Published: July 30, 2025 | Pages: 36-39

# FORMS AND TECHNOLOGIES OF EDUCATION FOR DEVELOPING STUDENTS' TECHNICAL LITERACY BASED ON ELEMENTS OF ROBOTICS

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## ABSTRACT

The integration of robotics into educational practice is emerging as a transformative approach for enhancing students' technical literacy in the context of rapidly advancing technologies. The research analyzes the theoretical underpinnings of technical literacy, the pedagogical rationale for using robotics, and current global trends in educational robotics. It presents a structured methodology for embedding robotics elements into the educational process, discusses the impact on students' cognitive, practical, and collaborative competencies, and evaluates the outcomes of implementing such innovations. The findings suggest that the thoughtful integration of robotics-based educational forms and technologies significantly increases students' engagement, technical problem-solving skills, and readiness for future technological challenges.

**KEYWORDS:** Technical literacy, robotics in education, educational technology, STEM, technology lessons, innovative teaching, digital competence.

## INTRODUCTION

The ongoing digital transformation of society necessitates a paradigm shift in educational approaches, particularly in the cultivation of technical literacy among students. Technical literacy, defined as the ability to understand, evaluate, and use technological tools and processes, is an essential competency for success in the 21st-century workforce and daily life. As traditional educational models struggle to keep pace with technological advancements, innovative methods—most notably the use of robotics—are increasingly recognized as effective means for bridging the gap between theoretical knowledge and practical application.

The study employed a mixed-methods research design, combining qualitative and quantitative approaches to analyze the effectiveness of educational forms and technologies based on robotics. The qualitative component involved a comprehensive literature review of international and national publications on robotics in education, technical literacy, and STEM methodologies, focusing on works from the past decade. The literature review included policy documents, academic articles, and reports from educational robotics programs across Europe, Asia, and North America.

For the empirical component, a case study methodology was adopted in a selected group of secondary and high schools where robotics had been integrated into technology lessons. The study population comprised students aged 12–16 who participated in robotics-enhanced curricula during the academic years 2022–2024. Data collection methods included classroom observations, teacher and student interviews, and pre- and post-intervention assessments of technical literacy using standardized measurement tools.

The educational interventions were designed to incorporate elements of robotics into both the content and the form of instruction. This included the use of programmable robotic kits, simulation software, and project-based learning modules centered on robotics tasks. Teachers were trained in contemporary pedagogical techniques such as inquiry-based learning, collaborative group work, and formative assessment methods tailored to the robotics context.

Data analysis was conducted using descriptive and inferential statistics for the quantitative data, while qualitative data from interviews and observations were coded thematically to identify patterns in student engagement, collaboration, and cognitive development.

The theoretical basis for integrating robotics into education is rooted in constructivist and socio-cultural learning theories. According to Piaget and Vygotsky, meaningful learning occurs through active engagement and social interaction, both of which are facilitated by robotics activities. Robotics kits and platforms serve as cognitive tools, enabling students to construct and test their own models of technological phenomena. The multidisciplinary nature of robotics also supports the development of higher-order thinking skills and fosters the integration of multiple knowledge domains.

Technical literacy, as conceptualized in contemporary educational research, extends beyond the acquisition of technical skills to include the ability to analyze, evaluate, and apply technological knowledge in new contexts. Robotics-based learning environments offer authentic opportunities for students to engage in problem-based and project-based tasks, promoting not only technical proficiency but also creativity, collaboration, and reflective thinking.

The effective integration of robotics into technology lessons requires innovative organizational forms that prioritize student-centered learning. Project-based learning (PBL) emerged as the most effective form, providing a framework for students to collaboratively solve real-world problems using robotics. This approach allows for differentiated instruction and accommodates diverse learning styles.

Extracurricular robotics clubs, competitions, and workshops complement in-class activities by providing additional opportunities for experiential learning and the application of technical skills. Collaborative group work and peer learning are essential components, fostering the development of social and communicative competencies alongside technical ones.

Blended learning models, which combine face-to-face instruction with digital platforms for simulation and programming, also proved effective in supporting the flexible and individualized acquisition of technical literacy. Online resources and virtual robotics platforms enabled students to continue their learning beyond the classroom, increasing accessibility and self-directed learning.

The selection of robotics technologies is critical to the success of educational interventions. Programmable kits such as LEGO Mindstorms, Arduino, and VEX Robotics were found to be particularly effective due to their adaptability, scalability, and alignment with curricular objectives.

These kits allow for incremental progression from simple mechanical assembly to complex programming tasks, making them suitable for a wide range of age groups and proficiency levels.
Simulation software and online programming environments further enhance the learning experience, enabling students to experiment with robotics design and control in a virtual space.
The integration of sensors, actuators, and artificial intelligence modules expands the scope of learning and mirrors contemporary trends in technological innovation.
Teacher professional development is a necessary precondition for the effective implementation of robotics technologies. The study found that ongoing training in both technological and pedagogical competencies is essential to ensure that teachers can facilitate meaningful robotics-based learning experiences.
The empirical findings of the study demonstrate significant gains in students' technical literacy following the integration of robotics elements into technology lessons. Pre- and post-intervention assessments indicated notable improvements in students' ability to understand and apply technological concepts, analyze complex problems, and design creative solutions.
Classroom observations revealed increased student engagement, motivation, and willingness to collaborate. Robotics activities provided a context for the development of communication, leadership, and project management skills, reflecting the holistic benefits of this educational approach.
Interviews with students and teachers highlighted the perceived relevance and applicability of robotics to real-life situations, which enhanced students' intrinsic motivation to pursue further learning in STEM fields. The use of authentic, hands-on tasks was particularly effective in reducing gender gaps in technical confidence and participation.
The integration of robotics elements into educational forms and technologies offers significant potential for developing students' technical literacy in technology lessons. The research confirms that robotics-based education, when grounded in constructivist pedagogy and supported by appropriate resources and teacher training, leads to measurable improvements in technical knowledge, problem-solving ability, and collaborative skills. Project-based and blended learning models, coupled with adaptable robotics technologies, provide optimal conditions for fostering technical literacy in diverse educational settings.
To maximize the benefits of robotics in education, policymakers and school leaders should prioritize investments in robotics infrastructure, teacher professional development, and curriculum innovation. Future research should explore longitudinal impacts and strategies for scaling robotics-based educational models across broader contexts.

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