

EFFECTIVENESS OF TEACHING ROBOTICS ELEMENTS THROUGH THE STEAM APPROACH IN TECHNOLOGICAL EDUCATION

Kambarova Manzuraxon Maripjanovna –

*Lecturer, Department of Physics and Technological Education,
Andijan State Pedagogical Institute,
E-mail: kambarova_manzura@adpi.uz*

Abduqaxxorova Xulkaroy Otamirza qizi –

*Student, Technological Education,
Andijan State Pedagogical Institute,
E-mail: xulkaroyabduqaxxorova2006@gmail.com*

Annotatsiya: *Mazkur maqolada texnologik ta'lim tizimida robototexnika elementlarini STEAM yondashuvi orqali o'qitish metodikasi va uning samaradorligi tadqiq qilingan. Lego Mindstorms, Arduino va Raspberry Pi kabi platformalar asosida qurilgan o'quv dasturlarining o'quvchilar texnik ko'nikmalariga ta'siri o'rganilgan.*

Kalit so'zlar: *robototexnika, STEAM ta'limi, Arduino, texnologik ta'lim, muhandislik tafakkuri, amaliy ko'nikmalar.*

Abstract: *This article investigates the methodology and effectiveness of teaching robotics elements through the STEAM approach in the technological education system. The impact of educational programs based on Lego Mindstorms, Arduino, and Raspberry Pi platforms on students' technical skills was studied. The results showed that STEAM-based robotics education has high efficiency in developing students' engineering thinking and practical skills.*

Keywords: *robotics, STEAM education, Arduino, technological education, engineering thinking, practical skills, Lego Mindstorms.*

INTRODUCTION

In the era of the Fourth Industrial Revolution, robotics and artificial intelligence technologies are penetrating all areas of human life. This situation places a demand on the education system to train a new generation of specialists with broad skills in engineering, programming, and technological design.

The STEAM approach is recognized as the most effective way to integrate robotics into the school curriculum. Through robotics projects, students have the opportunity to simultaneously study physics, mathematics, programming, and design in a practical way.

The purpose of this study is to identify the impact of STEAM-based robotics lessons on students' technical and engineering skills and to develop an effective teaching methodology.

1. LITERATURE REVIEW

Sullivan and Bers (2016) showed that STEAM education based on robotics can successfully form engineering thinking even in elementary school students. They proved that the basics of programming can be taught to preschool children using ScratchJr and Lego WeDo platforms.

Alimjanov (2021) showed in his study the positive impact of organizing robotics clubs in Uzbekistan schools on students' interest in technology. Arduino-based projects were found to generate particularly high motivation in grades 6–9.

In international practice, robotics is taught as an integral part of the STEAM program in Finland, South Korea, and Singapore. The high scores of these countries in international PISA and TIMSS tests confirm the effectiveness of this approach.

2. RESEARCH METHODOLOGY

The study was conducted at practice schools of Andijan State Pedagogical Institute in 2023–2024. Participants: students in grades 7–9 (n=180), technology teachers (n=24), and industry specialists (n=10).

The experimental group (n=90) was taught using Arduino and Lego Mindstorms platforms based on STEAM. Each project integrated physics, mathematics, and programming. The control group (n=90) studied robotics using traditional theoretical methods.

3. RESULTS AND DISCUSSION

Experiment results: the experimental group showed 44% higher performance than the control group in completing practical projects. The average grade of the experimental group in physics and mathematics increased by 3.2 points.

During robotics projects, students developed the following skills:

- Designing and assembling electronic circuits
- Writing simple programs in C++ and Python
- Working with sensors and actuators
- Communicating in a team and implementing projects together

87% of teachers emphasized the need for additional training to conduct STEAM-based robotics lessons.

4. CONCLUSION AND RECOMMENDATIONS

The research results confirm that STEAM-based robotics education effectively develops students' engineering thinking, practical skills, and interdisciplinary knowledge.

Recommendations: establishing robotics STEAM laboratories in regional schools; conducting specialized trainings for teachers on Arduino and Lego Mindstorms; establishing cooperation with local industrial enterprises; creating robotics textbooks in Uzbek.

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