| Impact Factor: | | | | | |
|---|---|---|---|---|---|
| | ISRA (India) = 6.317 | SIS (USA) = 0.912 | ICV (Poland) = 6.630 |
| | ISI (Dubai, UAE) = 1.582 | РИНЦ (Russia) = 0.191 | PIF (India) = 1.940 |
| | GIF (Australia) = 0.564 | ESJI (KZ) = 8.100 | IBI (India) = 4.260 |
| | JIF = 1.500 | SJIF (Morocco) = 7.184 | OAJI (USA) = 0.350 |

SOI: 1.1/TAS DOI: 10.15863/TAS

International Scientific Journal

**Theoretical & Applied Science**

**p-ISSN:** 2308-4944 (print) **e-ISSN:** 2409-0085 (online)

**Year:** 2024 **Issue:** 12 **Volume:** 140

**Published:** 02.12.2024 **http://T-Science.org**

Issue Article

**Almir Anfirovich Miniakhmetov**
Askino Secondary School №1
Headmaster's assistant, Teacher of Physics, Computer Science and Information Technologies
Republic of Bashkortostan,
Russian Federation
minalmir@yandex.ru

**Gulnara Filzatovna Sultanakhmetova**
Askino Secondary School №1
Teacher of Biology and Chemistry
Republic of Bashkortostan,
Russian Federation
g.sultanahmetova@yandex.ru

**Farit Rimovich Atdinov**
Gymnasium named after I.Sh.Muksinov, Yanaul
Teacher of Physics
Republic of Bashkortostan,
Russian Federation
fred_freda@mail.ru

**Albina Dinisovna Atdinova**
Gymnasium named after I.Sh.Muksinov, Yanaul
Teacher of Biology and Chemistry
Republic of Bashkortostan,
Russian Federation
atdinova@inbox.ru

# RESEARCH OF THEORETICAL AND METHODOLOGICAL FOUNDATIONS OF INTEGRATION OF PHYSICS AND CHEMISTRY IN THE PROCESS OF TEACHING ON THE BASIS OF SECONDARY COMPREHENSIVE SCHOOL AS SUBJECTS OF NATURAL SCIENCE CYCLE

***Abstract***: *The article provides a detailed analysis of interdisciplinary connections in the process of teaching natural science subjects such as physics and chemistry. In accordance with the generally accepted systematization, content-informational, operational-activity and organizational-methodological approaches to the implementation of interdisciplinary connections between physics and chemistry within the school curriculum were proposed. Within the framework of the natural science cycle, the interrelations between computer science and biology are considered as related scientific fields. The focus is on various models of interaction between a modern teacher and secondary school students (grades 7–9) and high school students (grades 10–11) in the context of interdisciplinary connections as a fundamental principle of the educational process. In the structure of a modern lesson, in accordance with the requirements of the Federal State Educational Standards of the new generation, key elements that determine the*

*stages of planning interdisciplinary connections are reflected. The methods and techniques used in solving interdisciplinary problems in the fields of physics and chemistry are described. A step-by-step system for developing students' skills in establishing interdisciplinary connections has been developed. As a subsequent scientific article based on this work, preparatory criteria for the selection of educational material for the chapter "Molecular-kinetic theory" in the field of physical chemistry and chemical physics, and possibly other sections of physics and chemistry, are presented. The article represents a significant theoretical and practical study that can be useful for teachers specializing in teaching physics, chemistry and biology. In the context of improving teaching methods in the natural sciences, the article represents a valuable source of information.*

***Key words**: education, upbringing, science, rural educational institution, modern school, Unified State Exam, Main State Exam, Federal State Educational Standards of the new generation, high school, physics, chemistry, biology, computer science.*

***Language**: English*

***Citation**: Miniakhmetov, A.A., Sultanakhmetova, G.F., Atdinov, F.R., & Atdinova, A.D. (2024). Research of theoretical and methodological foundations of integration of physics and chemistry in the process of teaching on the basis of secondary comprehensive school as subjects of natural science cycle. *ISJ Theoretical & Applied Science, 12 (140),* 1-11.*

***Soi**: http://s-o-i.org/1.1/TAS-12-140-1 **Doi**: https://dx.doi.org/10.15863/TAS.2024.12.140.1*

***Scopus ASCC**: 3304.*

## Introduction

**UDC 373.1**

In the context of profound social transformations occurring in the modern world and in Russia [1], new approaches to the development, renewal and improvement of the entire system of continuous transformation are becoming relevant.

