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Theoretical-Methodological Foundations Of Improving The Skills Of Teaching Natural Sciences Of Future Primary School Teachers On The Basis Of Steam Technology

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Abstract: This article highlights the principles of an integrative approach and the theoretical-methodological foundations of teaching natural sciences to primary school teachers based on STEAM. The STEAM approach aims not only at acquiring knowledge but also at developing creative and analytical thinking, teamwork, and scientific approaches. This article analyzes the principles of the integrative approach in teaching natural sciences to primary school teachers within the framework of STEAM. The importance of this methodology in education, its advantages, and the ways of applying it in practice are presented. Emphasis is placed on increasing students' interest, developing research skills, and enhancing their problem-solving abilities through STEAM education. Furthermore, the role and effectiveness of the integrative approach in the educational process are discussed.

Keywords: STEAM educational technology, primary education, integration, modern education, natural sciences, pedagogical technologies, interactive methods, modern approaches, method, production.

Introduction: Education and upbringing are the mirrors of the future of a nation. At the current stage of profound economic and social changes in our society, searching for ways and means of improving the quality of education and upbringing has become one of the main urgent tasks of modern pedagogy. Adapting the national education system to the processes of sustainable development and modernization, as well as actively applying innovative ideas, integrated technologies, and developments in the learning process in order to form students' core and subject-specific competencies, is of particular relevance today.

For instance, systemic measures are being implemented to create and strengthen the modern material and technical base of educational institutions, to use it rationally, and to equip them with highly efficient educational laboratories, computer technologies, and other information and communication tools. Enriching knowledge by making broad use of opportunities to form practical professional skills reflects the practical significance of the educational and upbringing process.

This, in turn, generates urgent demands to ensure an indirect connection between education and production. It also necessitates the development of new methods of using STEAM technologies widely in modern teaching to provide this linkage. The current stage of social development is characterized by the acceleration of information and technological progress. The improvement of data and technologies requires individuals to be constantly engaged in cognitive activity and to regularly assimilate innovations.

In the Presidential Decree of the Republic of Uzbekistan dated April 29, 2019, No. 5712, special attention is paid to ensuring high-quality education based on the most modern trends by gradually establishing Presidential schools specialized in STEAM fields in every region of the Republic during 2019–2021. Today, STEAM is one of the most prominent innovative technologies in the global education system.

At first glance, STEAM technology seems very complex, but when studied in detail, it becomes clear that it is simple and precise. That is: S – Science, T – Technology, E – Engineering, A – Art, M – Mathematics. In other words, these are the fields most in demand in today's modern world.

LITERATURE REVIEW

Scientists from the Commonwealth of Independent States (CIS) countries, such as L.V. Sheptuxovskiy, I.G. Kroxina, and L.P. Simonova, studied the pedagogical issue of forming natural-science competencies in students and developed criteria for shaping these competencies [2].

In the scientific research of F.I. Ochilov, a methodology for teaching natural sciences based on a competency-based approach was presented [3]. Researcher Z.B. Sangirova developed recommendations for the use of STEAM education in teaching natural sciences [4].

The analysis of scientific literature shows that the issue of integration in various areas of modern education is recognized as one of the pressing problems of the pedagogical process. In particular, in the general secondary education system, creating mechanisms for integrated teaching of subjects, determining its pedagogical and didactic foundations, and applying them in practice have become urgent issues.

Therefore, first of all, we found it necessary to focus on the meaning, essence, and definition of the term “integration.” Integration means the combination of certain parts or elements and their transformation into a whole. The word “integration” comes from the Latin integratio (“integr” – complete, whole, unified), meaning “reconstruction, restoration, replenishment”; “integration” – “to develop in an interconnected way”; “to integrate” – “to combine into a whole, to make unified.”

In didactics, special attention has been paid to the problem of ensuring interdisciplinary connections between subjects. Based on the analysis of these issues, the methodological directions of interdisciplinary relations were identified.

Particularly, research conducted under the leadership of V.N. Fedorova is important for presenting the theoretical foundations of interdisciplinary connections. It is noted that the didactic aspects of ensuring interdisciplinary relations are not limited only to expressing different knowledge and concepts within the content of specific academic subjects.

In the works of Russian researcher L.V. Pivovarova, the characteristics of a technological approach to integrative methodology in education are described as follows: the main purpose of using the term “integrative methodology” is to identify the main features of a technological approach to education and to develop models for applying them by harmonizing pedagogical and information-communication technologies.

At the same time, a number of studies have been conducted on international assessment programs that demonstrate the effectiveness of STEAM education. In particular, J. Tolipova developed methodological support for teaching natural science subjects through the STEAM approach [8], while E.O. Turdiqulov studied the problem of teaching natural sciences in an integrated manner as a separate research issue and defined educational integration as a process that allows the creation of comprehensive, integrated knowledge [9].

METHODOLOGY

The essence and advantages of the STEAM approach

The STEAM approach in education is based on the integration of Science (S), Technology (T), Engineering (E), Art (A), and Mathematics (M). Research shows that STEAM-based education develops the following qualities in future teachers:

- Development of critical thinking and creativity;
- Strengthening scientific and technical skills;
- Preparing flexible young people for the professions of the new era.

