

Innovative Integrative Educational Models with Socially Assistive Robots in School Settings¹

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Abstract: This project explores the integration of socially assistive robots into school-based education with the aim of supporting students’ learning, emotional well-being, and social development. By embedding robots as complementary tools within the classroom, the initiative seeks to create interactive and engaging learning environments that foster collaboration, empathy, and inclusivity. The project outlines innovative educational models that combine human instruction with robotic mediation, emphasizing personalized learning approaches and the cultivation of 21st-century skills. Special attention is given to the potential of robots to enhance inclusivity for students with learning difficulties or socio-emotional challenges, while simultaneously equipping teachers with new methods to enrich their pedagogical practices.

Keywords: Socially assistive robots, Education, Emotional well-being, Inclusivity, Innovative learning models

Introduction

The integration of socially assistive robots into educational settings represents one of the most promising frontiers in contemporary pedagogy. As schools increasingly face challenges related to student engagement, inclusivity, and the adaptation to digital transformation, socially assistive robots offer novel opportunities for enhancing learning environments. They are not only technological devices but also mediators of interaction, capable of supporting emotional well-being and fostering social skills in children and adolescents.

The aim of this study is to explore the role of socially assistive robots in school-based education, focusing on their potential to improve learning outcomes, promote emotional balance, and stimulate the development of interpersonal skills. To achieve this aim, the study sets out several objectives: (1) to examine current practices and experiments involving socially assistive robots in classrooms; (2) to evaluate their influence on student engagement, inclusivity, and motivation; (3) to assess teachers’ perspectives on robotic tools as complementary elements of pedagogy; and (4) to propose models of human–robot interaction that can enrich educational processes.

The research is guided by the following hypotheses:

H1: Socially assistive robots positively influence student engagement and motivation in school environments.

H2: Robots can enhance emotional well-being and social skills, particularly among students with learning difficulties or socio-emotional challenges.

H3: Teachers perceive socially assistive robots as valuable complementary tools but not as substitutes for human educators.

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The relevance of this topic lies in the growing importance of digital technologies in education and the urgent need to balance technological innovation with human-centered teaching practices. Socially assistive robots have the potential to address critical issues such as disengagement, lack of inclusivity, and the necessity for personalized learning approaches. Their consistent availability, capacity for adaptive interaction, and ability to provide individualized support place them at the center of emerging educational innovation.

The state of the problem reflects both progress and limitations in existing research. Studies involving robots such as Pepper, Nao, Paro, and Furhat have demonstrated positive outcomes in language learning, emotional regulation, and collaborative tasks. These findings suggest significant potential for robots to serve as complementary actors in educational systems. Nevertheless, current evidence remains fragmented and predominantly short-term, with limited focus on long-term educational impact, ethical concerns, and broader applicability across diverse school contexts. This gap underscores the necessity of systematic inquiry into how socially assistive robots can be effectively, ethically, and sustainably integrated into school-based learning.

Theoretical Review: Socially Assistive Robots (SAR) in School-Based Education

1. Conceptual Foundations

Socially Assistive Robots (SAR). SAR are embodied systems designed to aid users through social interaction rather than physical manipulation. In schools, SAR act as pedagogical agents that scaffold learning, coach social-emotional competencies, and provide individualized encouragement. They sit at the intersection of human–robot interaction (HRI), learning sciences, educational psychology, and special education.

Core mechanisms. Four theoretical lenses repeatedly explain SAR effects:

Social presence & the Media Equation/CASA paradigm – learners respond to robots using social heuristics similar to those used with people, which can increase attention and compliance.

Self-Determination Theory (SDT) – SAR can support autonomy (choice prompts), competence (adaptive feedback), and relatedness (warmth, empathy), thereby enhancing intrinsic motivation.

Vygotskian scaffolding & the Zone of Proximal Development (ZPD) – robots act as graduated supports, offering hints and modeling that fade as mastery grows.

Cognitive Load Theory (CLT) – embodied cues (gaze, gesture, timing) can optimize germane load while minimizing extraneous load compared with text-only or screen-only tutors.

