Editorial for the Special Issue: EduRobotX 2025 – Co-Creating Innovation for Educational Robots and Robotics for Learning*

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1. Introduction

The 3rd International Workshop on Educational Robots and Robotics, organized by the EATEL Special Interest Group EduRobotX and held during the European Conference on Technology Enhanced Learning (EC-TEL) 2025 in Newcastle, UK, aligned closely with the conference's overarching theme of inclusive and equitable quality education for all. This workshop specifically emphasized educational robots and robotics as tangible, embodied, and interactive technologies that enrich learning experiences within physical spaces, foster learner curiosity, and accommodate diverse learner needs.

Extensive research has demonstrated that educational robots and robotics can significantly enhance student motivation, engagement, curiosity, learning outcomes, attitudes, experiences, computational thinking, collaboration, and creativity across a broad spectrum of educational contexts, spanning from primary to tertiary levels [1–6]. The EduRobotX workshop aimed to advance the goal of inclusive and equitable education by exploring the varied applications of educational robots and robotics across different learning environments and age groups. Key thematic areas of interest included: (1) Robot-Assisted Language Learning (RALL), where educational robots support second language acquisition (SLA) and have shown particular effectiveness with elementary school students [7]; (2) Robot-Supported Collaborative Learning (RSCL), involving robots as complementary facilitators alongside teachers to improve learning environments in higher education [8]; and (3) hybrid learning utilizing telepresence robots, which enable remote learners, such as children in hospitals or individuals with mobility limitations, to participate synchronously in classroom activities while maintaining social connectivity [9]. Through these focal points, the workshop reflected on contemporary practices, empirical research, and their implications for pedagogically sound integration of robots and robotics in educational settings. The scope of the EduRobotX workshop extended beyond traditional classrooms to include all age groups, from preschool children who benefit from robots supporting sequencing and logical thinking through tangible programming, to senior learners engaging in individualized cognitive and collaborative learning activities. Furthermore, the workshop underscored the potential of educational robotics in special education, exemplified by using robots to support autistic learners in developing social and communication

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skills, supporting learners with reading impairments such as dyslexia, enhancing interpersonal interactions, reducing stress, and maintaining attention [10]. This event fostered the exchange of innovative approaches, didactic frameworks, empirical findings, and practical use cases across diverse educational contexts.

2. Themes of this Special Issue

Educational robots and robotics have transitioned from niche experimental tools to more widespread applications across diverse educational contexts. The papers in the special issue *EduRobotX 2026 – Co-Creating Innovation for Educational Robots and Robotics for Learning* reflect the rapidly expanding scope of educational robotics and the growing emphasis on co-creation, inclusivity, and AI-enhanced learning. This year's contributions illustrate how educational and social robots are increasingly applied across a full spectrum of learning contexts, from early childhood education and primary schools to special education, higher education, and teacher professional development. The contributions also highlight how robot-supported learning integrates computational thinking, literacy development, social–emotional growth, motivation, and hybrid participation, demonstrating an evolution towards co-creating innovation in education in interdisciplinary and learner-centered ways.

A unifying theme across the papers is the integration of educational robots and robotics with pedagogical models. Several contributions underscore that designing learning activities with educational robots requires structured design approaches, from pattern-based instructional frameworks to AI-enhanced lesson design models. These studies emphasize that robotics is most impactful when grounded in educational patterns, adaptive pedagogies, and interdisciplinary design practices that bridge technology, learning sciences, and human-robot interaction.

Another strong theme concerns the use of robotics to support diverse learners, including children with dyslexia, neurodivergent learners, and students in special education. The papers show how robot-assisted interventions focused on computational thinking can enhance specific cognitive and socio-pedagogical competencies, such as problem-solving, phonological decoding, resilience, and social interaction. These findings reinforce the workshop's central focus: using educational robots as inclusive tools that empower learners with different backgrounds, needs, and developmental trajectories.

The role of affect, motivation, and engagement also emerges as a theme. Several studies examine how learners respond to robots through embodied interaction, non-verbal cues, competitive play, and narrative experiences. For example, research on sound-driven turn-taking highlights both the motivational potential and the risks associated with unreliable multimodal systems, while embodied GenAI-driven storytelling shows how robots can deepen curiosity, creativity, and emotional engagement in humanities learning. These works demonstrate that individual, social and technical aspects of educational HRI are critical determinants of learning outcomes.