Recently, the system of secondary general education has undergone significant changes, which have resulted in the approval of a basic curriculum, the development of temporary state educational standards and the formation of new concepts of natural science education. In addition, new types of educational institutions have emerged, such as gymnasium-school, lyceum and college, and various integrated courses have been introduced.

The active involvement of the teacher in the process of continuous learning is the cornerstone for the development of his creative potential, professional competence and pedagogical skills, as well as for the formation of his social and professional mobility, civic position and professionally significant personal qualities. Interdisciplinary connections play a significant role in this process.

There is an urgent need in schools to establish interdisciplinary and interdisciplinary connections as a didactic condition that contributes to improving the quality of students' knowledge and plays a key role in the development of dialectical thinking in modern schoolchildren.

The results of numerous studies indicate that the inconsistency of the programs in physics and chemistry, the lack of a unified approach to the interpretation of general concepts and laws, as well as the lack of continuity in their formation lead to the fact that students' knowledge of natural science subjects is fragmented and disjointed.

Moreover, they lack an understanding of the scientific laws governing the development of the surrounding reality, as well as the ability to comprehensively apply the knowledge gained in the process of studying the basics of natural sciences at school.

## 2. Purpose of the study.

In this regard, the purpose of this work is to study possible ways to overcome these shortcomings within the framework of the traditional system of studying the basics of natural sciences in the conditions of an ordinary rural comprehensive school, where interdisciplinary connections play a key role in the process of preparing modern lessons.

In order to achieve the stated objective of the scientific article, we identified specific tasks, the successful implementation of which allowed us to achieve positive research results.

(1) Collection, analysis and synthesis of scientific works devoted to the issues under consideration, over a period of at least 3 to 5 years.

(2) A detailed presentation of the goals and objectives of the educational research in physics and chemistry, as well as a justification of its importance for subject teachers.

(3) Within the framework of this study, a detailed analysis of the content of educational work in physics [2] and chemistry [3] is carried out, and the basic requirements for the construction of a modern lesson in accordance with the Federal State Educational Standards of the new generation are determined.

(4) Analysis of fundamental approaches, methods and practices for organizing the educational process in physics and chemistry.

In writing this article, we aim to provide physics and chemistry subject teachers with comprehensive information on the key methodological and practical aspects of organizing the educational process at school. We examine in detail the content and

pedagogical requirements for these aspects, as well as their significance.

In the course of working on the scientific article, we conducted a study and analysis of educational and methodological literature devoted to the organization of the educational process in physics and chemistry in middle and high school.

**3. Types of interaction between different disciplines.**

There are many approaches to defining the essence of the didactic category of interdisciplinary connections and their classification. In this article, we will rely on the inter-network interaction and distance cooperation of a rural comprehensive school – *Askino Secondary School №1 Republic of Bashkortostan, Russian Federation* [4] and a city gymnasium – *Municipal budgetary educational institute named after I.Sh.Muksinov, Yanaul city, Republic of Bashkortostan* [5].

Scientific understanding of interdisciplinary connections and their types depends on a number of factors:

(1) Specific pedagogical research tasks that are solved with the help of interdisciplinary connections;

(2) Aspects of the problem of interdisciplinary connections and levels of their solution;

(3) Scientific methods for identifying specific connections.

In the field of education, there is a desire for a more comprehensive approach to the issue of interdisciplinary connections [6]. For this purpose, special criteria for their definition are being developed, and methods of systemic analysis of this phenomenon are also being used.

The system approach allows us to consider interdisciplinary connections in teaching physics and chemistry from different angles and understand their importance. This is achieved through a detailed analysis of the structure of the subject and the learning process. Such analysis helps to determine the essence and types of interdisciplinary connections.

Based on the similarities in the structure of academic disciplines and the learning process, which represent objective criteria for classifying interdisciplinary connections, we define three main types:

(1) Content-based and information-based connections;

(2) Activity-related and operation-related connections;

(3) Organization-related and method-related connections.