Importance in primary education

Teaching natural sciences in primary school is of great importance for developing students’ skills. It emphasizes the need to connect theoretical knowledge with real-life practice and to engage students through the use of experiments and visualization methods.

Global trends

Worldwide, the introduction of STEAM education — aimed at deeply studying science, technology, engineering, art, and mathematics — has led to the application of a competency-based approach in teaching natural sciences, including technology subjects. This also includes developing students’ scientific literacy, effectively implementing international assessment programs in the educational process, introducing “computer-based learning” into practice, integrating pedagogical and information technologies in teaching biology, and applying integrative approaches within the information-educational environment.

Practical skills development

In the process of developing skills, the following resources and methods are considered important for teachers:

- Methodological materials and online resources (e.g., interactive games);
- Laboratory experiments in natural sciences;
- Virtual laboratories;
- Small-scale projects.

Objectives and tasks

• To develop primary school teachers' practical skills in teaching natural sciences based on STEAM;

• To foster problem-based thinking and subject integration among students.

Research methods

• Theoretical analysis: studying advanced experiences in STEAM technologies and natural science teaching;

• Practical experiments: introducing STEAM-based teaching methods in experimental classrooms and observing results;

• Experimentation: testing virtual laboratories and creative group projects in teaching natural science topics.

Methodical approach

• Designing lesson plans in natural sciences based on STEAM (e.g., water cycle, photosynthesis, or climate change);

• Organizing experiment-based lessons (e.g., preparing a water filter, using solar energy);

• Making lessons interactive through online resources (Khan Academy, Google Earth).

Measurement and evaluation

• Conducting tests and surveys to diagnose students' knowledge;

• Observing experiment results and presenting them through charts and tables;

• Using training and seminars to improve teachers' professional skills.

RESULTS

Teaching natural sciences in primary school through STEAM not only develops theoretical knowledge but also creates opportunities to enhance creativity and technological skills.

The use of small projects and visual-demonstrative methods in lessons increases children's interest in natural sciences. For example, integrating methodological approaches into teacher training programs has proven effective. Within the framework of this approach, students of the "University of Economics and Pedagogy" (NOTM), specializing in primary education, carried out an experiment using the 4th grade Natural Sciences textbook. In the lesson on the topic "Respiratory System", students created a model to visually observe the structure and physiology of the lungs. As a result, their practical competencies were successfully developed.

By analyzing the experiences of countries that provide education based on STEAM technology, we concluded that this methodology is highly effective in developing the 4Cs skills (communication, collaboration, critical thinking, creativity) — which are essential for today's learners.

Creativity includes the following components:

• Curiosity – interest in the surrounding world and seeking answers to arising questions;

• Imagination – independently generating ideas and enriching personal imagination by reworking proposed ideas;

• Persistence – overcoming difficulties that arise during tasks and being resilient.

Critical thinking involves:

• Analytical component – evaluating facts, assessing arguments (reasoning presented to confirm the truth of a statement);

• Synthetic (applied) component – developing logical thinking among peers and shaping one's own position in a group;

• General component – observing cause-and-effect relationships and summarizing conclusions.

Communication and collaboration include:

• Interaction analysis and evaluation – assessing situations of interaction and the results of cooperation;

• Teamwork – uniting the efforts of group members toward a common goal and evaluating group performance;

• Communication skills – being able to convey information to interlocutors, choosing discussion topics of interest to the group, striving to understand peers, and using auxiliary communication tools effectively.

To improve the teaching process of natural sciences through subject integration, the following qualities of students should be developed in the first place: interest in learning, creative thinking skills, independent reasoning, and the ability to work systematically on self-development.

From this, it follows that before applying STEAM technology in primary education, it is essential to form students' creative abilities.

Types of integration include:

• Interdisciplinary integration

• Cross-subject integration

• Intra-subject integration – integration of concepts, knowledge, and skills within a particular academic subject

• Transdisciplinary integration – analysis of principles, concepts, facts, and evidence from two or more subjects

• Integration of core and supplementary components of the curriculum

CONCLUSION

Thus, the issue of applying an integrative approach in the educational process has a certain universal character. Since integrative technologies used in education require combining both pedagogical and information-communication technologies, their directions may differ, but they also share common aspects of interconnection.

For primary school teachers, teaching natural sciences based on STEAM (Science, Technology, Engineering, Art, Mathematics) and applying the principles of the integrative approach have become one of the main directions of the modern education system. Through this approach, attention is given to helping students understand interdisciplinary connections, developing logical and creative thinking skills, and forming practical competencies.

The STEAM methodology makes it possible to link natural sciences with real-life practice, thereby increasing students' interest in scientific inquiry. At the same time, the integrative approach establishes logical connections between various subjects and creates opportunities for conducting the learning process in a holistic manner.

These principles serve to shape independent thinking, problem-solving abilities, and innovative thinking in primary school students.

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