AMERICAN Journal of Language, Literacy and Learning in STEM Education
Volume 3, Issue 11, 2025 ISSN (E): 2993-2769

The Essence of Integration in Teaching Chemistry

Mamajonova Rashidaxon Tukhtashevna, Absarova Dilrabo Kamronovna
Fergana State Technical University

Abstract. *This article discusses the content of the principles of integration in teaching chemistry, its scientific and methodological foundations, the advantages of its application in the educational process, and modern approaches. It is explained that ensuring interdisciplinary connections in the teaching of chemistry expands the scientific worldview of students, provides a deep understanding of complex chemical processes, and allows for the implementation of a competency-based approach in practice. The article provides types, forms, and mechanisms for increasing the effectiveness of integration, as well as methodological recommendations for combining chemistry with such disciplines as biology, physics, mathematics, ecology, and technology.*

Key words: *Integration, chemistry teaching methodology, interdisciplinary connection, STEAM, competency-based approach, systematic approach, motivation, practical exercises, cognitive development.*

Introduction. In today's globalization environment, the most important task required of the education system is to form students as individuals who think independently, can apply knowledge in practical situations, and approach complex issues systematically. Such an approach serves not only to increase academic knowledge, but also to develop students' critical thinking, problem-solving, and creative solution skills. Chemistry includes fundamental knowledge about complex natural phenomena, the structure, properties, and interactions of substances. Therefore, the importance of an integrative approach in chemistry education is very great. Integration not only helps to strengthen interdisciplinarity, but also forms a holistic scientific imagination in the student, allows the application of theoretical knowledge in practice through various disciplines. For example, by linking chemical processes with biology, physics, or ecology, the student can see the sciences as a single system. Integration also makes laboratory work more effective and meaningful, forms complex problem-solving skills, and strengthens professional training. At the same time, this approach engages students in scientific research and guides them towards understanding modern technologies, resulting in effective, systematic, and practically rich chemistry education.

Theoretical foundations of the concept of integration

Integration (Latin integratio - "bringing into a whole") is the process of combining different disciplines, concepts, knowledge or skills into a single system. From a pedagogical point of view, integration serves to integrate the learning process, ensure logical connections between knowledge, and promote the comprehensive development of students' thinking. Because students' deep understanding of chemical processes often relies on knowledge from other subjects, integration in teaching chemistry is one of the most important methodological directions of modern education[1].

In the process of teaching chemistry, integration is carried out in several directions. First of all, interdisciplinary integration is of particular importance. This approach involves the integral connection of chemistry with such disciplines as physics, biology, ecology, mathematics, computer science, and geography. For example, the structure of matter and energy exchange are closely related to physics, biochemical processes to biology, chemical equilibrium to mathematical models, and atmospheric processes to ecology. Such an interdisciplinary approach allows the student to study reality in a comprehensive way, to combine knowledge gained from different disciplines with each other.

The second direction is internal integration, that is, strengthening the connections between different branches of chemistry: general, analytical, organic, inorganic, and physical chemistry. For example, in explaining the reactivity of organic substances, the general laws of chemistry (catalysis, equilibrium, kinetics) and the theories of physical chemistry (thermodynamics, molecular structure) serve as the basis. Such a connection helps the student to perceive chemistry as a holistic system, not divided into parts[2].

The third direction is practical integration, that is, the application of chemical knowledge to industry, technology, medicine, agriculture and environmental processes. For example, water treatment technologies, fertilizer production, drug synthesis, food chemistry, and biotechnological processes reveal the vital practical importance of chemistry for students. This serves to increase student motivation[3].

The fourth direction is STEAM integration (Science, Technology, Engineering, Art, Mathematics), which involves combining chemistry with mathematics, engineering, and technology. Through the STEAM model, students complete practical tasks such as building a 3D model, creating a chemical sensor, experimenting with energy sources, and preparing technological projects. This approach develops competencies such as critical thinking, problem solving, and a constructive approach in students.

Modern pedagogical research confirms that integration brings significant efficiency to the educational process. Integration broadens the scientific worldview of students, helps to systematize knowledge, enriches lessons in content, and increases learning motivation. That is why an integrative approach is considered the most important requirement of today's education[].

Types of integration in teaching chemistry

TABLE 1

Integration type	Content	Examples
Interdisciplinary integration	Connecting chemistry with other sciences	Chemistry-physics, chemistry-biology, chemistry-mathematics
Internal integration	Relationships between departments of chemistry	General chemistry + organic chemistry, physical chemistry + inorganic chemistry
Practical integration	Applying chemical knowledge to real-world applications	Industrial chemistry, environmental technologies, medicinal chemistry
STEAM integration	Combining chemistry with technology, engineering, and mathematics	Sensor training, 3D models, energy projects

2. The need for integration in chemistry teaching

Chemistry is a fundamental science at the heart of natural science, studying the composition, structure, properties of substances and the processes that occur in them. A deep understanding of these processes often requires sufficient knowledge of other natural sciences - physics, biology, mathematics and ecology. Therefore, integration in teaching chemistry is the most important methodological approach that strengthens interdisciplinary connections and forms a scientific worldview in students[4].

