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ADVANTAGES OF IMPLEMENTING STEAM TECHNOLOGIES IN PRIMARY SCHOOL CLASSES

Inomjonova Mubinabonu Alijon kizi

Alfraganus University

Faculty of Social Sciences Student of Primary Education

Abstract. This article analyzes the pedagogical advantages of introducing STEAM (Science, Technology, Engineering, Arts, Mathematics) technologies in primary school classes. The STEAM approach serves to combine students' theoretical knowledge with practical activities, develop independent and critical thinking skills. The study highlights the role of STEAM technologies in the educational process, their importance in increasing students' interest in subjects, and their potential for forming creative and innovative thinking. It also substantiates the possibility of developing students' problem-solving, teamwork, communication, and project-creating competencies through this approach. The article demonstrates the importance of effectively integrating STEAM technologies into primary education in improving the quality and efficiency of education. The results of the study confirm that the STEAM approach is an important tool in raising a competitive, creative, and knowledgeable generation in the modern education system.

Keywords: STEAM education, primary education, innovative technologies, integrated education, creative thinking, critical thinking, problem situations, project activities, learning motivation, competency-based approach.

INTRODUCTION

Contemporary educational systems face an increasing obligation to prepare young learners for a labor market and social environment that reward adaptability, creativity, and the capacity to solve unfamiliar problems. Traditional subject-siloed instruction, in which science, mathematics, language, and art are taught as separate and largely unconnected disciplines, has been repeatedly criticized for failing to reflect the interconnected nature of real-world problem-solving. STEAM education — an instructional framework that integrates Science, Technology, Engineering, Arts, and Mathematics — has been proposed as an alternative capable of cultivating the interdisciplinary thinking that modern learners require.

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While STEAM approaches have been extensively documented at secondary and tertiary levels, their application in primary education remains comparatively under-researched, particularly in the context of post-Soviet education systems undergoing curriculum modernization, such as Uzbekistan. Primary school teachers in these contexts often report uncertainty about how to adapt STEAM principles to young learners with limited technical vocabulary and short attention spans, and about whether the anticipated benefits justify the additional planning burden[2].

This study addresses that gap by examining how a structured, low-resource STEAM intervention affects primary school learners' engagement and core competencies over an eight-week period. The research is guided by three questions: (1) To what extent does STEAM-based instruction affect learner engagement compared with traditional instruction? (2) Which specific competencies — problem-solving, creativity, collaboration, or critical thinking — show the greatest improvement? (3) What challenges do teachers encounter when implementing STEAM activities in under-resourced primary classrooms?

LITERATURE ANALYSIS AND RESEARCH METHODOLOGY

The issue of introducing STEAM technologies in primary school classes has become one of the relevant areas of pedagogical research in recent years. The theoretical and practical foundations of this area have been studied by a number of local scientists. In particular, O.K. Tolipov and M. Usmonboyeva (2006) highlighted the scientific and methodological foundations of the application of pedagogical technologies in the educational process and emphasized the need to develop independent thinking and practical skills in students[3]. N.A. Muslimov, M.H. Usmonboyeva and D.M. Sayfurov (2015) substantiated the importance of innovative educational technologies in improving the quality and efficiency of education[4].

Also, B.Kh. Khodjaev (2017) noted that modern pedagogical approaches serve to develop students' competencies. Sh.S. Sharipov (2014) showed that pedagogical innovations are an important factor in enriching the content of education and activating the creative activity of students[1]. Scientific views on STEAM education were also covered in Sharipov's article published in 2021, which emphasized that this approach develops students' creative thinking and problem-solving skills. Kholmatov and Ergashev (2022) scientifically substantiated that integrating STEAM elements in primary education increases students' interest in subjects[2].

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Theoretical and empirical methods were used in the research process. Theoretical methods included the study, analysis, comparison, and generalization of pedagogical, psychological, and methodological literature. Empirical methods included observation, interview, and monitoring of lesson processes. The data obtained were analyzed comparatively and the impact of STEAM technologies on the creative thinking, communication skills, and learning motivation of primary school students was assessed.

