



SCIENTIFIC-THEORETICAL ANALYSIS OF FORMING CREATIVE COMPETENCE IN ROBOTICS AMONG SCHOOL STUDENTS

Hasan Hidoyatilloevich Ubaydullayev

Independent researcher, Uzbekistan State University of World Languages

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Article history:	Abstract:
Received: 28 th March 2026 Accepted: 26 th April 2026	<i>This paper presents a scientific and theoretical analysis of the formation of creative competence in robotics among primary school students of general secondary education. Educational robotics is described not only as a means of teaching coding or mechanical concepts but also as a comprehensive educational tool that develops students' deep understanding of technology. The article also analyzes ideas related to the design, creation, management, and modernization of high-tech and robotic devices. In addition, the study describes the collaborative learning environment and factors that increase sources of knowledge in the educational process.</i>
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The rapid development of modern society and the spread of technological literacy across all spheres are presenting the education system with new challenges. In particular, the formation of creative competence in robotics among primary school students and the development of innovative thinking abilities are considered urgent research issues in the field of pedagogy. Robotics and creative competence are becoming an important component of the primary education process. Robotics education is considered an effective tool for developing important skills among primary school students such as algorithmic thinking, logical analysis, problem solving, teamwork, and creativity. It enables the integration of primary school students' theoretical knowledge with practical activities and ensures interdisciplinary integration.

Educational robotics stands at the forefront of innovation in technological literacy, which is an important skill in 21st-century education. Robotics is not merely about teaching coding or mechanical concepts, but rather serves as a comprehensive tool for developing students' deep understanding of technology in education.¹ The demand for engineering specialists capable of designing, creating, managing, and modernizing high-technology and robotic devices has increased more than ever. Accordingly, an educational framework has been developed for developing individuals in engineering and technical fields. The development of this field begins from

preschool age and continues until graduation from higher education institutions. This field is divided into two directions: subject-based robotics within an integrated modern educational environment and practical educational robotics.

Subject-based robotics within an integrated modern educational environment includes:

- interactive equipment;
- hardware and software complexes;
- digital laboratories;
- digital interactive educational programs;
- the modern material and technical base of subject clusters.

These components are aimed at forming information-communication and technical competencies among primary school students.

Practical educational robotics is considered a direction in which students, during classroom lessons:

- develop technical creative competence through the integration of design and programming;
- implement modern approaches in introducing elements of the educational process.

Researchers such as Keisner, Raffo, and Wunsch-Vincent (2016) demonstrate that robotics is fundamental to the cultivation of engineering mindsets.² Consequently, robotics serves as a sophisticated medium for synthesizing knowledge,

¹ Лазарев М.В. О связи робототехники с механикой, электроникой и программированием, а также о междисциплинарных связях // Вестник ТГПУ (TSPU Bulletin). 2013. 11 (139). – С. 132-136.

² Keisner A., Raffo J., Wunsch-Vincent S. (2016) Robotics: Breakthrough Technologies, Innovation, Intellectual Property. Foresight and STI Governance, vol. 10, no 2, pp. 7-27.



providing a robust framework for systemic thinking in primary school students. While these cognitive paths may develop independently or converge at various developmental stages, the primary school years remain critical; they provide the essential scaffolding upon which lifelong technical competencies are built.

From a pedagogical perspective, the primary school stage is uniquely favorable for establishing fundamental knowledge, functional skills, and creative competencies. During this developmental window, the precursors to natural-scientific and engineering-technical literacy are formed. Cultivating these basics facilitates the development of advanced cognitive capabilities, including spatial reasoning, analytical problem-solving, and information literacy. In this context, it is essential to define the formation of "creative competence" in primary education: it involves transitioning from rote learning toward the active generation of original ideas, fostering a mindset conducive to ongoing self-directed development.

Game-based technologies in education are among the most effective didactic tools and represent one form of organizing lessons for primary school students, contributing to understanding the world, building teamwork, developing self-awareness, and enhancing creative competencies. The use of game technologies during lessons helps to form students' creative competence and contributes to the development of technological literacy while taking into account modern realities.

According to research by Springer (in accordance with the agreement signed between the Science Financing and Innovation Support Fund and the company "Springer Nature" (Germany), during 2022 the services of "Springer Journal Collection," "Springer Protocols," and "Springer Nature Ebook Collections 2021" were utilized), the use of robotics in education significantly improves the learning environment in classrooms. In this context, robotics, educational technologies, and the integration of subject teaching are considered more convenient and understandable approaches for learners. It also contributes to expanding knowledge covering various subjects among primary school students and introducing creative opportunities into learning activities. As Myounghoon Jeon, a researcher at Michigan Technological University, emphasized "robotics reveals technology syntactically. It brings abstract concepts into the material world, making them more understandable and engaging for learners." Such practical experience with robotics enables students to comprehend complex technological principles through intuitive perception and creates a

learning environment where experimentation and research are encouraged.

