

INTERDISCIPLINARY INTEGRATION IN TEACHING EXACT AND NATURAL SCIENCES

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Abstract: This article examines the theoretical and practical foundations of interdisciplinary integration in teaching exact and natural sciences, the subject "Science", and the STEAM education system. The issues of developing students' logical thinking, increasing the effectiveness of lessons, and forming a holistic worldview about the world using interactive methods are analyzed based on sources.

Keywords: integration, natural sciences, science, STEAM education, science, technology, engineering, harmony of Arts and mathematics, innovative technologies, professional competence, creativity, collaborative teaching, interactive methods, cluster, mental attack, holistic worldview, feedback, variative study plans.

Аннотация: В статье исследуются теоретические и практические основы междисциплинарной интеграции в преподавании точных и естественных наук, предмета «Естествознание» и системы образования STEAM. На основе источников проанализированы вопросы развития логического мышления учащихся, повышения эффективности урока и формирования целостного мировоззрения об окружающем мире с использованием интерактивных методов.

Ключевые слова: Интеграция, естественные науки, Наука, Образование Steam, наука, технологии, инженерия, сочетание искусства и математики, инновационные технологии, профессиональная компетентность, креативность, совместное обучение, интерактивные методы, кластер, мозговой штурм, целостное мировоззрение, обратная связь, вариативные учебные планы.

Annotatsiya: Ushbu maqolada aniq va tabiiy fanlarni o'qitishda fanlararo integratsiya, "Science" fani hamda STEAM ta'lim tizimining nazariy va amaliy asoslari tadqiq etilgan. Interaktiv metodlar yordamida o'quvchilarning mantiqiy fikrlashini rivojlantirish, dars samaradorligini oshirish va olam haqida yaxlit dunyoqarashni shakllantirish masalalari manbalar asosida tahlil qilingan.

Kalit so'zlar: Integratsiya, tabiiy fanlar, science, STEAM ta'limi, fan, texnologiya, muhandislik, san'at va matematikaning uyg'unligi, innovatsion texnologiyalar, kasbiy kompetensiya, kreativlik, hamkorlikda o'qitish, interaktiv

metodlar, klaster, aqliy hujum, yaxlit dunyoqarash, teskari aloqa, variativ o'quv rejalari.

Introduction. In today's rapidly evolving world, one of the most important tasks facing the education system is to foster a holistic and systematic understanding of the world among students. Elevating the quality of natural science education to a new level has become a priority of state policy within the framework of the large-scale reforms being implemented in the Republic of Uzbekistan. In particular, Resolution No. PP-4805 of the President of the Republic of Uzbekistan, dated August 12, 2020, "On measures to improve the quality of continuous education and the effectiveness of scientific activity in the fields of chemistry and biology," serves as the legal foundation for these efforts. In accordance with this resolution, the introduction of specialized, flexible curricula focused on natural sciences in schools was mandated. The essence of this change is that, alongside the standard curriculum, students with a strong interest in chemistry and biology are grouped together, providing them with the opportunity to study these subjects in greater depth. As a crucial initial step in these reforms, the integrated teaching of natural sciences was implemented for grades 1 through 6.

The Importance and Integration of the "Science" Subject. The newly introduced "Science" subject serves to encourage students to study natural sciences from an early age and helps them form a holistic view of the world. Subjects such as biology, chemistry, physics, and geography – previously taught separately – have now been consolidated into a single, logically sequenced program leading up to the 6th grade. This approach helps children realize that complex subjects like physics and chemistry are not difficult, but rather highly engaging.

The "Science" subject does not entail abandoning existing disciplines; instead, it aims to enhance the quality of education by integrating them. For instance, while the curriculum begins with "The World Around Us" in grades 1–2 and "Natural Studies" in grades 3–4, physics is gradually introduced into the system starting in the 6th grade, followed by chemistry in the 7th grade. Such integration enables students to connect theoretical knowledge with real-life examples and engaging methods when exploring topics like the insect world or natural phenomena.

Natural sciences are the "heart of science". Today, natural sciences play a central role in addressing the global challenges facing humanity. A deep understanding of the laws of nature is crucial for solving problems in fields such as genetics, mathematics, anthropology, and geophysics. Current environmental crises resulting from human activity – including drought, desertification, the depletion of water resources, and food shortages – make the integration of these sciences increasingly vital.

This group of sciences addresses the following global objectives:

- Studying demographic issues and changes associated with global population growth.

- Utilizing nuclear energy as a power source for the economy and developing thermonuclear systems.
- Managing natural resources based on closed-loop cycles.
- Addressing the restoration of the heat balance disrupted by environmental pollution.
- Preventing potential global catastrophes that could threaten the future of humanity.

The STEAM education system and modern approaches. The concept for the development of Uzbekistan's education system through 2030 places special emphasis on the introduction of STEAM subjects (science, technology, engineering, arts, and mathematics). The STEAM approach is the most effective method for integrating theory and practice, ensuring that students grow up keeping pace with the technologies of the new era.