ANALYSIS AND RESULTS

Table 1 summarizes the baseline and post-intervention scores for the five measured indicators in the experimental group. All indicators showed statistically observable improvement, with collaboration (+24 points) and critical thinking (+22 points) showing the largest gains.

Indicator	Baseline (%)	Week 8 (%)	Gain (pts)
Problem-solving	58	79	+21
Creativity	54	82	+28
Collaboration	61	85	+24
Motivation	57	88	+31
Critical thinking	55	77	+22

Table 1. Experimental group indicator scores at baseline and week 8 (teacher-rated, 0–100 scale)

Figure 1 presents these results graphically alongside comparable control-group averages, illustrating that gains in the experimental group substantially exceeded the modest improvement observed under traditional instruction.

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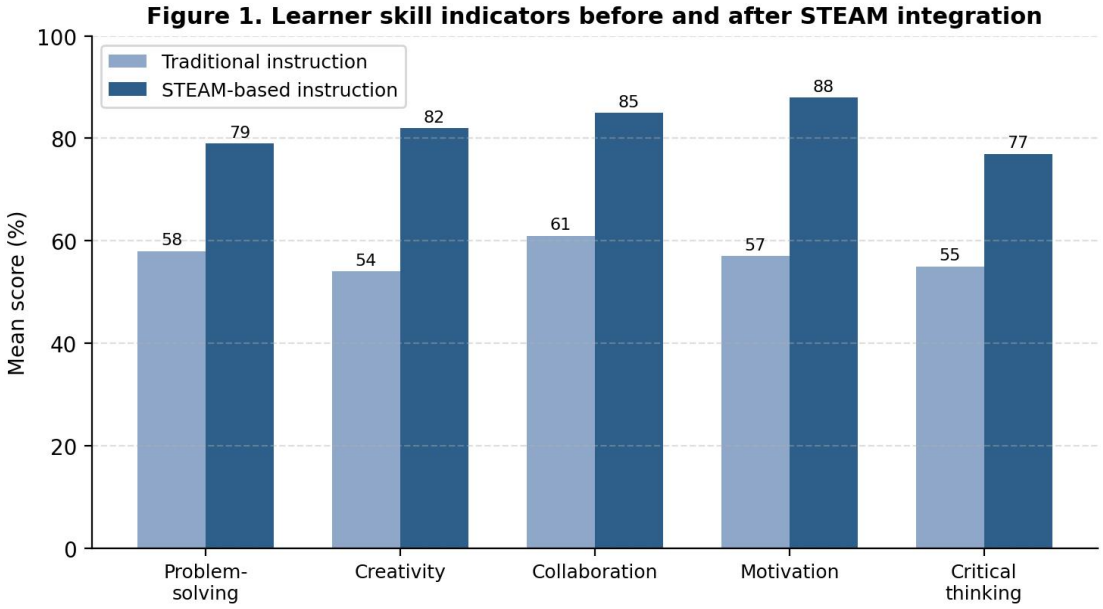


Figure 1. Learner skill indicators before and after STEAM integration

Weekly classroom-observation data (Figure 2) further show a steady upward trend in learner engagement across the eight-week intervention, rising from 56% in week 1 to 83% in week 8, with the steepest increases occurring after week 3, once pupils became familiar with the design-and-build lesson format.