The use of robotics in primary education is a transformative tool for enhancing learning outcomes, particularly in fostering problem-solving, creative, and critical thinking. These competencies are essential not only for technological literacy but also for navigating practical, real-world challenges. As Ingelore Mammes (2020) argues, robotics allows students to perceive technology not merely as an academic discipline, but as a versatile medium for innovation.³ Methods of using robotics in education serve as a bridge for making lessons more engaging and interesting. They offer a unique approach to realizing the didactic potential of education and make technological education more inclusive and effective. According to scientists from Nagoya University in Japan - Kohei gava, Koichi Taura, and Hiroshi Ishiguro "learning based on robotics stimulates the development of new educational technologies."⁴

The process of using robotics in developing the creative competence of primary school students directly requires technological literacy. Robotics helps develop technological literacy and supports the intuitive understanding of complex technological principles.

In the education of primary school students, robotics is one of the important issues in the field of pedagogy and has particular significance in eliminating gaps in education and advancing the educational process. As a versatile and flexible tool, robotics offers unique opportunities to address various educational needs. At the same time, it makes lessons more accessible and engaging for all students.

Modern educational technologies serve as the fundamental basis for the evolution of teaching methodologies aimed at developing creative competence among primary school students. Teaching methods based on robotics are designed to address the diverse needs present in the learning process. Robotics has an interactive nature, and a tactical

³ Mammes, I., Adenstedt, V. & Gooß, A. (2020). Das Technikverständnis von Grundschulkindern. In B. Geißel & T. Gschwendtner (Hrsg.), *Einblicke in aktuelle Forschungsarbeiten der Technikdidaktik*. – P. 39-66. Berlin: Logos Verlag GmbH.

⁴ Ogawa, K., Taura, K. Ishiguro, H. Possibilities of androids as poetry-reciting agent. In *Proceedings of the 21st IEEE International Symposium on Robot and Human Interactive Communication*, Paris, France, 9-13 September 2012. – Pp. 565-570.



approach can significantly assist in this work. As highlighted in Springer research, the introduction of robotics in classrooms has led to improvements in the learning environment. Such changes are especially evident in robotics-based lessons that adapt to the individual needs of learners and support students who encounter different learning difficulties.

The use of robotics in primary school lessons removes barriers that traditional teaching methods cannot overcome and introduces a new technological approach. From this perspective, robotics contributes not only to educational potential but also to creating a supportive and empathetic learning environment for students who experience difficulties in mastering the material. As Ingelore Mammes noted regarding the flexibility of robotics in primary education:

"Educational robotics is not limited to a single subject or teaching method. It can be integrated across various subjects and provide diverse learning experiences."

This flexibility ensures that robotics-based learning is effective for all primary school students, regardless of their level of mastery of subject content or their individual abilities.

The importance of providing primary school students with robotics-based teaching methods lies in the fact that, according to the Russian scholar Sergey Aleksandrovich Filippov, "Robotics encourages practical learning and can be particularly beneficial for learners who experience difficulties in mastering lessons based on traditional teaching methods."⁵ This practical approach is particularly engaging for students who learn best through hands-on experience, enabling them to understand the essence of subjects in a more meaningful way and to work with them effectively.

The use of robotics in primary school lessons demonstrates the existence of several didactic opportunities. In particular:

It enhances participation and accessibility in education. It eliminates barriers present in traditional teaching methods.

A robotized classroom environment contributes to the formation of students' creative competence.

Active interaction among teachers during lessons, as well as the availability of robotics equipment and appropriate conditions in classrooms, requires special attention. Such changes are not merely related to adopting new tools; rather, they represent a fundamental transformation in which traditional

sources of knowledge become assistants in an interactive learning process - thus forming a new educational paradigm. In primary education, the use of robotics requires teaching based on role-playing technologies rather than traditional teaching approaches. In a learning process significantly enriched with educational technologies, teachers become guides, mentors, and collaborators.

As emphasized in Springer research, "The integration of robotics into education requires changes in teaching methodologies." This situation calls for an emphasis on practical, research-oriented, and student-centered approaches.

These changes in teaching dynamics transform the teacher's role in robotics-based classrooms from being the sole distributor of knowledge to becoming a facilitator of learning experiences. In particular, students are guided to explore technology creatively and work with it actively. This transformation is essential for maximizing students' robotics-related potential - knowledge and skills - and for enabling active interaction during lessons.

Researcher Ingelore Mammes supports this view, emphasizing the importance of creative competence in helping teachers effectively adapt to such changes. She also notes that "Teachers should not only be familiar with the technical aspects of robotics but also understand how to integrate them pedagogically in ways that enhance learning."⁶ Such requirements emphasize the need for continuous training and support for teachers in order to overcome the challenges and effectively utilize the opportunities provided by educational robotics.