AI-powered educational robotics is another cross-cutting theme. Contributions in this issue explore how generative AI, LLMs, and intelligent analytics can enhance personalization, adaptivity, feedback, and content generation. From AI-supported telepresence robot configurations, through ML models of sound recognition, to robot-led Socratic dialogues, these studies illustrate the opportunities of AI-enhanced robotics while also calling attention to issues of transparency, reliability, cognitive load, and ethical deployment. The papers emphasize that AI should augment, but never replace, human-to-human interaction and facilitation.

The contributions in this special issue also highlight that educational robots and robotics can be effectively used across the lifespan. Papers on early childhood robotics demonstrate strong developmental benefits in emotional resilience, collaboration, and curiosity, while teacher training research emphasizes the importance of building educator confidence and professional competence to bring robotics into diverse school contexts. Across all contributions, educational robots and robotics are framed as tools which can support different forms of learning.

Taken together, the papers in this special issue illustrate that educational robots are most powerful when conceptualized as part of socio-technical ecosystems, co-created with educators, learners, designers, and researchers. They collectively demonstrate that robots and robotics can enrich learning, but only when supported by inclusive design, adequate pedagogy, reliable technologies, and human facilitation. As the field moves forward, these contributions point toward a future where AI-powered educational robots can play a central role in supporting engaging and meaningful learning experiences across educational contexts.

3. Papers in this Special Issue

This special issue, EduRobotX 2026 – Co-Creating Innovation for Educational Robots and Robotics for Learning, brings together nine contributions that advance our understanding of how educational robots can meaningfully support learning, development, inclusion, and teacher practice. The papers in this special issue represent diverse methodological approaches, from empirical studies, design frameworks, to exploratory prototypes, and scoping reviews, and cover a wide spectrum of educational settings, including early childhood education, primary and secondary school settings and special education. The contributions also span multiple application domains, such as computer science and computational thinking, literature and humanities education, and teacher professional development. Taken together, the nine contributions underscore a shift toward co-creation, where educators, learners, researchers, and intelligent robotic systems collaboratively shape educational experiences:

1. **The input Designing Pedagogically Grounded Robotics Activities:** The special issue begins with the first paper, "Towards Educational Patterns for Teaching Computational Thinking Using Robots" by Christian Glahn, which proposes a multilayered pattern-based approach for structuring robotics interventions. By organizing pedagogical intentions, learning events, and implementation strategies across interconnected pattern levels, the framework supports comparability, reusability, and contextual adaptation. Notably, the work demonstrates how Activity Theory and the Learning Events Model can jointly inform the design workflow. This paper outlines how educators can draw on these patterns to scaffold computational thinking instruction using robots while maintaining flexibility for classroom dynamics and learner diversity.
2. **AI-Enhanced Telepresence Robotics for Hybrid Learning:** The second paper, "AI-Enhanced Lesson Design within the TRinE 4D Pedagogical Model" by Maria Perifanou, introduces TRinE 4D+, an AI-augmented extension of the validated TRinE 4D model for telepresence robot–mediated learning. The enhanced framework incorporates AI-driven goal analysis, automated recommendation of telepresence robot configurations, adaptive collaborative learning design, and AI-supported creation of multilingual OERs. These additions transform the original model from a static design guide into a dynamic, data-informed ecosystem. Through the "TR Museum Quest" prototype, the paper illustrates how AI-generated content, positioning simulations, and differentiated scaffolds used with telepresence robots can improve inclusivity in hybrid learning environments. Planned pilot studies across schools and universities will further validate the model's transferability and scalability.
3. **Social Robots and GenAI for Computer Science Education**: The third paper, "Learn Code with a Social Teaching Assistant Robot (STAR)" by Ilan Pollak and Rinat B. Rosenberg-Kima, presents an intelligent tutoring system that integrates a NAO robot

with generative AI to assist students during programming tasks. STAR provides multimodal feedback, including gestures, spoken explanations, and real-time visual hints, and interfaces with a web-based coding platform that displays syntax errors, learning progress, and contextual cues. The authors provide a detailed system architecture, showing how learning logs, code histories, and AI-generated messages are orchestrated through a Node.js backend. Early tests with university students show promising results, including increased focus and confidence. The paper discusses design challenges in using social robots to support coding, such as balancing the roles of screen versus robot, managing conversational flow, and integrating AI explanations within embodied interaction.