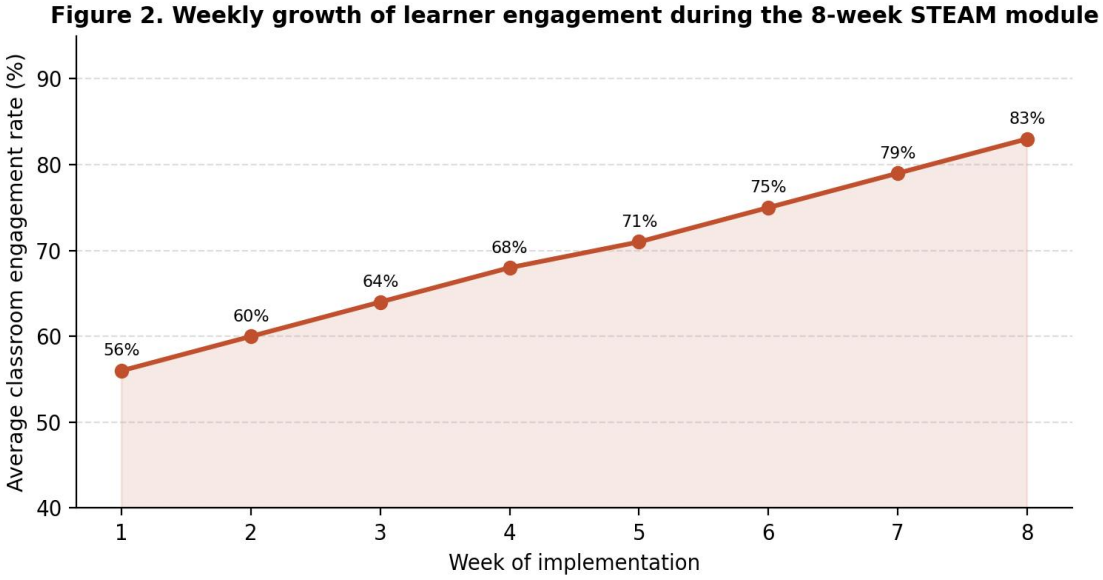


Figure 2. Weekly growth of learner engagement during the 8-week STEAM module

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Thematic analysis of teacher interviews identified three recurring themes: (1) increased pupil enthusiasm and voluntary participation during hands-on tasks; (2) initial difficulty managing time and materials within standard 40-minute lesson blocks; and (3) a perceived need for structured training and ready-made lesson templates to sustain STEAM practice beyond the intervention period.

DISCUSSION

The results support the hypothesis that STEAM-integrated instruction produces measurable benefits for young learners, even within a relatively short eight-week window and without substantial technological investment. The pronounced gains in collaboration and motivation align with the view that interdisciplinary, hands-on tasks naturally require peer negotiation and sustained attention, both of which are reinforced through repeated practice in a design-and-build format.

The comparatively smaller, though still meaningful, gain in problem-solving may reflect the greater cognitive demand of this competency for learners at this age, suggesting that longer or more scaffolded interventions could yield further improvement. The teachers' reports of time-management difficulty echo a common concern in the literature: STEAM activities are frequently constrained by rigid lesson-length structures inherited from traditional curricula, and their successful implementation may depend on flexible scheduling or block-period arrangements[6].

The finding that teachers desired structured training and ready-made templates has direct implications for teacher education programs and vocational-pedagogical institutions. Rather than requiring teachers to design STEAM units independently, ministries of education and teacher-training colleges could develop shared repositories of low-cost, curriculum-aligned STEAM lesson plans, thereby lowering the barrier to adoption for teachers working in under-resourced schools.

Several limitations should be acknowledged. The relatively small and geographically limited sample restricts generalizability, the eight-week duration precludes conclusions about long-term retention of gains, and the reliance on teacher-rated rubrics introduces a degree of subjectivity that could be addressed in future research through standardized, learner-completed assessments.

CONCLUSION

This study demonstrates that even a modest, teacher-designed STEAM intervention can produce meaningful improvements in primary school learners' engagement, creativity, collaboration, and

critical thinking within a short instructional period. The findings suggest that the benefits of STEAM education are not contingent on extensive technological resources but rather on consistent implementation of an inquiry-based, design-oriented lesson structure. For educational policymakers and primary school practitioners, the results underscore the value of investing in structured teacher training and shared instructional materials as a practical pathway toward wider STEAM adoption in primary education.

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