Each subject within the educational program represents a system of scientific knowledge that has been adapted for educational purposes. This system includes information from various scientific fields. All components of the subject serve as the basis for interaction between various disciplines in the learning process.

In each subject, in addition to specific scientific knowledge, there are elements of methodological and ideological knowledge. The connections between subjects based on the content of knowledge can be classified as *content-informational*.

In the process of teaching physics and chemistry at school, we use different types of connections:

(1) According to the structure of scientific knowledge: factual, conceptual and theoretical;

(2) According to knowledge about the process of cognition: philosophical, historical and scientific, gnostic, semiotic and logical;

(3) According to knowledge about value orientations: ideological, dialectical and materialistic, ideological and political, political and economic, ethical, aesthetic and legal.

In the context of educational and cognitive activity and students' skills in the process of studying various disciplines, a special type of connections can be identified, which can be called *operational-activity*. The need to identify and develop these connections is due to the structure of the subject, which includes not only substantive but also procedural elements.

These elements determine cognitive activity, including scientific methods, generalized methods of cognition, creative activity, specific skills and abilities, as well as the language of science. In addition, they cover other types of student activity in the learning process.

The educational process is a complex and multifaceted phenomenon. We believe that its foundation is cognitive activity, but in the learning process, students also use elements of other types of activity: practical, communicative, aesthetic and value-oriented.

In our educational activities, we distinguish the types of interdisciplinary connections that can be attributed to the operational-activity approach by several parameters:

(1) By the methods of applying theoretical knowledge in practice – *"practical"* – contribute to the development of motor, labor, constructive-technical, calculation, measurement, computational, experimental and visual skills, as well as oral speech skills;

(2) By the methods of obtaining new knowledge in the learning process – *"cognitive"* – form general educational skills of thinking, creativity, educational activity, as well as skills of organization and self-control in the learning process;

(3) By the methods of forming value guidelines – *"value-orientation"* – are necessary for the development of skills of assessment, communication and artistic-aesthetic perception, which plays an important role in the formation of the student's worldview.

In both of our general education institutions, interdisciplinary connections are implemented in the learning process, which are carried out using various methods and organizational forms. This allows us to single out a secondary type of connections, which has an independent meaning and complements the first two types of *organizational* and *methodological connections*.

There are several types of connections that can be classified by various criteria:

(1) By the method of acquiring knowledge – reproductive, exploratory and creative;

(2) By scope – inter-course, intra-cycle and inter-cycle;

(3) By time – successive, accompanying and prospective;

(4) By the nature of interaction – one-sided, two-sided and multi-sided;

(5) By regularity – episodic, constant and systematic;

(6) By the level of organization of the educational process – lesson, thematic and others;

(7) By the form of work of students and teachers – individual, group and collective.

We use an interdisciplinary approach in various formats of teaching and extracurricular activities [6], for example, in overview lessons, integrated seminars, lectures, complex excursions, homework, interdisciplinary electives, conferences, thematic events, in the work of scientific societies of students, and so on.

Depending on this, the nature of the students' learning activities and the teaching activities of teachers will differ: it can be individual, group or collective.

If there is no single agreed curriculum, then interdisciplinary connections are implemented in the educational process in different ways. This may be due to the requirements of new school programs *("program"* connections), teachers' initiatives to expand the use of connections between subjects, or cover the entire education system at school, including extracurricular activities.

**4. Multidimensionality of the concept of "interdisciplinary connections".**

The diversity of connections between subjects in the process of studying physics and chemistry demonstrates that the definition of this concept cannot be unambiguous. Connections between subjects have many aspects and are not limited only to the content, methods and forms of teaching.

Based on the research conducted in [7], we believe that the systematization of the semantic aspects of this concept, as well as the classification of interdisciplinary connections, can only be carried out using a systems approach.

The connection between different disciplines is a methodological phenomenon that can be represented as a system consisting of three elements:

(1) Information and skills obtained within one subject;

(2) Information and skills obtained within another subject;

(3) Combination of this knowledge and skills in the learning process.

Each of these components is flexible. The connections cover various areas of learning – social, natural and technical sciences. The integration of knowledge (the process of synthesis) in each case performs a specific cognitive function: explanation of cause-and-effect relationships in common objects, generalization and creation of new generalized knowledge, clarification of general concepts, classification of related phenomena, proof of generalized ideas.

