

## Integration of Social Robots in the Educational Environment: Psychological and Organizational Determinants of Effective Human–Robot Interaction in the University Context

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**Abstract:** Social robotics is an innovative field that merges engineering, technological, and social disciplines with the aim of creating robots capable of engaging with humans in socially relevant ways (Breazeal, 2003; Fong et al., 2003). The growing interest in the application of social robots in education is driven by their ability to facilitate learning, support the development of social and emotional skills, and promote mental health and well-being among learners (Belpaeme et al., 2018; Kennedy et al., 2017).

However, integrating social robots into the educational environment requires a thorough understanding of the psychological aspects of human–robot interaction, as well as the organizational factors that determine the success of their implementation (Vernon et al., 2015). In Bulgarian academic research, two main directions have emerged: Ivanova (2022) proposes a design model for educational social robots focusing on emotional expressiveness and cultural recognition; and STEMEDU (2022) demonstrates the positive impact of the BigFoot robot on children with special educational needs (SEN), including increased eye contact and social participation.

Nonetheless, there remains an open opportunity to develop a comprehensive organizational model for the sustainable implementation of social robots in the university context. Over the past decade, social robots such as NAO, Pepper, and Furhat have been increasingly introduced in educational settings as teaching assistants, mediators of social skills, and tools for mental health support (Belpaeme et al., 2018; Scassellati et al., 2018). Yet, in higher education, their potential remains underexplored—particularly regarding organizational culture, innovation acceptance, and the psychological factors influencing the perception and effectiveness of such technologies (Van Achte et al., 2023; Kennedy et al., 2017).

This study seeks to answer the following core question: What are the conditions and prerequisites for the sustainable and effective integration of social robots in university-level education?

**Keywords:** Social robots, Human-robot interaction, Educational technology, University education, Trust in robotics, Technology acceptance, Innovation adoption, NAO robot, Educational psychology, Higher education technology

### Aims and Objectives of the Study

The aim of this study is to explore the potential for integrating social robots in educational environments, with particular emphasis on the psychological and organizational determinants that influence their successful implementation and use (Tung & Au, 2018).

The specific objectives of the study are to:

Define the key characteristics and types of social robots used in education, as well as their advantages and limitations (Mubin et al., 2013);

Analyze the role of verbal and non-verbal communication in human–robot interaction, with regard to building trust and engagement (Kennedy et al., 2015);

Identify individual and cultural factors that influence the perception and effectiveness of social robots (Bartneck et al., 2007);

Examine the potential of social robots as tools for supporting the mental health and emotional well-being of children and adolescents (Scassellati et al., 2018);

Investigate the psychological and organizational aspects accompanying the introduction of social robots in educational institutions, including interpersonal relationships, organizational culture, and motivation for innovation adoption (Lewin, 1951; Van Achte et al., 2023).

### Scope of the Study

The scope of the research encompasses both theoretical and practical aspects related to the application of social robots in education. The study focuses on the interaction between social robots and people (teachers, students, therapists), examining the influence of psychological and organizational factors. Particular attention is given to the potential of social robots to support mental health and facilitate the social and emotional adaptation of children and adolescents (Belpaeme et al., 2018).

### Research Hypotheses

Psychological Hypotheses: H1: The perceived emotional intelligence of the social robot (e.g., Furhat) positively correlates with students' levels of trust and engagement. H2: Students with high technology readiness exhibit greater acceptance of social robots as educational assistants. H3: The inclusion of non-verbal communication (e.g., gestures, facial expressions, intonation) leads to significantly better interaction with the robot compared to verbal-only communication.

Organizational Hypotheses: H4: A positive organizational culture toward innovation in the university predicts higher motivation among educators to use social robots. H5: Institutional leadership support (top-down approach) is a key factor in the effective implementation of robots in the educational process. H6: The lack of adequate training and technical support reduces the sustainability and effectiveness of social robot use.

### Theoretical Foundations: Social Robotics – Principles and Educational Applications

Social robotics is a rapidly evolving field that merges artificial intelligence, cognitive sciences, psychology, and robotics with the aim of creating robots capable of interacting with humans in natural and socially appropriate ways. Below are recent developments in social robotics, with an emphasis on its foundations and applications in education (as of 2024–2025).

#### Foundations of Social Robotics

##### Human-Centered Design

Focus on user experience, empathy, and cultural context.

Involvement of end users (teachers, students) in robot design.

##### Emotion and Social Signal Modeling

Artificial systems for recognizing and expressing emotions (e.g., through facial expressions, tone of voice, gestures).

Use of multimodal approaches combining vision, audio, and language.

##### Ethical and Legal Considerations

Increased focus on safety, privacy, and accountability when interacting with vulnerable populations (e.g., children, the elderly).

