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Awakening Inventive Capabilities in Primary School Students Through Steam Education

Mavluda S. Achilova

Associate Professor, Doctor of Philosophy in Pedagogical Sciences (PhD), Faculty of Preschool and Primary Education, Chirchik State Pedagogical University, Uzbekistan

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Abstract: This article investigates the development of inventive and creative thinking skills in primary school students through the STEAM (Science, Technology, Engineering, Art, Mathematics) approach. Considering the psychological and physiological characteristics of early school-age children, a methodology for creating new structures and models using simple, low-cost everyday materials (cardboard, plastic bottles, wires, clips, etc.) is detailed. The paper presents the pedagogical experimental-test processes conducted by the author, alongside lesson scenarios and the dynamic assessment of students' inventiveness coefficients.

Keywords: STEAM education, primary school, inventive capability, creativity, project-based learning, integration, engineering mindset, school pedagogy.

Introduction: In the modern world, the primary mission of the educational system is not merely to transmit ready-made knowledge to students, but to teach them to think independently, find non-standard solutions to problems, and innovate. The 21st-century labor market demands high levels of creativity, engineering mindsets, and technological literacy. The Law "On Education" of the Republic of Uzbekistan and the National Curriculum also designate the introduction of innovative pedagogical technologies, particularly interdisciplinary integration, as a priority task.

Primary school age (7–11 years) is the most sensorially receptive and creative period in human life. During this stage, children exhibit a high level of curiosity, an eagerness to understand the world, and highly developed visual-figurative thinking. If a child's inventive potential is not properly guided during this crucial window, conventional, template-based thinking can solidify.

The STEAM (Science, Technology, Engineering, Art, Mathematics) concept serves as an effective tool for linking science to real life and turning theory into practice right from the elementary grades. The unique value of STEAM lies in the fact that it does not impose rigid restrictions on students; instead, it creates a baseline for finding the right solutions by learning from mistakes (the trial-and-error method). By building new devices out of ordinary everyday objects, a child begins to feel like a real inventor, fostering deep intrinsic motivation toward learning.

LITERATURE REVIEW

The STEAM educational framework originally emerged as STEM in the United States and Western European countries during the late 20th century, later incorporating the "Art" component to foster creativity and aesthetics.

Globally, classical pedagogues like J.A. Comenius and John Dewey highly valued the role of practical application and labor in education. In his work The School and Society, John Dewey emphasized that a child's education must be firmly rooted in their personal actions and active experiences.

Scholars such as Georgette Yakman (the founder of STEAM), Mitchel Resnick, and Ken Robinson have conducted extensive research on adapting the STEAM approach to primary education. In his book Lifelong Kindergarten, M. Resnick highlights the four pillars of creativity ("4Ps": Project, Passion, Peers, Play) and demonstrates that inventive traits in primary school students can be catalyzed effectively through these elements.

Researchers from the CIS region, including T.V. Kudryavtsev, have thoroughly studied the psychological and sociological aspects of developing technical creativity in children. In Uzbekistan, scholars like R. Ishmukhamedov and M. Akhmedova have investigated the implementation of innovative technologies in education. However, a comprehensive methodological system for nurturing inventive capabilities through simple tools via a primary school STEAM approach has not yet been fully established. This article aims to bridge that specific academic gap.

METHODOLOGY

To execute this research project, a combination of traditional and modern pedagogical-psychological methods was utilized:

1. Pedagogical Observation: The practical actions, behaviors, and tool-handling skills of students were closely monitored during regular classes and extracurricular clubs.

2. Pedagogical Experiment (Trial-Testing): Control and experimental classes were designated within a school setting to implement specially designed STEAM modules.

3. Torrance Tests of Creative Thinking (Adapted Variant): Students' creative thinking levels, cognitive flexibility, and original ideation were formally evaluated.

4. Mathematical-Statistical Methods: The experimental results were analyzed dynamically, and data reliability was validated using specialized software.

The research database comprised a total of 120 primary school students from the 3rd and 4th grades of general education schools located in Tashkent city and the Tashkent region. The experimental group (60 students) participated in classes and clubs organized around the STEAM methodology twice a week, while the control group (60 students) studied under the conventional curriculum.

RESULTS

1. Pedagogical Model for Awakening Inventiveness in Primary Grades

Fostering inventiveness using simple items (cocktail straws, cardboard boxes, rubber bands, magnets, plastic cups) was structured based on a 4-stage pedagogical model (Table 1).

Table 1. Stages of Developing Inventiveness Based on STEAM

Stage Name	Objective	Student Activity	Simple Tools Used
1. Motivation & Problem (Science)	Identifying a problem & sparking curiosity	Observes phenomena, asks exploratory questions	Pictures, videos, real-life problem scenarios
2. Design & Sketch (Art & Math)	Defining the visual appearance & dimensions of the future invention	Drawings on paper, measures scales, colors	Rulers, pencils, colored paper
3. Construction (Engineering & Tech)	Bringing the model to life, working with tools	Glues, cuts, and fastens parts together	Cardboard, glue, scissors, strings, rubber bands
4. Testing & Presentation	Verifying functionality & refining the invention	Fixes flaws, presents the work to peers	Completed physical model

2. Practical Lesson Frameworks (Case Studies)

Let us examine two of the primary STEAM projects conducted within the experimental group that yielded the highest educational efficacy:

Case A: "Wind-Powered Car" (3rd Grade)

The Problem: Design a vehicle that does not pollute the surrounding environment.