As a result of our research conducted in recent years [8], we have come to the conclusion that interdisciplinary connection in its logical completeness is a universal and conscious relationship between the elements of the structure of various academic disciplines.

Such an attitude can be presented as *new knowledge* that has arisen as a result of the assimilation of connections between knowledge from different subject areas. This knowledge, in its content and the way it is formed in the learning process, is interdisciplinary in nature.

Examples of such knowledge include physical-chemical, biochemical, historical-geographical, political-economic, and in the above-mentioned source, literary-historical concepts.

On the other hand, such an attitude may represent a *new generalized skill*, a broader skill that is formed as a result of establishing connections between the teachings and learning methods used in different disciplines. As an illustration, we can cite the source of our research mentioned above. We assume that this new skill is interdisciplinary, since it can be applied in different subjects using the interdisciplinary knowledge common to them. For example, these may be oral and written speech skills, calculation and measurement skills, artistic and visual abilities, graphic skills, as well as generalized thinking skills.

Ultimately, these may also be new, interdisciplinary-based, *value-based aspects* of knowledge that shape the student's worldview and morality.

We believe that the success of developing interdisciplinary knowledge, skills and value orientations in schoolchildren depends on how interdisciplinary connections are implemented in the learning process. This concerns working methods, teaching techniques, conditions for organizing the educational process and other aspects.

It is important that these elements are effective both in teaching and in the assimilation and application of knowledge by students in new situations. In the process of integrating various disciplines, a key direction in pedagogy is formed, which becomes the basis for the actions of teachers.

In the learning process, interdisciplinary connections play an important role, contributing to the fulfillment of the main tasks of education: development, upbringing and training. In addition, they themselves perform methodological, structural and formative functions.

Depending on the purpose, their content and meaning may change, as well as their connection with certain concepts. As already mentioned, in the study of interdisciplinary connections, several directions can be distinguished: philosophical, general pedagogical, didactic, methodological and psychological.

Interdisciplinary connections are a specific didactic tool that helps implement the philosophical principle of system city. They play a *methodological role*, combining knowledge from different areas and creating a holistic picture of the world.

Interdisciplinary connections also play a *constructive role*, helping to build learning systems based on the integration of knowledge from different disciplines. This can be either the study of a specific topic, or the solution of an educational task, extracurricular activities, and other learning formats.

Interdisciplinary connections perform an important function in the educational process. They are a tool that helps teachers apply a *comprehensive approach* to teaching. Thanks to this tool, students can develop their worldview, cognitive activity and independence.

In the learning process, interdisciplinary connections are realized under the influence of methodological and psychological aspects that influence the change in the educational and cognitive activities of students and the teaching activities of teachers.

In the process of teaching, we come to the conclusion that deepening the understanding of the didactic category of interdisciplinary connections within the framework of pedagogical science allows us to recognize their multi functionality, variability and relativity in the context of the general organization of the educational process.

This means that we use interdisciplinary connections as a tool for creating a modern didactic approach to building the content and organizing the learning process. This approach is based on the general principles of system city, complexity and is aimed at high-quality preparation of 9th and 11th grade graduates for final exams – Main State Exam and Unified State Exam.

**5. Integration of academic disciplines as the basis of the educational process.**

It is well known that didactics studies the interaction between teacher and students in the learning process. At what level of the didactic system do interdisciplinary connections contribute to the increase in the effectiveness of this interaction in teaching practice? We found the answer to this question in the principles of learning.

In modern didactics, the issue of principles of teaching is actively discussed. The essence of this category and traditional classifications of didactic principles are being rethought. Using a systemic approach, modern scientists are trying to determine a set of principles that will be applied in the learning process.

Since the question remains open, some believe that principles have lost their significance in the modern educational process and can be excluded. However, this statement cannot be agreed with.

According to the results of recent studies [9], the principles of teaching are the fundamental principles of organizing the educational process, which are determined by social goals, methodological foundations, patterns and practical experience.

These principles are oriented towards the activities of both the teacher and the students. They contain knowledge about the goals, essence, content and structure of teaching, which should serve as the basis for practical activities.

The principles are implemented through a system of methodological and pedagogical guidelines. In the context of didactics, principles are distinguished based on the following criteria: universality, social orientation, methodological validity, management functions, focus on the internal aspects of the teacher and students' activities, reflection of the holistic characteristics of the learning process and its functions.