The first reason why integration is necessary is the complex structure of chemical processes. For example, understanding the mechanisms of reactions requires knowledge such as the laws of energy conservation in physics, functions and equations in mathematics, and metabolic processes in biology.

The structure of substances cannot be imagined without concepts such as quantum mechanics, chemical kinetics, and thermodynamics.

The second reason is the need for practice-oriented education. Today, chemical knowledge is widely used in industrial processes, medical diagnostics, biotechnology, environmental monitoring, agriculture and food technology. In order for the student to understand the role and practical significance of chemical processes in life, it is necessary to study them in connection with technological systems[5].

The third reason is the increasing demands for a competency-based approach. Integrative education develops universal competencies in students, such as analytical thinking, problem solving, drawing conclusions from experience, creativity, and independent decision-making. Because in the process of integration, students can compare, generalize, and apply information from different disciplines in practical situations.

The fourth reason is the emergence of new educational approaches in the era of innovative technologies. Currently, methods such as STEAM, CLIL, project-based learning, problem-based learning, and inquiry-based learning are widely used. All of these technologies are based on integration, as they require students to think interdisciplinary. For example, in STEAM projects, students create an innovative product or project by combining chemistry with mathematics, technology, engineering, and art[6].

Therefore, integration in teaching chemistry in accordance with modern requirements is considered not only a methodological necessity, but also a strategic tool that improves the quality of education.

Types of integration in teaching chemistry

Table 2

Integration type	Description	Application in chemistry education
Interdisciplinary integration	Teaching chemistry in harmony with other subjects	Chemistry-biology, chemistry-physics, chemistry-ecology lessons
Internal integration	Interconnection between chemistry departments and topics	The relationship between organic and inorganic chemistry, the laws of reactions
Vertikal integratsiya	The sequential connection of topics in different classes	Consistent connection of chemistry courses for grades 7–11
Horizontal integration	The combination of different subjects in one class	The integration of chemistry topics with physics and biology in the same classroom

3.Types of integration in teaching chemistry

Integration in chemistry education takes many forms. Each type serves to systematize students' knowledge, strengthen interdisciplinary connections, and make learning more effective.

Horizontal integration - Horizontal integration focuses on strengthening connections between subjects taught at the same educational level. This type of integration helps students understand the unified nature of science. Areas such as chemistry-physics, chemistry-biology, and chemistry-mathematics are the main manifestations of horizontal integration. Horizontal integration broadens students' scientific horizons and helps them understand the internal logical connections between different disciplines[7].

Vertical integration - Vertical integration involves a gradual deepening of knowledge. This process ensures that chemistry is taught sequentially, from simple concepts to complex chemical processes.

Internal subject integration - Internal subject integration refers to the connections between the departments within the subject of chemistry. The departments of chemistry are interconnected, and the laws in one department are important in explaining another. Internal integration allows students to understand that chemistry is a holistic system[8].

Practical and technological integration - Connecting chemistry education with real-life and industrial processes is achieved through practical and technological integration. This approach plays an important role in preparing students for practical activities.

I will recommend.

4. Ways to integrate chemistry with other disciplines

In order to effectively organize chemistry education, it is important to link it with other disciplines. In integration with physics, energy changes, heat capacity, catalysis, diffusion, and optical phenomena are explained together. For example, the Arrhenius equation is explained with mathematical foundations in physics. The connection with biology is manifested in photosynthesis, respiration, metabolism, enzyme activity, and DNA structure, since all these processes are based on chemical equilibria.

Mathematics integration plays an important role in chemical calculations, finding concentrations, balancing reaction equations, and calculating logarithmic pH. Integration with ecology teaches air pollution, water purification, waste disposal, and the principles of green chemistry. The connection with computer science enhances learning through molecular modeling, graphing, digital experiments, and virtual laboratories.

Within the STEAM approach, chemistry is connected to 3D modeling, technological design, sensor fabrication, and chemical batteries in robotics. These integrations develop innovative thinking and practical skills in students[9].

5. The impact of integration on the learning process

Integration in teaching chemistry is one of the most effective approaches in modern pedagogy, which creates great opportunities for improving the quality of the educational process, teaching students to think deeply and comprehensively. Integration primarily develops students' skills in understanding natural phenomena as a whole system, seeing the interconnectedness of disciplines, and connecting theoretical knowledge with real life and practice[10].

This approach helps students develop a holistic scientific understanding - chemical processes are explained in terms of physical laws, and biological processes are explained in terms of chemical equilibria. This further develops their analytical and logical thinking skills. Lessons organized on the basis of integration teach students to think independently, conduct scientific research, and effectively solve problem situations[11].