4. **Embodied GenAI for Literature and the Humanities:** The fourth paper, "When a Reading Club Meets a Robotic Don Quixote: Embodied GenAI for Literary Dialogue" by Dan Kohen-Vacs and Gila Kurtz, introduces RoBook, an innovative book-club format where the NAO robot embodies Don Quixote using generative AI for dynamic, character-driven conversations. Participants engage in theatrical role-play, scene construction, and philosophical questioning that extends literary interpretation beyond the text. The system employs AI-driven voice synthesis, gesture control, visual marker detection, and responsive storytelling to create an emotionally rich narrative experience. Pilot sessions show that the robot's character embodiment fosters curiosity, deeper engagement with literary themes, and collaborative meaning-making, demonstrating how GenAI and social robots can enhance humanities education in novel ways.
5. **Non-Verbal Interaction and Motivation in Robot-Assisted Games**: In the fifth paper, "Sound-Driven Turn-Taking in Robot-Assisted Quizzes" by Rezaul Tutul and Ilona Buchem, the authors explore how non-verbal audio-driven interaction, with buzzer-sounds detected by the Pepper robot through a machine-learning classifier, shapes motivation in group-based quiz activities facilitated by a social robot in introductory computer science courses. The study offers a detailed analysis of the audio features required to reliably detect fast-paced buzzing in noisy environments, as well as an experimental comparison with sequential turn-taking. While the novelty and competitiveness of real-time buzzing increased immersion and challenge-driven motivation, reliability issues generated tension, reduced trust, and negatively affected positive affect. The paper emphasizes the importance of multimodal redundancy, robust signal processing, and adaptive pacing to ensure that motivational effects in educational HRI remain stable under real-world conditions.
6. **Educational Robotics and Reading Skills in Children with Dyslexia:** The sixth contribution, "The Influence of Serious Games and Educational Robotics on Computational Thinking to Promote Reading Ability and Motivation in Children with Dyslexia" by Annemarie Graus and Nardie Fanchamps, examines how two digital-learning interventions, i.e., Serious Games and Educational Robotics, affect computational thinking, reading fluency, and motivation in dyslexic children. Both interventions improved computational thinking scores as measured by standardized tests, with robotics showing stronger gains in pseudoword decoding, which is closely linked to phonological processing. Although reading motivation did not significantly improve, the study's regression analyses reveal that computational thinking is positively associated with reading motivation, suggesting an indirect pathway between structured problem-solving and learners' attitudes toward reading. The findings highlight the value of embedding computational thinking activities into literacy support programs for neurodiverse learners.

7. **Computational Thinking for Socio-Pedagogical Development in Special Education:** The seventh paper, "Computational Thinking by Means of Digital Technology-Enhanced Learning Environments" by Lisa Bosgoed, Nardie Fanchamps, Heike Gerger and Roland Klemke, is a scoping review which consolidates evidence on how digital technologies used in computational thinking, including social robots and robotics, support psychological, social, and pedagogical development of children with autism spectrum disorder (ASD) and attention deficit hyperactivity disorder (ADHD). The paper highlights fragmentation in current research, with studies often focusing on single technologies, limited competencies, or narrow participant groups. By mapping prior work across target populations, developmental outcomes, and technological approaches, the scoping review aims to build a clearer foundation for future research. The authors argue that the inherent structure of computational thinking, i.e. breaking problems into manageable steps, may provide important developmental scaffolds for learners in special education.
8. **Holistic Development Through Robotics in Early Childhood:** The eighth paper, "Fostering Holistic Development through Educational Robotics" by Moshe Leiba, reports on a large-scale, two-year evaluation of a robotics program in public kindergartens using LEGO WeDo 2.0 / SPIKE Essential. Across emotional, social, and cognitive domains, children demonstrated significant improvements in perseverance, communication, teamwork, and problem-solving, supported by the high reliability of measurement instruments. The comparison of two cohorts shows how program maturation, teacher expertise, and prior community exposure influence performance and learning gains. Qualitative teacher reports further highlight increased classroom cohesion, peer support, and children's willingness to explore new challenges. The study provides a large empirical dataset on the long-term developmental impact of robotics in early childhood education.
9. **Teacher Training for Integrating Humanoid Robots into Schools:** Finally, the ninth contribution, "Integrating Humanoid Robots into School Education" by Emily Evermann, Niklas Bäcker, Ilona Buchem, Igor Balaban and Ivana Ružić, presents preliminary results from an international teacher training program designed to prepare educators to use the humanoid NAO robot in schools, with a thematic focus on sustainability and climate education. Survey results reveal high interest and perceived relevance, though participants expressed varying levels of confidence. The study also offers valuable insights into how teacher preferences differ across teacher training modules. While hands-on programming is perceived as highly motivating, conceptual scenario design requires additional scaffolding. The authors outline opportunities for improving the training, such as enhanced peer exchange, more concrete classroom examples, and iterative updates to the instructional materials. These findings contribute to ongoing efforts to build teacher capacity for robotics-enhanced learning.