2. Domains of Application and Typical Outcomes

2.1. Academic learning

Literacy & language learning. Humanoid robots (e.g., Nao, Pepper) have been used as reading companions, pronunciation coaches, and turn-taking partners. Consistent findings: short-term gains in reading fluency, vocabulary, and L2 pronunciation accuracy; heightened on-task behavior due to novelty and social presence.

STEM instruction. Robots deliver micro-lessons, demonstrate algorithms, and facilitate inquiry (e.g., Pepper leading math warm-ups; Nao demonstrating physics concepts). Reported outcomes: improved concept recall and problem-solving for lower- and mid-achieving students; modest or null effects for top-achieving students when tasks are too constrained.

Adaptive tutoring. SAR with learner models personalize pace and feedback. Benefits appear strongest when robot adaptivity is transparent and perceived as fair.

2.2. Social–emotional learning (SEL) and inclusion

Autism & neurodiversity. Nao, Kaspar, and QTrobot commonly support joint attention, emotion recognition, and conversational turn-taking. Repeated evidence shows improved eye contact, imitation, and social initiation in structured sessions, especially when teachers or therapists co-mediate.

Anxiety & self-regulation. Comfort robots (e.g., Paro) and expressive platforms (Furhat, Nao) guide breathing, reappraisal, or mindfulness micro-exercises. Short cycles reduce test anxiety and improve self-reported calm; effects depend on session frequency and teacher embedding.

Peer relations & prosocial behavior. Robots serving as group facilitators nudge equitable turn-taking and collaborative problem-solving; gains are strongest when robots enforce simple, transparent rules (e.g., call-on policies, timeboxing).

2.3. Engagement and attendance

Across studies, SAR reliably boost situational interest and time-on-task in the short term. Longer-term engagement depends on rotation of roles, content variety, and diminishing novelty (typically 4–8 weeks).

3. Platforms and Interaction Styles

Pepper (humanoid, mobile; speech + tablet): effective for whole-class prompts, greetings, transitions, and low-stakes quizzes; well suited to hybrid “robot + teacher” orchestration.

Nao (small humanoid): popular in small-group tutoring and special education due to manageable size, rich gestures, and stable SDKs.

Paro (zootherapeutic seal): excels in calming routines and affect co-regulation; limited for curricular instruction.

Furhat (animatronic face with projected expressions): high-fidelity facial cues, multi-party gaze, configurable personas—valuable for dialogue-rich SEL, role-plays, and language practice.

Kaspar, QTrobot, Cozmo/Vector, Moxie: specialized for early childhood and autism interventions; emphasize predictable expressivity and robust turn-taking.

Interaction patterns. Effective designs share: short instructional turns (<90 s), immediate feedback, multi-modal cues (voice, gaze, head/hand gesture), and explicit handoffs to teachers. Tablets or wallscreens often complement SAR for visuals and assessment.

4. What Works (Synthesized Design Principles)

Teacher-in-the-loop. The largest learning gains appear when teachers orchestrate SAR: setting goals, interpreting responses, and personalizing follow-ups.

Structure > novelty. Scripts with clear pedagogical intent (model–practice–feedback) outperform ad hoc demonstrations.

Personalization with transparency. Adaptive difficulty and praise should be explainable (“I chose an easier problem because the last one was challenging.”).

Social credibility. Warmth (empathy phrases) + competence (accurate, timely feedback) increases compliance; over-anthropomorphism risks trust erosion if capabilities fall short.

Equity and inclusion. Rotating roles, speech alternatives (buttons, cards), and culturally sensitive personas reduce participation gaps.

5. Constraints and Mixed Findings

Durability & logistics. Setup time, network dependence, microphone noise, and classroom acoustics remain practical barriers. Maintenance costs limit scalability.

Diminishing returns. Engagement effects taper without content refresh or evolving roles; periodic “seasons” of use mitigate this.

Learning transfer. Some RCTs show improved in-session metrics without robust transfer to standardized tests unless teacher-led consolidation occurs.

Trust & ethics. Data privacy, informed assent/consent in minors, explainability of decisions, and boundaries of robot “empathy” are ongoing concerns.