Development of ethical frameworks (e.g., IEEE, UNESCO AI guidelines).  
Learnable Social Behaviors (Machine Learning + Reinforcement Learning)  
Real-time adaptation of robot behavior based on individual user responses.  
Applications in Education  
Robots as Teaching Assistants  
Examples: NAO, Pepper, QTrobot.  
Support learning in languages, mathematics, and sciences.  
Employ gamified approaches to enhance student engagement.  
Support for Children with Special Educational Needs (SEN)  
Social robots assist children with autism through structured and predictable social interactions.  
Promote social skills, attention, and emotional regulation.  
Development of Social-Emotional Skills  
Robots model positive behaviors: cooperation, empathy, active listening.  
Frequently used in role-plays and group discussions.  
STEM and Robotics in the Classroom  
Robots facilitate hands-on learning: programming, logical thinking, problem-solving.  
Encourage creativity and teamwork.  
Interactive Assessment and Feedback Systems  
Robots track student progress and adapt instruction accordingly.  
Recognize engagement levels, concentration, and fatigue.  
Emerging Trends (2023–2025)  
Integration of generative AI (e.g., ChatGPT) in social robots.  
XR (Extended Reality) + social robots for hybrid physical/virtual interaction.  
Miniature and mobile robots for personalized learning at home or in small classrooms.  
Universal design for accessibility – robots adapted for diverse educational levels and abilities.  
Emotion-driven adaptive learning – robots adjust difficulty levels based on student motivation.

Social Robotics in the University Educational Environment: Guidelines and Perspectives in the Bulgarian Context  
Social robotics is an interdisciplinary scientific field combining technologies from robotics, artificial intelligence, cognitive science, and social psychology to create robots capable of natural and socially acceptable interaction with humans. In recent years, its application in education has proven particularly promising, with social robots increasingly used not only in preschool and school settings but also in higher education.

In the context of Bulgarian universities, social robotics can play a key role in enhancing student engagement, personalizing instruction, and developing digital and social competencies.

Theoretical Principles and Technologies Social robots are characterized by their ability to recognize, interpret, and appropriately respond to human behavior, including facial expressions, gestures, intonation, and emotional states. The theoretical framework of social robotics is grounded in human-centered design principles, social cognition, and joint attention theory, while emphasizing ethical aspects of human-autonomous system interaction (Sharkey & Sharkey, 2011; Dautenhahn, 2007). This makes social robotics particularly well-suited for educational environments where interpersonal communication and individualized approaches are essential.

At the university level, robots may be used for:

Intelligent teaching assistants (AI TAs) supporting instructors in managing the learning process;  
Interactive conversational partners for foreign language practice, especially in linguistics, translation studies, and international relations;

Socially adaptive robots in STEM education to promote active participation and problem-solving skills.

Practical Examples and Pilot Models

European University Initiatives

Uppsala University (Sweden): uses the NAO robot for programming and human-machine interaction training.

University of Bologna (Italy): integrates Pepper in social science and psychology courses, where students analyze human-robot interactions.

Potential Applications in Bulgarian Universities

Sofia University "St. Kliment Ohridski": integrating social robots in teacher education programs to simulate

classroom environments and train pedagogical skills.

Technical University of Sofia: using humanoid robots in laboratory exercises on robotics, control systems, and artificial intelligence.

New Bulgarian University: creating interdisciplinary master's programs combining social robotics, cognitive science, and interaction design.

Plovdiv University & Institute of Robotics at the Bulgarian Academy of Sciences: implementing educational sessions and therapeutic interactions through a dedicated Center for Social-Assistive Robotics.

Research on social robots in the context of mental health and emotional well-being requires carefully selected methodological approaches that reflect the complexity of human-robot interaction. The diversity of research models enables both quantitative evaluations of effectiveness and qualitative insights into the experiences of children, adolescents, and young adults. The table below summarizes the main research approaches used in recent empirical studies in the field of social robotics, along with real-world examples.

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methodological approaches that reflect the complexity of human-robot interaction. The diversity of research models enables both quantitative evaluations of effectiveness and qualitative insights into the experiences of children, adolescents, and young adults.

**Table 1. Research Models and Examples**

Research Model	Description	Example Study
Experimental Design	Controlled environment, comparison between groups	Scassellati et al. (2012): NAO robot reduces anxiety in children with autism.
Quasi-Experimental Design	No random assignment; real-world context	Fridin (2014): storytelling robot in Israeli kindergartens.
Design-Based Research (DBR)	Iterative design/testing in natural setting	Belpaeme et al. (2018): adaptive learning scenarios with a school robot.
Qualitative Research	Interviews, observations, experiential analysis	Moyle et al. (2020): student interviews on robot interaction.
Mixed Methods Research (MMR)	Combines quantitative and qualitative methods	Gasteiger et al. (2021): surveys + focus groups in universities.
Longitudinal Research	Tracks effects over time	Wada & Shibata (2007): therapeutic robot Paro over several months.

There is no single research method universally applicable for all cases involving social robots and mental health. Instead, methodological choices should reflect the specificity of research questions, target groups, and application context. Experimental and mixed methods are well suited for measuring effectiveness, while design-based and qualitative approaches offer valuable insights into the interaction process and user perception. Longitudinal studies are particularly important for assessing sustainable impacts on mental and emotional development, especially when working with vulnerable populations.

