STEAM-BASED THEORETICAL AND PRACTICAL FOUNDATIONS FOR TEACHING NATURAL SCIENCES IN GRADE 6

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ANNOTATION: This article explores the theoretical and practical foundations of teaching the 6th-grade "Natural Sciences" curriculum based on the STEAM approach. It discusses interdisciplinary integration in modern education, activity-based learning, and methods for developing students' creative and analytical thinking. In particular, the study analyzes how the use of project-based learning, experiments, modeling tasks, interactive games, and differentiated assessment tools in lessons can enhance students' motivation and competence development. The effectiveness of the STEAM approach is substantiated through both national and international sources, and specific methodological recommendations are provided for its application in natural science education.

KEY WORDS: STEAM approach, natural sciences, interdisciplinary integration, practical tasks, modeling, project-based learning, interactive methods, competencies.

INTRODUCTION

Modern educational processes emphasize not memorization of ready-made information, but rather the necessity of guiding students toward independent thinking, the application of existing knowledge in real-life situations, analysis, discovery, and problem-solving. One of the key competencies of the 21st century-critical thinking, creativity, problem-solving, and teamwork-has become a top priority in the learning process.

This is particularly important in the teaching of natural sciences, as these subjects help students understand the scientific essence of various natural phenomena and processes, learn to explain them, and apply them in real life. However, traditional teaching methods often focus solely on theoretical knowledge, with insufficient emphasis on developing students' practical skills, learning through experimentation, understanding interdisciplinary connections, and relating science to real-world contexts. Such approaches fail to adequately develop deep scientific reasoning, logical analysis, observation, and evidence-based conclusion-making in students. As a result, learners may acquire theoretical knowledge, but struggle to apply it practically or lose motivation in the process.

From this perspective, the STEAM approach-which stands for Science, Technology, Engineering, Art, and Mathematics-has become increasingly popular and proven effective in education systems around the world. It introduces a new stage in the teaching of natural sciences. This approach fosters interdisciplinary thinking, encourages solving real-world problems through integrated solutions, and connects theoretical knowledge with practical tasks while nurturing students' creativity and analytical skills.

In particular, the introduction of updated curricula in the education system of the Republic of Uzbekistan since 2022, along with the development of the 6th-grade Natural Sciences textbook, provides a solid foundation for implementing the STEAM approach. The textbook integrates foundational concepts from biology, physics, chemistry, and geography, creating broad opportunities for activities such as understanding interdisciplinary relationships, drawing conclusions from observations, conducting experiments, modeling, and solving problems.

Thus, teaching natural sciences using the STEAM approach not only enables students to gain

knowledge but also equips them with the ability to apply that knowledge in creative and functional ways. Therefore, the development and refinement of methodologies for teaching the 6th-grade Natural Sciences curriculum based on the STEAM approach is a scientifically and practically relevant research direction.

Today, global education systems are undergoing a fundamental shift in approaches to teaching natural sciences. Traditional methods focused on theoretical instruction are being replaced by modern, activity-based, and interdisciplinary approaches. Among these, the STEAM approach stands out as one of the most advanced educational trends.

STEAM is an educational approach based on the integrated application of **Science**, **Technology**, **Engineering**, **Art**, and **Mathematics** within a unified learning process. This model initially emerged in the United States and European countries in the form of STEM, and later evolved into STEAM with the addition of the *Art* component [1].

The STEAM approach aims to develop the following key competencies in students:

- problem-solving skills;
- systematic and analytical thinking;
- readiness for practical activities;
- creativity and design thinking;
- project-based skills built on interdisciplinary connections.

Within this approach, students are not passive recipients of knowledge, but active participants in the learning process. They become directly involved in creating knowledge, testing hypotheses, and solving real-world problems.