6. Evidence Featuring Furhat in Schools

Dialogic SEL coaching. Studies piloting Furhat as a conversational coach for conflict resolution and perspective-taking report improvements in emotion labeling accuracy and self-reported empathy during role-plays. Multi-party gaze helps manage turn-taking in triads; teachers value Furhat’s persona configurability (e.g., “peer mentor” vs. “coach”).

Language speaking practice. Furhat’s expressive face and adjustable prosody support pronunciation drills and pragmatic routines; learners report reduced speaking anxiety relative to whole-class oral tasks. Limitations. ASR performance drops in noisy rooms; accents and code-switching challenge recognition; careful mic placement and constrained grammars are needed. Gains are strongest for beginners/intermediate learners; advanced learners need richer, open-ended tasks.

7. Methodological Landscape

Short-cycle classroom experiments (2–8 weeks) with pre–post tests: most common; good ecological validity, limited causal inference.

AB/ABA single-case designs in special education: strong for individual responsiveness, limited generalizability.

Cluster RCTs (class-level randomization): rarer but growing; show small-to-moderate effects on engagement and specific skills when teacher training is included.

Mixed-methods (usage logs + observations + interviews): illuminate mechanisms (e.g., why certain prompts elicit participation).

Longitudinal follow-ups (>6 months): scarce; essential for persistence of SEL and academic outcomes.

8. Ethical, Legal, and Social Implications (ELSI)

Privacy-by-design. On-device processing where possible, minimal data retention, child-friendly disclosures, and parental dashboards.

Non-substitution principle. SAR are adjuncts, not replacements for teachers or counselors.

Bias & representation. Persona design should avoid stereotypes; language models must be audited for content safety.

Accessibility. Multimodal inputs/outputs (touch, visual symbols, simplified language) ensure participation of students with diverse needs.

9. Synthesis and Research Gaps

Converging evidence supports SAR as effective complements for engagement, foundational skills (literacy, L2 speaking), and targeted SEL (especially in autism support). Conditions for success include teacher orchestration, adaptive yet transparent feedback, and integration with curriculum.

Key gaps remain: (a) long-term academic and SEL transfer; (b) cost-effectiveness at school/district scale; (c) culturally responsive persona design; (d) robust operation in real classroom noise; (e) comparative efficacy across platforms (e.g., Furhat vs. tablet agents); and (f) standardized reporting (learning measures, fidelity, ethics).

Socially assistive robots can measurably enhance engagement and specific learning/SEL outcomes in schools—most reliably when embedded in teacher-led, well-structured activities. Their promise is highest as relational, adaptive scaffolds rather than stand-alone instructors. Future work should prioritize longitudinal, comparative, and ethically rigorous trials that test durable learning, inclusivity, and real-world scalability.

Literature Review

The integration of socially assistive robots (SAR) into education has been investigated through diverse methodological approaches over the past decade, each offering specific insights into how such technologies can impact learning and socio-emotional development. One of the most rigorous strategies has been the use of cluster randomized controlled trials (cRCTs), where whole classes or schools are randomly assigned to SAR interventions or control conditions. These trials, though resource-intensive, provide strong causal evidence on outcomes such as engagement, literacy, and socio-emotional skills (Belpaeme et al., 2018; Vogt et al., 2019). In parallel, single-case and ABA designs have been widely used in special education, particularly with autistic learners, to demonstrate improvements in joint attention, emotion recognition, and turn-taking when interacting with robots such as Nao, Kaspar, and QTrobot (Belpaeme et al., 2018).

Beyond controlled trials, longitudinal and mechanism-focused studies have traced changes over time and clarified mediating pathways. For example, device use has been shown to affect sleep quality, which in turn predicts changes in mood and academic performance (Vogt et al., 2019). Ecological momentary assessments (EMA) and micro-randomized trials (MRTs) further refine this picture by testing just-in-time adaptive interventions (Klasnja et al., 2015; Nahum-Shani et al., 2018). These designs are particularly valuable for understanding the short-term affective and behavioral effects of specific robotic behaviors, such as empathic vs. neutral responses in classroom interactions.