These nine papers in the special issue of EduRobotX 2025 collectively illustrate the rapidly evolving landscape of educational robots and robotics research, highlighting a shift toward co-created, inclusive, AI-enhanced, and developmentally meaningful learning experiences. They emphasize not only technological innovation but also the pedagogical, socio-emotional, and organizational conditions under which educational robots can enhance learning but also pose challenges to both educators and learners. Together, the contributions underscore the importance of robust learning design, teacher agency, and interdisciplinary collaboration in designing and implementing learning activities with educational robots. The contributions also reveal how embodied AI systems can support curiosity, collaboration, engagement and computational thinking across diverse populations, from young children and learners with special educational needs to university students and in-service teachers. Ultimately, this special issue shows that educational robots have to be integrated as part of human-centered educational environments, in which innovation is created in inter- and trans-disciplinary teams.

4. Conclusions and Future Directions

This special issue demonstrates that educational robots and robotics continue to evolve into versatile, pedagogically rich tools capable of enhancing learning across a broad range of contexts, ages, and learner needs. Rather than serving as technological fixes for systemic challenges, the papers collectively highlight that robots are most impactful when thoughtfully integrated into learning environments that prioritize co-creation, inclusion, and human facilitation. Whether supporting computational thinking, fostering socio-pedagogical development, enhancing motivation, or empowering educators, educational robots, due to their embodiment, interactivity, and social presence, can make learning more tangible, engaging, and responsive to diverse learners. Several key areas emerge as important for shaping the future of educational robots and robotics:

1. Inclusive and equitable learning opportunities: Ensuring that robotics-based learning is designed for a diversity of learners is essential. The papers demonstrate promising developments for dyslexic learners, neurodivergent students, and children in special education, as well as inclusive robotics programs in multicultural early childhood settings. These findings reinforce the need for equitable access to robotics technologies, professional development, and adaptable pedagogical designs that embrace learner diversity.
2. Human-centered and ethical integration of AI: The integration of generative AI and intelligent analytics into educational robots presents significant opportunities for personalization, multimodal feedback, adaptive scenario design, and rich interaction. At the same time, the studies underscore the importance of addressing ethical considerations such as transparency, trust, cognitive load, potential misuse of automated feedback, and the preservation of meaningful human oversight. As AI-enhanced robotics becomes more widespread, responsible design practices will be essential to ensure that these tools support, rather than replace, human educators.
3. Pedagogical robustness and teacher empowerment: Multiple contributions show that instructional quality, teacher agency, and well-designed learning patterns are crucial for successful robotics integration. Teacher training programs, AI-enhanced pedagogical models, and pattern-based robotics designs all point to the need for structured but flexible pedagogies that help educators translate robotics into tangible classroom practices. Long-term impact depends on institutional support, accessible training resources, and opportunities for educators to co-create and adapt robotics activities.
4. Reliability, interaction quality, and learner experience: The success of educational robotics hinges on the reliability and responsiveness of multimodal interaction systems. Papers examining non-verbal sound-driven turn-taking, embodied GenAI narratives, and telepresence-mediated learning all illustrate that when technical limitations arise such as misrecognition, latency, or limited embodiment the learner experience can be compromised. Continued research into robust sensing, adaptive interaction design, and multimodal redundancy is vital to ensuring that robots can sustain motivation, trust, and emotional engagement.
5. Co-creation and interdisciplinary collaboration: Finally, the papers highlight the power of co-creation, between educators, learners, robotic systems, and interdisciplinary teams as a driving force for educational innovation. Whether

designing storytelling applications, computational thinking interventions, hybrid learning scenarios, or inclusive classroom practices, meaningful collaboration fuels creative and impactful solutions. This aligns with the workshop's broader vision: scenarios and applications for educational robots and robotics should be co-developed within communities of practice.

In conclusion, the contributions in this special issue illustrate both the promise and the complexity of advancing educational robots and robotics. Robots, whether humanoid, social, teleoperated, or AI-augmented, are most effective when they are applied as partners in learning and teaching, guided by reliable pedagogical and ethical considerations. We invite readers to build upon the insights shared in this special issue to explore new pathways for integrating robots and robotics into education.

5. Declaration on Generative AI

During the preparation of this work, the author(s) used Grammarly for the spelling check.

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