Our research and experience as subject teachers show that one of the key principles in modern education is the principle of an interdisciplinary approach. This principle is based on social and methodological prerequisites that are associated with the need for comprehensive development of the individual, trends in the integration of scientific knowledge and the development of a systemic approach to cognition.

In this regard, there is every reason to believe that interdisciplinary connections are one of the main provisions of modern pedagogy based on the Federal State Educational Standards of the new generation. As an element of the educational system, interdisciplinary connections interact with all its other elements.

The *scientific approach* is based on understanding the phenomena being studied from the point of view of modern natural science techniques in organizing and constructing a lesson. This is

impossible without establishing connections between different disciplines and topics. The principle of *systematics* and *consistency* in teaching is implemented through logical structuring of educational material and ensuring continuity in acquiring knowledge, skills and abilities.

In the process of mastering new material, it is useful to use knowledge previously acquired in other disciplines. This allows you to identify key concepts and ideas that are common to several subjects. Teachers of different courses systematically return to these ideas, revealing them from different angles.

The idea of *conscious* and *active* participation of students in the learning process is aimed at developing the skills of independent analysis of the relationships between processes and phenomena, understanding their essence, identifying patterns, as well as developing the ability to set new cognitive goals and actively achieve them.

The relationship between the principle of awareness and interdisciplinary connections has been studied by many scientists. They believed that the systematic nature of knowledge implies not only the relationship between concepts within one subject, but also between several subjects within a certain cycle, as well as between different cycles.

In other words, a true system, and therefore true awareness of knowledge, is impossible without establishing continuity between different disciplines.

The essence of the concept of *integrating theory* and *practice*, learning and life is to apply an interdisciplinary approach to the practical activities of students. This is realized through solving problems, conducting laboratory work, practical training, experiments and observations, as well as in the process of work training and productive work. Practical tasks related to life and works are usually complex tasks that require the application of knowledge from various fields simultaneously.

Using a variety of materials, such as textbooks, experimental results, and observations from other fields of knowledge, enriches *visualization*. Visual materials related to different disciplines, such as posters and other similar materials, can be used to deepen understanding.

Using cross-curricular links allows for variety in visualization by using abstract forms, such as models, graphs, and charts, to explain complex ideas.

In the process of implementing the principles of *accessibility* and *durability* of knowledge, interdisciplinary connections also play their role. Complex and intricate issues often become understandable and accessible when knowledge from other subjects comes to the rescue. Therefore, we believe that durable knowledge is that which is integrated into the system and actively used when studying new topics.

Ultimately, to ensure an *individual approach* to each student, it is necessary to take into account their interests and knowledge of other disciplines. This allows for the organization of joint educational activities.

As a result, interdisciplinary connections help to implement all pedagogical principles, making their interaction more effective in the learning process. And if interdisciplinary connections are one of the tools for implementing pedagogical principles, then the principles themselves set the goal for using interdisciplinary connections.

**6. Interdisciplinary connections as an element of the educational process.**

We believe that in the course of a real educational process the relationship between means and goal can be reversed, depending on the position of the teacher. Interdisciplinary connections can act as an independent principle that determines the focus of all other principles on the formation of a scientific worldview and a holistic system of knowledge about nature and society.

In this case, clarity, orderliness, individual approach, teamwork, practical focus and activation of the learning process become tools for implementing the principle of interdisciplinary interaction. As an independent principle, interdisciplinary interaction performs its constructive function: it influences the structure of the curriculum, programs and textbooks, the choice of content, methods and forms of teaching.

One of our latest works [10] clearly demonstrates the broad interdisciplinary connection between both the subjects of the natural sciences and the humanitarian aspect. Like other foundations of learning, interdisciplinary connections in our work are universal. They apply to all academic disciplines, and almost every topic can include elements related to other subjects.

Based on the analysis of the presented scientific research, it can be concluded that interdisciplinary connections play an important role in the development of all aspects of learning: the formation of a scientific knowledge base, the development of universal cognitive skills, the stimulation of broad cognitive interest and the formation of a worldview in students.

In our research examining the interrelationships between disciplines such as physics, chemistry, biology and computer science, we found that interdisciplinary connections place special demands on all aspects of the learning process.