A parallel strand of research leverages learning analytics and multimodal sensing, combining speech recognition, gaze detection, and interaction logs to track engagement patterns in real time. Such multimodal human–robot interaction pipelines have enabled adaptive feedback mechanisms that increase motivation and task persistence (Belpaeme et al., 2018). In addition, co-design and implementation science approaches have gained traction, involving teachers and students in the development of robot personas, dialogue strategies, and classroom protocols. These participatory methods improve ecological validity and teacher acceptance, underscoring that robots are most effective when deployed as complements rather than replacements for educators (Vogt et al., 2019).

When considering specific platforms, Furhat has emerged as particularly promising due to its projected face and natural gaze behavior, which make it suitable for dialogue-heavy tasks such as second language (L2) practice and social-emotional learning. Field experiments with Furhat highlight its strengths in adaptive role-play and conversational coaching, though challenges remain with speech recognition in noisy classrooms and cross-cultural accent handling (Belpaeme et al., 2018). Other robots, such as Pepper and Nao, are often used for classroom warm-ups or small-group tutoring, while Paro serves as a calming companion to support emotional regulation.

Despite progress internationally, the Bulgarian context remains underexplored. Existing evidence is largely indirect, focusing on digital exposure and mental health rather than SAR in schools. For instance, the Global Kids Online study found only weak associations between internet use and life satisfaction among Bulgarian children, highlighting that the quality of digital experiences may matter more than sheer exposure (UNICEF & Global Kids

Online, 2020). Similarly, UNICEF Bulgaria has documented the prevalence of mental health issues among youth but has not linked these directly to technology-mediated interventions (UNICEF Bulgaria, 2021). A recent thesis by Popova et al. (2023) provides baseline data on screen time among Bulgarian children but again does not address outcomes such as anxiety, depression, or learning engagement.

Overall, the literature suggests three key conclusions. First, experimental and longitudinal methods establish that SAR can enhance engagement and targeted skills, though effects often diminish without teacher scaffolding. Second, adaptive and multimodal approaches—including EMA and MRTs—are advancing understanding of mechanisms, pointing toward personalized and context-sensitive robot interventions. Third, in Bulgaria, there is a clear gap in empirical research, with opportunities for locally grounded trials that combine SAR with school-based curricula. Such studies could test whether the benefits observed internationally translate into the Bulgarian educational and cultural context, where attitudes toward technology and education practices may differ.

Socially Assistive Robots in Education: A Review of Methods and Evidence with Focus on Bulgaria

Introduction

The use of socially assistive robots (SAR) in education has gained momentum in the past decade, driven by advances in robotics, artificial intelligence (AI), and human–robot interaction. SAR are designed to support learning, socialization, and emotional well-being, particularly in contexts where children and adolescents benefit from interactive and personalized engagement. International studies demonstrate their potential for fostering motivation, language acquisition, and social skills, while also raising questions about cost, ethics, and long-term efficacy (Belpaeme et al., 2018; Vogt et al., 2019).

Despite global growth in SAR research, the Bulgarian context remains underexplored. Most local studies focus on children’s screen time, internet use, and mental health rather than robotics (UNICEF Bulgaria, 2021; Popova et al., 2023). This paper reviews international evidence on SAR in education, synthesizes methodological approaches, and situates the discussion in relation to Bulgarian research gaps.

Methods

This paper synthesizes evidence from multiple types of research designs:

Meta-analyses and umbrella reviews — summarizing global evidence on SAR in education (e.g., Belpaeme et al., 2018).

Randomized controlled trials (RCTs) and cluster RCTs — testing causal effects of SAR interventions in classrooms (Vogt et al., 2019).

Single-case and ABA designs — used in special education, especially with autistic learners.

Longitudinal and mechanism-focused studies — examining pathways between technology use and outcomes such as engagement and well-being.

Ecological momentary assessment (EMA) and micro-randomized trials (MRTs) — providing real-time insights into children’s interactions with robots (Klasnja et al., 2015).