Integration also enhances the motivational aspects of the educational process. When educational materials are linked to real-life processes, technologies, and modern innovations, lessons become more interesting and students' interest in knowledge increases. In addition, adding elements related to biology, physics, computer science, or ecology to laboratory exercises increases the effectiveness of experiments[12].

Another advantage of integration is that the learning process is organized on the basis of a logical system. The sequence of topics is arranged not only by the level of complexity, but also by their interdisciplinary connections. This allows students to understand the topics more deeply and master knowledge holistically. As a result, students develop competencies such as creativity, practical thinking, analysis, project creation, and technical thinking.

Advantages of integration

Table 1

№	The advantage of integration	Content
1	Holistic scientific vision	It allows you to see the connections between disciplines and perform complex analysis

2	Analytical-logical thinking	Develops skills in understanding and analyzing processes on a scientific basis
3	Orientation to practice	It creates an opportunity to connect theoretical knowledge with technology, ecology, and industry
4	Increased motivation	Interesting, interactive, and practical lessons increase interest in learning
5	Competence development	Develops problem-solving, creativity, and scientific research skills
6	Laboratory efficiency	Interdisciplinary experiences strengthen the student's practical knowledge
7	Structural logic	Learning is easier because the learning material is presented in a logical system

Conclusion

Integration in teaching chemistry allows students to gain a deeper understanding of interdisciplinary connections. This approach develops scientific thinking and analytical thinking, helps to understand complex chemical processes at a conceptual level, and facilitates the connection of theoretical knowledge with practice. Through integration, students can combine chemical theory and laboratory work with disciplines such as biology, physics, mathematics, ecology, and technology, while having the opportunity to study interdisciplinary connections in more depth. This methodology develops students' skills in solving problems in a comprehensive way, increases interest in scientific research, and helps them gain practical experience in experimental work. Integration also encourages students to think creatively, develop new ideas, and develop professional skills. As a result, chemistry education serves not only to consolidate knowledge, but also to train students as highly qualified specialists. In general, interdisciplinary integration is an important tool for enriching chemistry education in an effective, systematic, modern, and practical way, which is crucial in transforming students into mature specialists capable of solving complex scientific and technological problems.

References

1. A.A. Khaidarov (2022) "General chemistry" Fergana publishing house.
2. Maria S. Pak (2015) "Chemistry teaching theory and methodology" Petersburg izdatelstvo RGPU im.A.I. Gertsena
3. S. Masharipov (2018) "Tibiian chemistry" Tashkent publishing house
4. N.T. Olimkhojayeva (2005) Bioinorganics and Physcolloid Chemistry. National encyclopedia of Uzbekistan. State National Publishing House.
5. I.R. Askarov, Y.T. Isayev, A.G. Makhsumov, Sh.M. Kirgizov. (2012) "Organic chemistry" publishing house named after Gofur Ghulam.
6. Нишанов, М. Ф., Хайдаров, А. А., & Мирзаев, Д. М. (2020). Значение изучения среды раствора при профессиональной подготовке студентов направления «Пищевая технология». *Universum: технические науки*, (10-2 (79)), 92-94.
7. Нишонов, М., Абдуллажонов, Х., Хайдаров, А. А., & Собиров, А. О. (2019). Инновационный подход к обучению курса «химия» в направлении «технология пищевых продуктов». *Universum: технические науки*, (12-2 (69)), 33-36.
8. Хайдаров, А. А., & Абдуллаева, М. А. (2020). Математический подход к решениям задач на практических занятиях по химии. *Universum: психология и образование*, (7 (73)), 8-11.
9. Хайдаров, А. А. (2022). ИННОВАЦИОННЫЕ МЕТОДЫ ПРЕПОДАВАНИЯ ХИМИИ В ТЕХНИЧЕСКИХ ВЫСШИХ УЧЕБНЫХ ЗАВЕДЕНИЯХ. *Oriental renaissance: Innovative, educational, natural and social sciences*, *2*(5), 364-371.

10. Сайдазимов, М. С., Хайдаров, А. А., & Абсарова, Д. К. (2020). Способы получения анионных поверхностно-активных веществ из неионогенных. *Universum: технические науки*, (12-4 (81)), 40-44.

11. Хайдаров, А. А. (2022). Методы Закрепления Теоретических Знаний В Обучении Химии.

12. Хайдаров, А. А. (2022). ИННОВАЦИОННЫЕ МЕТОДЫ ПРЕПОДАВАНИЯ ХИМИИ В ТЕХНИЧЕСКИХ ВЫСШИХ УЧЕБНЫХ ЗАВЕДЕНИЯХ. *Oriental renaissance: Innovative, educational, natural and social sciences*, *2*(5), 364-371.