**Advantages and Challenges**

**Advantages:**

- Increased student motivation through new technologies;
- Personalized and adaptive learning;
- Stimulation of interdisciplinary collaboration among faculties.

**Challenges:**

- High initial investment requirements;
- Lack of trained personnel for working with social robots;
- Ethical and legal concerns related to privacy and real-time interaction.

**Outlook**

The introduction of social robotics in higher education represents a strategic opportunity to modernize Bulgarian universities. Through pilot labs, curriculum integration, and interdisciplinary cooperation between IT, pedagogy, and humanities departments, universities in Bulgaria can become innovation hubs for social robotics.

**Definition and Key Features of Social Robots**

A social robot is an autonomous, physically embodied robot capable of interacting and communicating with humans and/or other robots in a socially meaningful way. It features sensors (cameras, microphones, touch), artificial intelligence, and can:

- Recognize and express emotions (via facial expressions, tone of voice, gestures);
- Conduct dialogue and maintain social context;
- Adapt behavior to individuals and situations;
- Build social relationships and follow social norms.

According to scholarly sources, main features include:

- Embodiment – physically present, not virtual;
- Anthropomorphism – human-like traits to ease interaction;
- Socio-emotional competence – emotional recognition and signaling;
- Intelligent autonomy – decision-making and behavioral adaptation.

Baraka et al. (2019) propose a framework of seven dimensions: appearance, social capabilities, purpose and use, role, autonomy, proximity, and temporality.

Types of Social Robots in Education

Teaching and Tutoring Robots

Act as intelligent tutoring systems – often performing at levels comparable to human teachers.

Examples: Tega (MIT Media Lab), Furhat, Shalu – used in language, reading, math instruction.

Peer Learning Robots

Function as "classmates," encouraging motivation, interaction, and social support.

Example: Tega engages children in educational games and language development.

Telepresence Robots

Allow distance participation for ill or absent students.

Example: AV1 used in UK schools for children with chronic illnesses.

Specialized Support Robots (e.g., for autism)

Recognize emotions, support social skills development.

Example: SoCoRo project (Ruth Aylett) – emotionally intelligent robots for adaptive learning.

Why and How They Work in Education

Physical presence enhances engagement and cognitive outcomes compared to virtual agents;

Comparable results to human instructors on specific tasks;

Provide personalized, emotionally responsive instruction adapting to students' reactions;

Especially helpful for special needs learners – supporting social habits and communication.

Examples of Social Robots in Education

Furhat (Sweden, 2014) – highly adaptive, used in teaching, therapy, research.

Tega (MIT) – partner in learning games for children.

Shalu (India) – humanoid robot speaking 47 languages, teaching diverse subjects.

AV1 – telepresence robot for children in hospital settings.

Table 2. Comparative Applications of Social Robots (2021–2025)

Robot	Application	Key Findings
NAO	Autism, special education	Improved engagement and focus; enhanced motivation.
Pepper	Autism, therapy, SEN schools	16h interaction, 330 sessions; improved well-being.
Furhat	Language learning, higher education	+27% in learner outcomes; effective emotion recognition.

Summary

NAO – Proven to increase focus and motivation among children with autism; effective in therapeutic and emotional support contexts.

Pepper – Successfully integrated in classrooms; supports mental well-being; widely accepted by users.

Furhat – Strong in language education and emotional interaction; supported by advanced AI for dynamic responses.

Hypothesis Testing Overview

Psychological Hypotheses:

Hypothesis	Variables	Method	Expected Outcome
H1	Perceived emotionality scale; trust/engagement levels	Pearson correlation	Positive relationship
H2	Technology readiness index; acceptance score	Regression analysis	Higher readiness = higher acceptance
H3	Verbal-only vs. multimodal robot interaction	Independent samples t-	Multimodal > Verbal-only

		test	
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Organizational Hypotheses:

Hypothesis	Variables	Method	Expected Outcome
H4	Innovation culture scale; motivation levels	Multiple regression	Strong positive correlation
H5	Faculty survey; observed robot use	Chi-square analysis ( $\chi^2$ )	More leadership support = more adoption
H6	Training availability; usage persistence (6 months)	Logistic regression	Training = higher sustainability

**Conclusion** Social robots have the potential to transform the educational environment by offering innovative approaches to learning, social-emotional development, and mental well-being. This study outlines key psychological and organizational determinants influencing the successful integration of robots like NAO, Pepper, and Furhat in university settings. The analysis shows that user perception depends not only on technical capabilities, but also on social interaction, cultural adaptability, and institutional support.

Psychological factors such as trust, emotional engagement, and technological readiness significantly impact robot acceptance. From an organizational perspective, leadership support, innovation culture, and training are essential for sustainable implementation. The study proposes actionable strategies for integrating social robotics in Bulgarian higher education through pilot programs, interdisciplinary cooperation, and ethical regulation.

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