Required Simple Tools: Plastic bottle caps (for wheels), cocktail straws (for axles), pieces of cardboard (for the chassis), and leftover balloons (to act as the motor).

STEAM Integration:

Science: Introduction to air pressure and the laws of motion.

Technology: Rules for safely handling scissors and hot glue.

Engineering: Ensuring wheels and axles are parallel to maintain balance.

Art: Decorating the vehicle with a futuristic style concept.

Mathematics: Measuring how many centimeters the car traveled using the balloon's air release with a ruler.

Result: When the children inflated the balloon and watched the car propel forward, they witnessed the transformation of energy from one form to another. Impressively, 15 students independently discovered that reducing the weight of the chassis made the vehicle travel much faster (an authentic element of invention).

Case B: "Building a Sturdy Bridge from Cardboard Paper" (4th Grade)

The Problem: Span a bridge between two desks capable of supporting a 500-gram load (books or toys) across its center.

Required Simple Tools: Ordinary A4 paper sheets, scraps of cardboard, and adhesive tape.

STEAM Integration:

Engineering: Realizing that simply placing paper flat will not support weight. Discovering that folding paper into an accordion shape or rolling it into cylindrical tubes exponentially increases structural integrity.

Mathematics: Calculating the weight-distribution properties of geometric shapes (triangles, cylinders).

Result: Students grasped the underlying core principles of architecture and structural engineering. The highest-performing student team combined paper into triangular archways, producing a bridge capable of holding up to 1.5 kg of weight.

3. Statistical Analysis of Experimental-Test Work

Following a full academic year of targeted sessions, the inventive and creative thinking capacities of the students in both the control and experimental groups were re-tested. The definitive results are detailed below in Table 2.

Table 2. Creativity Indicators Before and After the Experiment (On a 100-Point Scale)

Groups	**Metrics**	**Before Experiment**	**After Experiment**	**Growth Dynamics (%)**
Experimental Group (STEAM)	Fluency of Ideas	48.2	82.5	+ 34.3%
	Flexibility	42.1	79.4	+ 37.3%
	Originality	35.6	72.8	+ 37.2%
Control Group (Conventional)	Fluency of Ideas	47.9	53.4	+ 5.5%
	Flexibility	43.0	48.2	+ 5.2%
	Originality	36.1	40.5	+ 4.4%

The statistical data clearly illustrates that while the growth rate in conventional classrooms hovered around 4–5%, the group exposed to STEAM technology demonstrated an increase of over 37% in generating original ideas and finding creative solutions to problems.

Additionally, student attendance in the experimental group increased by 18%, and performance anxiety or depressive states (such as the acute fear of making mistakes) dropped drastically during lesson hours.

DISCUSSION

The gathered results indicate that nurturing inventive skills in primary school children does not strictly require expensive robotics kits (such as Lego Mindstorms) or high-end 3D printers. On the contrary, working with simple, accessible materials broadens a child's imagination more effectively. In pre-fabricated plastic construction sets, every piece has a designated spot based on a predefined schematic. However, when a child is tasked with building a robot using a plain cardboard box, they are forced to invent the structural schematic entirely from scratch.

During the pedagogical implementation, it became apparent that adhering to the following core principles is critical in STEAM lessons:

1. The Principle of "Zero Prohibitions": Any inventive idea a child presents, no matter how eccentric it may initially seem, must be supported. Uttering phrases like "That is wrong" or "That will not

work" instantly snuffs out a child's innovative passion.

2. Positive Re-framing of Mistakes: If a constructed bridge collapses or a car fails to move, the teacher must explain that this is not a failure, but rather "an opportunity to debug version 1.0 of the invention." Reminding children that Thomas Edison underwent thousands of unsuccessful experiments before perfecting the lightbulb is highly effective.

3. Collaborative Frameworks: Inventiveness thrives in a community environment. Children learn to brainstorm and build constructively upon one another's ideas.

Nevertheless, rolling out the STEAM approach on a wider scale presents certain obstacles. These include a lack of technical training among primary school teachers and the strict 45-minute lesson limit, which is often insufficient for hands-on projects. To resolve this, STEAM projects are best integrated into extracurricular clubs or structured as interdisciplinary block-lessons (e.g., merging technology, mathematics, and visual arts into a single extended session).

CONCLUSION

Based on the pedagogical-scientific research conducted, the following conclusions have been reached:

1. STEAM education transforms primary school students from passive consumers of theoretical knowledge into active inventors capable of creating physical and intellectual value.

2. Utilizing everyday scraps and recycled materials (cardboard, plastics, wire, etc.) instills an eco-friendly mindset while teaching children to derive creative solutions under constrained resource conditions.

3. The implementation of STEAM lessons boosted students' baseline creativity markers (flexibility, originality) by an average of 35–37%, which also dynamically improved their performance in mathematics, natural sciences, and native language studies.

RECOMMENDATIONS

• Develop and launch standardized "We Are Inventors" STEAM club curricula specifically tailored for primary grades across general education schools.

• Introduce a dedicated "STEAM Modules in Primary Education" course into the curriculum of Higher Education Institutions training future primary school teachers.

• Organize regular school exhibitions and competitive festivals featuring inventions constructed by students using basic everyday materials.

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