Robotized classroom lessons become a collaborative process in which teachers and students learn from each other. This cooperation allows both sides to contribute their strengths. Such a collaborative environment promotes a more engaging and dynamic learning experience in developing creative competence among primary school students.

The collaborative environment described above requires primary school teachers to organize the learning process based on factors that enhance sources of knowledge. In particular:

– improving teachers' professional development;

⁵ Филиппов С.А. Робототехника для детей и родителей. СПб.: Наука, 2011. 263 с

⁶ Mammes, I., Adenstedt, V. & Gooß, A. (2020). Das Technikverständnis von Grundschulkindern. In B. Geißel & T. Gschwendtner (Hrsg.), Einblicke in aktuelle Forschungsarbeiten der Technikdidaktik. – P. 39-66. Berlin: Logos Verlag GmbH.



- emphasizing collaborative learning with robotics;
- providing institutional support for educational robotics and overcoming related challenges.

Although the integration of robotics in primary education has significant potential, it also brings considerable challenges. These challenges include logistics, technical issues, cooperation with partner organizations, and the need for institutional support. In addition, educational robotics requires sufficient infrastructure and resources. As the German scholar Ingelore Mammes emphasized “successful integration of robotics in education requires not only technical tools but also supportive infrastructure, including reliable internet access and technical assistance”.⁷ Such a need corresponds to the protection and support of comprehensive systems in which robotics in education can develop.

Primary education plays an important role in the adoption and integration of robotics. Although there is enthusiasm for robotics in the implementation of education, it is necessary to ensure its effective integration into curricula and to provide a methodological platform through educational regulatory documents. There is also a need for methodologies that support the introduction of robotics into education and provide guidance on its effective use. In addition, there are requirements to develop methodological lesson designs that ensure the effective integration of robotics with primary education subjects. These requirements emphasize the importance of thoroughly integrating robotics into primary education systems in order to maximize its advantages.

The role of teachers is particularly important in implementing the tasks of introducing robotics into primary education lessons while ensuring sufficient training and resources. In order to provide teachers with the knowledge, skills, and competencies necessary for the effective use of robotics, the following factors are considered essential:

- The need for infrastructure and supporting tools.
- The requirement for well-planned lesson design for robotics integration.
- The necessity of preparing educational resources that support integrated robotics.

⁷ Mammes, I., Adenstedt, V. & Gooß, A. (2020). Das Technikverständnis von Grundschulkindern. In B. Geißel & T. Gschwendtner (Hrsg.), *Einblicke in aktuelle Forschungsarbeiten der Technikdidaktik*. – P. 39-66. Berlin: Logos Verlag GmbH.

- The effective implementation of the robotics revolution in education.

As a result of the analysis of research related to robotics in education, it has been determined that it is a relevant issue in the field of pedagogy and that there is a need to improve our teaching and learning methods. Robotics is not limited only to futuristic concepts associated with technological progress, high speed, industry, and future visions in fields such as art, architecture, and design. Rather, in accordance with the demands of the modern era, robotics has already become an integral tool of education and clearly demonstrates the necessity of integrating robotics into classroom lessons for primary school students in general secondary schools of Uzbekistan.

The integration of robotics in education serves as a bridge to new technologies. Technological literacy plays an important role in forming creative competence among primary school students by transforming complex concepts into simpler ones and making difficult ideas more understandable. Robotics transforms classrooms into dynamic and interactive environments where learning is not only about acquiring information but also about experiencing and applying knowledge in real-world conditions.

The ability of robotics to meet a wide range of learning needs and its flexible nature ensures that every student can enhance their technological potential, regardless of their learning style or difficulties. It also aligns with the innovative goals of education by creating an equal and engaging learning environment for all primary school students. A classroom equipped with robotics provides opportunities to move from traditional pedagogical approaches toward more facilitative and collaborative teaching methods. These educational innovations help develop primary school students’ potential in using robotics and provide opportunities to develop skills such as managing the learning process, critical thinking, creativity, and problem solving.

According to research analyses, the integration of robotics into education is not without challenges. There are important components involved in overcoming barriers such as institutional support and professional development for teachers. The integration of robotics goes beyond mere technological advancement and requires collaborative efforts between educational institutions and industry leaders in order to truly enrich the educational experience. The impact of robotics in education has contributed not only to developing understanding about robotics itself but also to gaining a deeper comprehension of global



challenges. In particular, robotics in education has clearly demonstrated itself as a comprehensive tool for creativity, collaboration, and sustainable development. Robotics serves as a factor of significant changes in education. In particular:

- the formation of creative competence among primary school students is closely connected with technology integration;
- the robotics revolution in education signifies more than simply adapting to technological achievements;
- the future of education will shape the technological landscape;
- students develop their creative competence through robotics;
- robotics prepares students for a technological future;
- robotics involves effective collaborative efforts.

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