In the process of setting goals and objectives for learning a subject, topic or lesson, it is necessary to take into account the application, development, consolidation and generalization of knowledge and skills acquired by students in studying other disciplines. In the structure of the educational material, it is important to highlight topics that require reliance on previously acquired knowledge from other subjects, as well as to note topics that will be developed further in the study of other disciplines.

Within each unit of study, it is important to identify special terms related to a specific discipline and more general concepts applicable in several subjects. The development of the latter occurs due to interdisciplinary connections. A special role in the formation of a worldview is played by ideas that can be learned through interdisciplinary connections when studying individual topics or a whole block of topics in generalizing lessons.

In the learning process, the use of interdisciplinary connections stimulates creativity in the application of knowledge obtained in other disciplines. This activates the students' thinking activity, encourages them to analyze, synthesize and generalize information from various scientific fields, theories and systems of concepts.

The idea of interdisciplinary teaching involves developing tasks, questions and problems for students that require the application and unification of knowledge and skills from different areas. Regular use of interdisciplinary connections allows for diversification of didactic materials and visual aids. To do this, our subject teachers try to use textbooks, tables, devices, maps, filmstrips, slides, films, posters, dummies and other materials from other subjects.

In the process of teaching, there is a need to use various methods that cover various aspects of the educational material. These can be complex lessons, seminars, excursions, conferences that combine knowledge from different areas. Such events require joint solutions to interdisciplinary problems, and also include individual assignments that take into account the interests and inclinations of students in different subject areas.

In this regard, we believe that effective interaction between different disciplines requires that teachers of different subjects work together. This involves studying curricula in related subjects, organizing mutual visits to lessons, and other forms of joint activity. The interdisciplinary approach affects all aspects of the educational process, from setting goals to assessing results.

Finally, to implement these ideas, it is first necessary to identify key directions in structuring information from different disciplines using interdisciplinary connections.

**7. The concept of interdisciplinary skills and ways of developing them in school natural science lessons.**

Skills are the tools that students use to achieve a specific educational goal. To solve problems that require a comprehensive approach, special skills are needed: the ability to integrate and systematize knowledge from various fields, to see an object in all its versatility and connections, to evaluate the particular in the context of the general. These skills help students develop scientific thinking.

In our modern studies [11], the terms *"interdisciplinary skills"* and *"interdisciplinary abilities"* are used as an example of the relationship between the disciplines of the natural sciences and humanities. These terms denote various methods of work that provide a connection between different subjects.

These methods include:

(1) General thinking skills, such as analysis, synthesis and generalization, which are used in different subjects;

(2) Creative work skills, which are developed when solving problems that are similar in structure but have different content;

(3) Skills that are used in activities common to several subjects, such as measuring, constructing, calculating, drawing, designing;

(4) Skills in working with specific content that is related to two or more subjects, for example, establishing historical cause-and-effect relationships when studying the economic geography of a country or drawing historical analogies to explain modern economic and geographical development.

In addition to the categories mentioned, attention should be paid to skills that allow using knowledge from various academic disciplines to solve complex interdisciplinary problems and perform complex tasks. The most complex type of skills is the ability to comprehensively analyze an object. These skills allow students to establish complex interdisciplinary connections.

They are characterized by the ability to transfer knowledge and skills from one subject area to another, applying them in new conditions. These skills are based on knowledge from different academic disciplines and general ideas, and their application includes various actions:

(1) Specific actions with specific material from different subjects;

(2) Generalized actions that characterize mental and creative activity and acquire specificity in the context of interdisciplinary connections;

(3) Actions to transfer and establish connections between elements of knowledge and skills from different subjects when solving interdisciplinary problems;

(4) Actions in verbal communication, adaptation of terms and language tools from different sciences;

(5) Evaluation actions that reflect the unity of the cognitive and value attitude of students to knowledge from different subjects, united into a system based on ideological ideas.

This structure can change depending on the characteristics of interdisciplinary problems.

On the other hand, problem-based learning, according to the authors of the work [12], as well as interdisciplinary connections, makes the content and process of learning more difficult for students. Therefore, it is important to gradually introduce

elements of problematic and increase the volume and complexity of interdisciplinary connections.