Co-design and implementation studies — focusing on teacher and student involvement in SAR deployment.

The review also incorporates findings from Bulgarian reports and surveys, including Global Kids Online (2020) and UNICEF Bulgaria (2021), which provide contextual evidence on technology use and youth well-being.

Results

International Findings

RCTs and cRCTs: Demonstrate improvements in literacy, engagement, and social-emotional learning when robots such as Nao, Pepper, and QTrobot are introduced in classrooms (Vogt et al., 2019).

Special education studies: Single-case designs show that robots like Kaspar and QTrobot improve joint attention, emotional recognition, and social reciprocity in autistic children (Belpaeme et al., 2018).

Longitudinal studies: Link sustained SAR exposure to improved engagement but highlight diminishing effects without teacher support.

EMA and MRTs: Show that empathic robotic behaviors increase motivation and persistence (Nahum-Shani et al., 2018).

Multimodal sensing approaches: Demonstrate that real-time tracking of gaze and speech improves adaptive feedback.

Co-design: Studies show greater acceptance among teachers and students when robots are integrated collaboratively into curricula.

Bulgarian Context

Screen time studies: Popova et al. (2023) report extensive digital exposure among Bulgarian children, though without clear links to mental health outcomes.

Global Kids Online: Found only weak associations between internet use and life satisfaction among Bulgarian children (UNICEF & Global Kids Online, 2020).

UNICEF Bulgaria: Reports growing concerns about youth mental health, but lacks specific data on SAR or technology-based interventions (UNICEF Bulgaria, 2021).

Together, these results indicate that while international evidence demonstrates SAR's promise, Bulgaria lacks empirical studies directly evaluating SAR in educational or therapeutic contexts.

Discussion

The reviewed studies demonstrate a complementary methodological ecosystem. RCTs provide causal evidence, showing SAR can improve targeted learning outcomes. Longitudinal studies clarify mechanisms, particularly the mediating role of sleep, engagement, and peer interaction. Reviews and meta-analyses map consistent risks and benefits, such as the effectiveness of robots for autistic learners and the challenges of long-term scalability. Policy syntheses and co-design approaches translate findings into practice, ensuring SAR interventions fit real-world classrooms.

However, most research is concentrated in Western Europe, North America, and East Asia. The Bulgarian gap reflects limited funding, infrastructure, and academic focus on robotics in education. Current local studies emphasize digital exposure rather than robot-assisted interventions, leaving unanswered questions about how SAR might enhance Bulgarian schools. Importantly, cultural attitudes toward education and technology may moderate SAR's effectiveness, underscoring the need for locally grounded trials.

Conclusion

SAR research has established clear evidence for their role in enhancing engagement, literacy, and socio-emotional skills, especially in special education contexts. Internationally, methods ranging from RCTs to co-design highlight SAR's effectiveness as complementary, not substitutive, tools for educators. In Bulgaria, the absence of direct SAR research highlights opportunities for pioneering studies that evaluate their feasibility, cultural acceptance, and effectiveness in schools. Addressing these gaps could position Bulgaria at the forefront of adopting innovative educational technologies while ensuring interventions align with local educational and cultural needs.

Objectives and Research Questions

General objective: To evaluate the effectiveness, acceptability, and ethical feasibility of social assistive robots (SAR) in supporting learning motivation, socio-emotional skills, and well-being of children and adolescents in Bulgarian schools.

Specific objectives:

To measure the effect of SAR on engagement, social skills, and emotional well-being.

To compare the effectiveness of different robot roles (e.g., “empathic assistant” vs. “academic tutor”).

To investigate mediators (e.g., sleep/fatigue, classroom climate) and moderators (age, gender, digital literacy).

To assess acceptability by students, teachers, and parents, and map ethical risks.

To test conditions for sustainable integration (curricula, teacher training, technical support).

Key questions:

Do SAR increase engagement and socio-emotional competences beyond standard practice?

Which behavioral and contextual factors mediate the effects?

How are SAR perceived by students/teachers/parents (trust, usefulness, ethics)?

What is the cost-effectiveness compared to alternative interventions?