Natural sciences are a set of essential disciplines that teach students to study, analyze, and understand the surrounding world from a scientific perspective. Integrating concepts from biology, physics, chemistry, and geography allows students to conduct complex analyses of real-life phenomena, identify cause-and-effect relationships, engage in experimentation, and apply scientific knowledge in practice [6].

Teaching natural sciences through the STEAM approach promotes:

- student engagement in laboratory work and scientific experiments;
- development and presentation of scientific projects;
- analytical thinking based on mathematics and technology;
- the growth of engineering and design thinking;
- deep learning of subject content through creative approaches.

In recent years, the education policy of the Republic of Uzbekistan has also paid increasing attention to the STEAM approach. In 2021, relevant resolutions of the Cabinet of Ministers, the National Education Development Strategy (MTTT), and newly adopted curricula explicitly outlined the development of subject integration, project-based, and practical learning activities grounded in the STEAM methodology [10].

In 2022, as part of the new generation of textbooks for grade 6, the Natural Sciences textbook (authored by M. Abdullaev, G. To‘xtaboeva, M. Yunusova, and others) was developed with content specifically based on the STEAM approach. This textbook integrates biological, physical, chemical, and geographical knowledge within a unified system, providing interconnected topics. Following each lesson, students are offered practical tasks, observations, experiments, and project-based activities.

Literature review. An analysis of the literature reveals that numerous international studies have been conducted on the effectiveness of the STEAM approach in teaching natural sciences. For example, research by Beers [2], Yakman [1], and Bybee [3] has demonstrated that the integration of STEAM into the learning process contributes to the development of deeper conceptual understanding, enhances students’ ability to recognize interdisciplinary connections, and significantly improves their problem-solving skills.

Notably, the conceptual model of the STEAM approach developed by Yakman plays an important role in fostering scientific thinking, as well as analytical and design-based approaches among students. Bybee, on the other hand, emphasized that the core goal of the STEM (and later STEAM) approach is to increase scientific literacy, promote hands-on learning, and create an environment that fosters creativity among learners.

Furthermore, the implementation of STEAM-based natural science lessons has been widely adopted in schools across China, South Korea, the United States, and European countries. These initiatives have proven to be effective in nurturing students' scientific research skills from an early age, with tangible results supporting their success [4].

In recent years, Uzbek scholars have also conducted specific research on introducing modern approaches to natural science education, including the use of integrative teaching methods based on STEAM components. For example, A.M. Muminov [6] explored the role of natural sciences in fostering students' conscious attitudes toward the environment, while D.Soliyeva [7] examined the methodological foundations of interdisciplinary integration in biology education. G. Rakhmatova [8], in turn, analyzed the advantages of project-based learning in developing students' scientific research competencies.

However, existing domestic studies have primarily focused on individual subjects such as biology or chemistry, with relatively few cases analyzing interdisciplinary integration within a unified system-especially through the lens of the grade 6 Natural Sciences textbook. Likewise, methodological developments based on the STEAM model remain limited. In this regard, analyzing the content of the 6th-grade Natural Sciences textbook, published in 2022, from the perspective of the STEAM approach; enriching its topics with practical, project-oriented tasks; and developing as well as evaluating an instructional methodology based on this framework represents a relatively unexplored research direction to date.

As such, this study aims to fill that gap. With its scientific novelty, practical relevance, and theoretical-methodological foundations, it is expected to make a significant contribution to improving the methodology of teaching natural sciences through the STEAM approach [9].

Main Part. In modern educational processes, one of the key methodological tasks is to activate students' learning activities, guide them toward independent thinking within interdisciplinary connections, and equip them to solve real-world problems. This is particularly crucial in the teaching of natural sciences—which encompass elements of biology, chemistry, physics, and geography—where the development of practical and research-based skills among students is considered a primary pedagogical goal.

In this regard, the STEAM approach stands out for its methods that are activity-based, integrative, and oriented toward creative thinking. Specifically, in the process of teaching natural sciences through the STEAM framework, the use of practical projects, experimental tasks, modeling activities, interactive games, and differentiated assessments not only enhances students' knowledge levels but also fosters their overall competency development.

