefits of Interactions with Physically Present Robots over Video-Displayed Agents”, International Journal of Social Robotics, 3(1), 41-52, 2011, https://doi.org/10.1007/s12369-010-0082-7.
21. J Li, “The benefit of being physically present: A survey of experimental works comparing copresent robots, telepresent robots and virtual agents,” International Journal of Human-Computer Studies, 77, 23-37, 2015, https://doi.org/10.1016/j.ijhcs.2015.01.001.
22. T. Belpaeme et al., “Multimodal Child-Robot Interaction: Building Social Bonds, Journal of Human-Robot Interaction”, 1(2), 33-53, 2012, https://doi.org/10.5898/jhri.1.2.belpaeme.
23. C. Chase et al., “Teachable Agents and the Protégé Effect: Increasing the Effort Towards Learning”, Journal of Science Education and Technology, 18(4), 334-352, 2009, https://doi.org/10.1007/s10956-009-9180-4.
24. I. Halim et al., “A Review on Usability and User Experience of Assistive Social Robots for Older Persons”, International Journal of Integrated Engineering, Vol. 14, No. 6 (2022).
25. F. Bertacchini et al., “A social robot connected with chatGPT to improve cognitive functioning in ASD subjects”, Front. Psychol., 2023 Sec. Neuropsychology, Vol/ 14, 2023 https://doi.org/10.3389/fpsyg.2023.1232177.
26. V. Charisi et al., “Child-Robot Collaborative Problem-Solving and the Importance of Child's Voluntary Interaction: A Developmental Perspective”, Front. Robot. AI, Sec. Human-Robot Interaction, Vol. 7, 2020, https://doi.org/10.3389/frobt.2020.00015.
27. M.S. Erden, Social Robotics and Engineering Students: Do They Match? Does Culture Matter?, Int J of Soc Robotics 12, 1149–1157, 2020.
28. A. Abate, et al., "Social Robot Interactions for Social Engineering: Opportunities and Open Issues," in 2020 IEEE Intl Conf on Dependable, Autonomic and Secure Computing, Intl Conf on Pervasive Intelligence and Computing, Intl Conf on Cloud and Big Data Computing, Intl Conf on Cyber Science and Technology Congress (DASC/PiCom/CBDCom/CyberSciTech), Calgary, AB, Canada, 2020 pp. 539-547.

29. Social robots in real-life environments – Ideas in ALL
30. Social Robots: The Friend of the Future or Mechanical Mistake? - IEEE Technology and Society
31. J. Rosen et al., “Previous Experience Matters: An in-Person Investigation of Expectations in Human–Robot Interaction”, International Journal of Social Robotics, 2024, https://doi.org/10.1007/s12369-024-01107-3.
32. A. Corrales-Paredes et al., “User Experience Design for Social Robots: A Case Study in Integrating Embodiment”. Sensors (Basel). 2023 Jun 1;23(11):5274. doi: 10.3390/s23115274. PMID: 37300001; PMCID: PMC10256079.
33. https://uwspace.uwaterloo.ca/handle/10012/16030
34. W. Syafitri et al., “Social Engineering Attacks Prevention: A Systematic Literature Review”, Digital Object Identifier 10.1109/ACCESS.2022.3162594.
35. A. Dembovski et al., “A Socially Assistive Robot for Stroke Patients: Acceptance, Needs, and Concerns of Patients and Informal Caregivers”, Front Rehabil Sci. 2022 Jan 25;2:793233. doi: 10.3389/fresc.2021.793233. PMID: 36188775; PMCID: PMC9397920.
36. J. Young et al., “Evaluating human-robot interaction”. Int/ Journal of Social Robotics 3: 53–67, 2011.
37. A. Salih, “Artificial Intelligence in Engineering and Society - Current Trends and Applications”, DOI: 10.12903/DHBW_RV_FN_03_2020, 2020.
38. R. Blake et al., “Impact of Artificial Intelligence on Engineering: Past, Present and Future”, 54th CIRP Conference on Manufacturing Systems, Procedia CIRP 104 (2021) 1728–1733.
39. www.tenable.com/blog/3-types-of-cyber-attackers-which-organizations-do-they-target
40. C. Romero-González et al., "Spoken language understanding for social robotics," 2020 IEEE International Conference on Autonomous Robot Systems and Competitions (ICARSC), Portugal, 2020, pp. 152-157, doi: 10.1109/ICARSC49921.2020.9096175.
41. https://builtin.com/artificial-intelligence/ai-assistant
42. R. Vagnetti et al. Social Robots: A Promising Tool to Support People with Autism. A Systematic Review of Recent Research and Critical Analysis from the Clinical Perspective. Rev J Autism Dev Disord (2024). https://doi.org/10.1007/s40489-024-00434-5.
43. M.R. Fraune et al., “Socially facilitative robots for older adults to alleviate social isolation: A participatory design workshop approach in the US and Japan”, Front Psychol. 2022 Oct 19; 13:904019. doi: 10.3389/fpsyg.2022.904019. PMID: 36337527; PMCID: PMC9629871.
44. A. Góngora et al.. “Social Robots for People with Aging and Dementia: A Systematic Review of Literature”, Telemed J E Health. 2019 Jul;25(7):533-540. doi: 10.1089/tmj.2018.0051. Epub 2018 Aug 23. PMID: 30136901.
45. J-P. A. Yaacoub et al., “Ethical hacking for IoT: Security issues, challenges, solutions and recommendations”, Internet of Things and Cyber-Physical Systems, Vol. 3, 2023, pp.280-308, ISSN 2667-3452, https://doi.org/10.1016/j.iotcps.2023.04.002.