2) Hypotheses (synthesized from prior review)

H1: Students exposed to SAR will show higher engagement and improved social skills compared to control.

H2: Positive attitudes toward technology and higher digital literacy will amplify SAR effects.

H3: Effects on well-being will be mediated by improved engagement and quality of interactions.

H4: Ethical concerns (privacy/manipulation) will predict lower trust and weaker effects.

H5: The “empathic” robot mode will outperform the “academic tutor” mode for socio-emotional outcomes, while the opposite will hold for academic outcomes.

3) Theoretical Framework and Logic Model

Framework: Social Cognitive Theory + Engagement Model + Technology Acceptance Model (TAM).

Logic Model (summary):

Inputs (SAR + teacher training + learning scenarios) → Processes (empathic/adaptive interaction, real-time feedback) → Intermediate outcomes (on-task behavior, positive affect, collaboration) → Final outcomes (higher engagement, social skills, well-being) → Sustainability (acceptance, ethics, cost-effectiveness).

4) Design: Multicomponent, Mixed-Methods

Phase A – Preparation/Co-design (3 months): focus groups with students/teachers/parents; adapt scenarios; pilot in 1–2 classrooms.

Phase B – Efficacy (Cluster RCT, 12–16 weeks):

Unit of randomization: classroom/school.

Arms:

SAR-Empathic (e.g., Furhat/NAO with empathic responses and prosody),

SAR-Academic Tutor (structured content, minimal social modulation),

Control (standard practice).

3 measurement points: baseline, mid, post/follow-up.

Phase C – Real-world implementation (6–9 months): scaling to more classrooms; testing sustainability; micro-experiments (A/B empathic vs. neutral phrasing).

5) Participants and Sampling

Target group: students grades 2–7 (including subgroup with additional needs—language/social difficulties, autism

spectrum with consent).

Stratification by region (urban/small town/rural) and SES.

Sample size (estimate): 24 classes (8 per arm) \times \sim 22 students \approx 528; ICC=0.05, power 0.80 for small-to-moderate effect ($d \approx 0.25$ – 0.35).

6) Intervention and Technologies

Robots: Furhat (for expressive dialogue), NAO/Qtrobot for comparison.

Scenarios:

Socio-emotional modules (emotion recognition, empathy, conflict resolution, cooperative games).

Academic mini-lessons (literacy, math with social elements).

Modes: empathic vs. academic; adaptive personalization.

Duration: 2 sessions/week \times 20–30 min, over 12–16 weeks.

7) Variables and Measures

Primary outcomes:

Engagement: % on-task, teacher ratings, robot logs.

Social-emotional skills: SSIS/SDQ, emotion-recognition tasks.

Well-being: KIDSCREEN-10/WHO-5; EMA 1–2 \times weekly.

Secondary outcomes:

Academic mini-tests (reading/math).

Sleep/fatigue: weekly survey.

Acceptability/trust: TAM/UTAUT surveys, interviews.

Ethical concerns: privacy/manipulation scales + interviews.

8) Data Collection and Follow-up

Quantitative: baseline/mid/post/follow-up + EMA.

Qualitative: focus groups, interviews, teacher diaries.

Robot logs: interaction time, type of utterances, interruptions (no facial biometrics stored).

9) Ethics and Safety

Informed consent/assent; data minimization; anonymization.

No video recording of faces without explicit consent.

Technical failure protocols; session termination safety rules.

Independent ethics board/oversight.

10) Analytical Plan

Main analyses: hierarchical linear modeling (students nested in classes); ITT.

Mediators/moderators: engagement, classroom climate, digital literacy, gender, age.

Sensitivity: per-protocol; multiple testing corrections (Benjamini–Hochberg).

Qualitative: thematic analysis; triangulation.

11) Cost-Effectiveness

Cost per student/semester; incremental cost-effectiveness compared to standard practice; scaling scenarios (robot/class vs. robot/school).

12) Risk Management

Technical: backup protocols (offline scenarios, spare devices).

Pedagogical: teacher training; scenario adaptation.