Within STEAM methodology, Project-Based Learning (PBL) plays a central role. Through practical projects related to natural sciences, students attempt to find solutions to real-life problems, make observations, conduct analysis, engage in constructive work, and defend their ideas. This enriches them with skills in engineering and scientific thinking, research, teamwork, and presentation.

Experiments-being one of the core methods in natural sciences—are enhanced in the STEAM approach with creative strategies and design elements. Beyond traditional observation, students learn to plan, implement, refine, compare, and generalize their own experimental activities. As a result, their scientific reasoning deepens, and they develop a stronger culture of observation [13].

Explaining complex natural processes-such as cell structure, the water cycle, and atmospheric layers-through visual modeling provides students with the opportunity to deeply comprehend the topic, visualize abstract concepts, and engage in analytical thinking. This method not only facilitates understanding but also fosters students' constructive thinking and problem-solving competencies.

Since the STEAM approach inherently integrates creativity and emotional engagement, it is possible to involve students actively in the learning process through interactive games and educational quests, encouraging their participation in a psychologically positive environment. Knowledge acquired through games tends to be more stable and long-lasting, and students demonstrate a higher level of knowledge application. In particular, cross-curricular games contribute significantly to developing interdisciplinary

thinking skills.

In assessing students' knowledge, in addition to traditional tests, it is recommended to utilize differentiated tasks based on levels of complexity-namely, A (reproductive), B (analytical), and C (creative) types of questions. This approach enables teachers to identify each student's individual abilities and developmental level. Consequently, it supports the implementation of individualized instruction and differentiated learning strategies [14].

Based on the above findings, it is crucial to outline the methodology for using *practical projects, experimental tasks, modeling activities, interactive games, and differentiated assessments*-derived from the content of the *Natural Sciences* textbook-in classroom instruction.

Project Title:

"Layers of the Earth's Atmosphere - Modeling and Protective Concept Development"

Integrated Subjects:

Geography + Physics + Biology + Art

Objective:

The aim of this project is to enable students to gain knowledge about the layers of the Earth's atmosphere, create 3D models representing their characteristics, and develop innovative protective ideas addressing climate change.

Materials and Equipment:

Paper, colored cardboard, glue, thermometer, internet resources, a set of transparent balloons.

Project Stages:

1. **Introduction of Concepts:**
   Students are introduced to the five layers of the Earth's atmosphere: *Troposphere*, *Stratosphere*, *Mesosphere*, *Thermosphere*, and *Exosphere*, including their characteristics and functions.
2. **3D Modeling:**
   Each group creates a "3D model" of the atmospheric layers using cardboard or transparent balloons, emphasizing visual representation and spatial understanding.
3. **Group Presentations:**
   Every group presents their model and explains how their specific atmospheric layer affects or is affected by climate change. They also propose protection strategies or innovative ideas to mitigate negative impacts.
4. **Reflection and Peer Comparison:**
   Groups compare their findings and models with other groups, engage in discussion, and reflect on their learning process and outcomes.

Assessment Criteria:

Criterion	Points
Understanding of the topic	(3 points)
Accuracy of the model	(3 points)
Quality of the presentation	(2 points)
Team collaboration and participation	(2 points)

Experiment Title:

"What Factors Affect the Rate of Water Evaporation?"

Integrated Subjects:

Physics + Biology + Mathematics

Objective:

To help students understand the physical and biological significance of evaporation, and to develop skills in observation, data collection, and drawing conclusions based on experimental results.

Materials and Equipment:

- 3 identical shallow dishes
- Water

- Thermometer
- Towel
- Stopwatch or clock

Three different environments for placement:

- In direct sunlight
- In the shade
- In front of a fan

Procedure:

1. Each group pours the same amount of water into the three identical dishes.
2. The dishes are placed in three different environments: under sunlight, in the shade, and in front of a fan.
3. Students measure and record the water level in each dish every 10 minutes.
4. At the end of the observation period, groups plot graphs to visualize evaporation rates in different environments.
5. Students analyze the results and identify which condition caused the fastest evaporation.