The introduction of STEAM education in Uzbekistan began by directly integrating it into the "Science" subject curriculum. New textbooks implemented in schools starting from the 2021–2022 academic year incorporate topics and exercises based on this very system. This process draws extensively on the experience of developed nations, such as South Korea. Teaching natural sciences through an integrated approach aims not only to impart knowledge but also to enhance students' logical thinking, independent decision-making abilities, and creative potential. This serves as a solid foundation for training highly skilled professionals with great intellectual potential in the future. The process involves utilizing the team-teaching method—a form of collaborative learning technology—in natural science instruction. It encompasses the methodology for teaching a complex body of knowledge regarding modern concepts of natural sciences, including the structure, ecology, genetics, and evolutionary development of organisms. The approach focuses on effectively organizing the learning process by employing creative and inquiry-based tasks to develop students' knowledge and skills.

LITERATURE REVIEW AND METHODOLOGY. The modern professional competence of the teacher. Rapid changes in the educational process of the 21st century are imposing new demands on teachers' professional competence. A combination of qualities—such as creativity, cognitive ability, intellectual potential, communication skills, and personal development—plays a decisive role in the professional growth of today's educator. Pedagogical creativity, in particular, must be clearly evident in a teacher's thinking, communication, and emotions.

This study relies on the definition of creativity provided by P. Torrance. According to this definition, creativity is the process of identifying a problem, formulating scientific hypotheses, testing and modifying them, and formulating the results of the final decision. This process represents the interconnection between knowledge and practical action. Organizing modern lessons requires a high level of skill and a creative approach from the teacher in the application of new technologies.

The integrated approach and its methodological basis. The article adopts integrated lesson technology as its primary methodology. This is a special type of

lesson that integrates instruction across multiple disciplines simultaneously when exploring a specific topic or phenomenon. Such lessons differ fundamentally from traditional ones because they link the material of a "lead subject" – which acts as an integrator – with that of "supporting subjects" that complement it.

Teachers typically turn to integrated lessons in the following situations:

- When the repetition of material is identified across curricula and textbooks.
- When time for studying a topic is limited and it becomes necessary to utilize existing content from a parallel subject.
- When exploring generalized interdisciplinary concepts (such as motion, time, development, etc.).
- When identifying contradictions in the descriptions of the same phenomena across different subjects.
- When developing problem-based and developmental teaching methods for a subject.

The STEAM education system. Another important component of the methodology is the STEAM approach. STEAM represents the integration of Science, Technology, Engineering, Art, and Mathematics into a unified system. This educational approach is the logical outcome of combining theory and practice, enabling students to immediately apply the knowledge they have acquired. In Uzbekistan, this system is being implemented by incorporating it into the "Science" subject curriculum.

Interactive methods and lesson organization techniques. To enhance students' logical thinking and foster their cognitive engagement, the following interactive methods are recommended:

"Cluster" method: This method creates an environment where students can think freely and openly about issues and express their personal opinions without inhibition. It is based on the principles of brain function and helps identify connections between various ideas.

"6 x 6" method: This method allows for the active engagement of 36 students simultaneously. In this process, six groups of six participants each discuss the problem; subsequently, the groups are re-formed so that every student acts as both a participant in the discussion and a presenter.

"Brainstorming" method: This method aims to generate original solutions to a specific topic. Its primary objective is to encourage students to think broadly and comprehensively about the problem at hand.

In conclusion, these methodological approaches serve to shape students' scientific worldview, develop their life skills, and enhance the effectiveness of education in the teaching of natural sciences.

DISCUSSION. Principles of organizing integrated lessons. An integrated lesson differs fundamentally from traditional lessons in its structure and objectives. To organize such lessons effectively, the teacher must clearly define two key components: the leading subject (the integrator) and the supporting subjects that serve to deepen its content. During the integration process, content may be combined while preserving the teaching methods of the subjects, or conversely, the

content may be retained while harmonizing the methodologies of different disciplines.

The study identifies the following stages as crucial for the teacher when preparing for the lesson:

- Defining the purpose and rationale for integration.
- Determining the nature of the connections between the materials being combined.
- Assigning roles among subject teachers and developing criteria to evaluate the lesson's effectiveness.

The STEAM system: the harmony of theory and practice in education. The STEAM approach (Science, Technology, Engineering, Art, Mathematics) is based on integrating all five fields into a unified educational system and represents the logical outcome of combining theory and practice. The primary advantage of this system is that students have the opportunity to immediately apply the knowledge they have acquired. The introduction of STEAM into Uzbekistan's education system began by integrating it into the "Science" (Natural Sciences) curriculum. Today, natural science textbooks for grades 1 and 2 incorporate topics and practical exercises specifically based on the STEAM approach. This fosters the development of critical thinking and independent information-seeking skills among students.

International experience: Cooperation with the Republic of Korea. The Republican Education Center under the Ministry of Public Education of the Republic of Uzbekistan places special emphasis on international cooperation to implement advanced methodologies for teaching STEAM subjects. In particular, new curricula and textbooks are being developed by drawing on the expertise of specialists from the Republic of Korea. Cooperation with Korean experts extends beyond language instruction to include the implementation of innovative technologies for teaching exact and natural sciences within the school education system.