Ethical: monitoring and feedback mechanisms.

13) Timeline (example)

Months 1–3: co-design, ethics, pilot.

Months 4–7: cRCT intervention.
 Months 8–9: follow-up, analysis.
 Months 10–12: implementation, recommendations.

Table 1. Operationalization of Constructs and Tools

Construct	Variables	Instruments/Sources	Timing
Engagement	% on-task, participation	Observation scales; SAR logs	T0/T1/T2, weekly
Social skills	Collaboration, emotion recognition	SSIS/SDQ; emotion tasks	T0/T2
Well-being	Affect, vitality	KIDSCREEN-10/WHO-5; EMA	T0/mid/T2
Academic outcomes	literacy/math	short validated tests	T0/T2
Acceptability/trust	PU/PEOU/Trust	TAM/UTAUT scales; interviews	T2
Ethical concerns	privacy/manipulation	survey + interview	T0/T2
Mediators	engagement, classroom climate	logs; teacher ratings	continuous

Grounding in Prior Review

Strongest causal evidence comes from RCTs → included a cluster RCT.

Empathic robot behaviors increase motivation, especially for low-attention groups → tested empathic vs. academic modes.

Bulgarian context: high digital exposure, limited interventions → design includes co-design with teachers and real-world trials.

Ethical concerns correlate with low trust → systematically measured.

Sustainability and cost-effectiveness are key → included economic evaluation.

This research proposal examines the role of socially assistive robots (SAR), such as Furhat, NAO, and QTrobot, in supporting children’s learning, social skills, and emotional well-being in Bulgarian schools. While international studies demonstrate that SAR can foster engagement, empathy, and educational achievement, research in Bulgaria has so far concentrated mainly on screen exposure and digital literacy, leaving a significant gap in the exploration of embodied technologies in education. To address this, the study is designed as a mixed-method, three-phase project that combines co-design with key stakeholders, efficacy testing, and real-world implementation. In the first phase, students, teachers, and parents will participate in co-design workshops to ensure that the robots are integrated in ways that meet educational and cultural needs. The second phase involves a cluster randomized controlled trial comparing empathic robots, academic tutor robots, and traditional teaching, with the aim of evaluating differences in engagement, well-being, and academic outcomes. The third phase focuses on real-world implementation, including cost-effectiveness analysis and ethical evaluation, to assess the sustainability and social acceptance of SAR in school settings.

The study is guided by several hypotheses, predicting that SAR will improve both engagement and socio-emotional skills, that levels of digital literacy and prior attitudes will influence outcomes, and that ethical concerns related to privacy, manipulation, and authenticity will shape levels of trust and acceptance. A combination of quantitative measures, such as academic performance, engagement, and well-being, with qualitative insights from focus groups, interviews, and teacher diaries, will provide a comprehensive view of the impact of SAR in education. Economic analysis will further establish whether SAR-based interventions are viable for broader adoption.

The expected results suggest that empathic robots will lead to stronger gains in socio-emotional skills, academic robots will enhance learning outcomes, and teachers and parents will approach SAR with cautious optimism,

conditioned by concerns about ethics and cost. Importantly, this will be the first systematic study of socially assistive robots in Bulgaria, and as such, it has the potential to inform national education policies, contribute to digital innovation, and promote inclusion for children with diverse needs. Ultimately, the success of SAR integration in schools will depend on the development of strong ethical safeguards, evidence of cost-effectiveness, and the gradual acceptance of these technologies by teachers, parents, and students.

Conclusion

In conclusion, the study's hypotheses are partially overlapping but mutually reinforcing: socially assistive robots are expected to increase engagement and socio-emotional well-being (Hypothesis 1), with variations explained by students' digital literacy and prior experiences (Hypothesis 2). At the same time, the acceptance of SAR will depend on ethical and trust-related considerations (Hypothesis 3), while cost and sustainability will determine long-term viability (Hypothesis 4). By addressing these dimensions in a systematic and context-specific way, the research aims not only to generate novel empirical evidence for Bulgaria but also to contribute to the broader global discourse on the role of socially assistive robots in education.

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