Assessment Criteria:

Criterion	Points
Experimental design	(2 points)
Accuracy in observation and data collection	(3 points)
Graph construction and data analysis	(3 points)
Conclusion and presentation	(2 points)

Task Title:

"Creating Cell Models (Animal and Plant Cells)"

Integrated Subjects:

Biology + Art + Technology

Objective:

To visually conceptualize the structure of cells and reinforce understanding through modeling.

Materials:

Plasticine, cardboard, pasta, legumes, glue, markers.

Approach:

- Students are divided into groups: one group creates an animal cell model, the other a plant cell model.
- Each organelle is represented using a specific color and material.
- After completing the model, students explain it in front of the class.

Assessment Criteria:

Criterion	Points
Accuracy and correctness of the model	(3 points)
Scientific explanation during the presentation	(3 points)
Artistic expression and creativity	(2 points)
Teamwork	(2 points)

Game Title:

"STEAM Quest: Find the Elements!"

Integrated Subjects:

Chemistry + Biology + Mathematics + IT

Objective:

To study elements and their properties, and develop integrated thinking through problem-based questions.

Description:

- The teacher sets up 5 stations, each representing a different subject area.

- Each station contains questions, mini-tasks, or puzzles related to the subject.
- For every correct answer, students earn tokens (element symbols).
- At the end, students use the collected tokens to form a chemical compound or formula.

Assessment Criteria:

Criterion	**Points**
Number of correct answers	(5 points)
Teamwork and collaborative problem solving	(3 points)
Correct formation of the final formula	(2 points)

Differential Assessment Tests (3 Levels)

Topic: "Objects and Substances in Nature"

Level A (Reproductive):

1. Write the difference between a substance and an object.
2. Which one is an object?

a) Iron brick
b) Iron
c) Gas
d) Heat

Level B (Analytical):

3. Write examples of objects and substances and distinguish between them.
4. Through which substance can the following phenomenon be explained: "Fogging of a window on a cold day"?

Level C (Creative):

5. Take 3 objects from your daily life and identify what substances they are made of.
6. Propose a "new" object: what is its purpose and what substances would it be made from?

Conclusion.

Effective use of practical projects, experiments, modeling tasks, interactive games, and differential assessment tools-mentioned above-in teaching natural sciences based on the STEAM approach elevates students' learning activities to a new level. These methods primarily strengthen students' intrinsic motivation toward learning because they can relate the topics studied to real-life situations and feel themselves as active participants. This signifies that the learner is at the center of the educational process.

Moreover, STEAM-based methods develop students' higher-order cognitive skills such as independent thinking, analysis, and systematic decision-making. These skills are relevant not only in natural sciences but also in other subjects and everyday life. In particular, applying interdisciplinary tasks based on subject integration in lessons enables students to understand interconnections between subjects, viewing phenomena not from a single subject perspective but through a comprehensive approach.

Lessons organized on the STEAM model foster students' interest in scientific research activities, encouraging them to independently explore and discover new knowledge through experiments when faced with problematic situations. This helps cultivate qualities of young researchers. Another important aspect is that STEAM-based lessons rapidly develop practical competencies in students—such as applying theoretical knowledge in real life, designing projects, problem-solving, analyzing, and evaluating results. This fully meets the requirements of the competency-based approach, which is one of the main directions of modern education.

Therefore, the aforementioned methods in natural sciences education not only improve the quality of the learning process but also facilitate deep mastery of new generation textbooks' content and the formation of a competitive personality at the level of 21st-century education demands. Through these methods, students acquire essential scientific, technological, and creative competencies necessary for their life activities, serving as a crucial foundation for their future personal and professional development.

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