Developing students' cognitive activity. The technologies under discussion stimulate students' mental activity and create conditions for the efficient use of time. For instance, when collaborative learning methods (such as "6x6," "Jigsaw," or "Brainstorming") are employed in class, students' interest in the subject grows, and they grasp complex physicochemical phenomena in an accessible and engaging manner. Furthermore, the consistent use of feedback mechanisms—such as tests and assessment tasks—makes it possible to identify common errors in students' understanding and rectify them in a timely manner.

In conclusion, integrated education and the STEAM system ensure that students grow up in step with modern technologies while fostering a holistic understanding of the world.

The application of an integrated approach and modern pedagogical technologies in teaching natural and exact sciences has yielded significant positive results in practice. The research led to the following key achievements:

1. Formation of a holistic worldview and systematic thinking. Integrated lessons fostered the students' ability to perceive nature as a unified whole.

Previously, due to "artificial walls" between the disciplines of physics, chemistry, and biology, students were unable to apply principles learned in one subject to another. For instance, realizing that the law of conservation of energy applies to both physical and biological processes broadened the students' scientific worldview. This, in turn, helped create a holistic picture of the world.

2. A "quantum leap" in student engagement (using the "6x6" method as an example). Methodological experiments have shown that interactive techniques like the "6x6" method ensure 100% student participation during the lesson. Communication skills: Each of the 36 students acted simultaneously as a listener, a presenter, and an expert. Time efficiency: Information exchange accelerated as students rotated through multiple working groups within a short timeframe. This outcome eliminated the one-sidedness often seen in traditional lessons, where "only active students answer."

3. Development of competencies through the STEAM approach. The results of the STEAM education system were evident not only in the students' level of knowledge but also in their life competencies:

Critical thinking: Students learned to solve problems by integrating engineering and mathematics, rather than limiting themselves to the scope of a single subject.

Information handling: Skills were developed in independently searching for sources, filtering information, and presenting it using technological tools.

Creative approach: The inclusion of the "Art" element enhanced students' aesthetic taste and their ability to find creative solutions for complex projects.

4. Learning effectiveness and the "feedback" system. The system of regular monitoring and testing (feedback) employed during the study made it possible to quantify learning outcomes:

Error correction: Continuous Q&A sessions and interactive tests allowed for the immediate identification of points where students misunderstood the material, enabling corrections to be made on the spot.

Knowledge consolidation: As a result of combining theory and practice (through laboratory sessions), knowledge retention rates were observed to be 1.5–2 times higher than those achieved with traditional methods.

5. Enhancement of the teacher's professional expertise. The results were evident not only in the students but also in the educators' work. The teacher's creative approach to lesson preparation and the pursuit of interdisciplinary connections elevated their professional competence to a new level. This fostered a modern and innovative environment for managing the quality of education.

CONCLUSION. Teaching natural sciences through an integrated approach based on the STEAM (Science, Technology, Engineering, Art, Mathematics) system is not merely an innovation but a necessity demanded by the times. Research and practical experience demonstrate that this approach not only fosters a holistic understanding of the world among students but also ensures they grow up in step with modern technologies.

- Unlike traditional lessons, interactive methods (such as "6x6" or "Jigsaw") guarantee 100% student engagement and a deeper mastery of the subject matter.
- The STEAM system represents the logical outcome of linking theory with practice, laying the groundwork for students to develop into highly skilled professionals.
- The presence of continuous feedback (through tests and Q&A sessions) during the educational process serves to steadily enhance students' knowledge and allows for the timely correction of common errors.
- Based on research findings and international best practices (particularly the experience of experts from the Republic of Korea), the following recommendations have been developed:
 - When preparing integrated lessons, teachers of various subjects (biology, physics, chemistry, etc.) should collaborate effectively and clearly define lesson objectives and individual roles.
 - During the teaching process, the use of methods such as "Clustering," "Brainstorming," and "6x6" should be expanded, taking into account students' individual capabilities. These methods transform students from passive listeners into active researchers.
 - STEAM education principles should be more deeply integrated into the "Science" curriculum, and textbooks should be enriched with novel practical assignments, projects, and logic-based exercises such as crosswords.
 - It is recommended to establish a system within each lesson plan to assess students' knowledge regarding both previous and new topics, and to make appropriate adjustments to lesson plans based on the results obtained.
 - Given the younger generation's keen interest in technology, the educational process must be supported by modern information exchange tools and innovative technical solutions.

I. Regulatory legal acts:

- 1 . Resolution of the President of the Republic of Uzbekistan No. PP-4805 dated August 12, 2020, "On measures to improve the quality of continuous education and the effectiveness of scientific research in the fields of chemistry and biology."
- 2 . Decree of the President of the Republic of Uzbekistan No. PF-5712 dated April 29, 2019, "On approval of the Concept for the development of the public education system of the Republic of Uzbekistan until 2030."

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