We believe that it is important to develop cognitive skills and learning achievements that strengthen pupils' independence and interest in exploring connections between knowledge from different fields.

The learning process is organized as follows:

(1) One-way interdisciplinary connections are established in lessons on related subjects. The teaching is based on a reproductive approach and includes elements of problem-based learning.

(2) Interdisciplinary cognitive tasks gradually become more complex, and pupils become more independent in solving them.

(3) Teachers coordinate their activities to establish two-way and then multi-way connections between subjects. This includes putting forward common learning problems and solving them step-by-step within lessons.

(4) Teachers develop a comprehensive system of work that includes interdisciplinary connections both in the content and methods of teaching and in the forms of its organization. This includes comprehensive homework, lessons, seminars, excursions, conferences, as well as extracurricular activities and expansion of the curriculum.

For students who do not have a solid knowledge base, solving problems that require the application of knowledge from different areas may be too difficult, which can lead to a loss of interest in learning. For students with deep knowledge across multiple disciplines, it is important to use cross-curricular connections so that they can continue to grow in their learning.

Therefore, we are convinced that in the process of organizing the creative activities of students using interdisciplinary connections, educational work is of key importance, which contributes to the assimilation of the system of subject knowledge and the development of skills for their transfer and generalization.

Students are taught through a system of independent practical work aimed at developing individual skills for the integrated application of knowledge.

In the process, students learn to:

(1) Recognize interdisciplinary connections in academic texts, excerpts from scientific articles, and primary sources;

(2) Select factual material from different fields of knowledge to confirm and prove the laws of dialectics, general scientific ideas, and concepts;

(3) Analyze specific examples from biology, physics, chemistry, and history from the point of view of general patterns and categories;

(4) Understand the interdisciplinary nature of educational tasks of the school curriculum;

(5) Independently formulate interdisciplinary tasks and problems based on comparison and analysis of scientific facts from related fields of knowledge (biochemistry, physical chemistry, and biophysics);

(6) Draw up a plan for solving an interdisciplinary problem.

Demonstrating a sample of how to perform such tasks, as well as conducting introductory conversations that help to understand the logic of reasoning and realize the order of actions, are key elements of the educational process. In addition, it is important to take into account the individual characteristics and needs of each student.

In order to develop students' ability to establish interdisciplinary connections, it is necessary to go through several stages:

(1) Arouse students' interest in solving interdisciplinary problems;

(2) Teach them to recognize and understand the need to use knowledge from different areas;

(3) Practice individual methods of creative activity based on interdisciplinary connections;

(4) Combine individual skills into a holistic ability to comprehensively apply knowledge in solving interdisciplinary problems.

For the successful transfer of knowledge from one subject area to another, it is necessary that the structure of the content and procedural elements in a series of interdisciplinary cognitive tasks be similar or analogous. In lessons, it is important to stimulate students to independently solve such tasks. In doing so, they must act according to a model and learn general guidelines in the synthesis of knowledge.

**8. The relationship between interests and skills in the course of performing tasks that require knowledge from different areas.**

The formation of interest in learning depends on how well students have mastered information search skills and the ability to establish connections between different disciplines. Research in the field of psychology of thinking has shown that the key factor stimulating search activity is the awareness of the goal and cognitive need.

These internal motivators act together with knowledge and skills, regulating the search process and influencing its emotional intensity.

The solution of an interdisciplinary task is largely determined by how keen the student is on studying philosophy and ideological aspects within the framework of his subject.

During the implementation of interdisciplinary tasks in social studies lessons [13], a close connection was observed between the students' interest in this subject, which has an ideological character, and their ability to consciously identify general cognitive tasks. The correlation coefficient was 0.83.

Identifying an interdisciplinary task is one of the types of creative activity of students. It helps to

establish the relationship between the knowledge and skills necessary to solve it. Analysis of the correlation between knowledge and skills showed that students who independently identified an interdisciplinary task demonstrated a close connection between the level of their knowledge and the ability to apply it in practice.

In the process of solving an interdisciplinary cognitive task, students apply knowledge from different subject areas. Their activity depends on the level of interest in the subjects studied. There is also a correlation between interest in the subject, the breadth of application of knowledge and the success of its use. Students turn to additional sources of information; find non-standard approaches to analysis and connections with the curriculum.

A student who does not have stable subject interests and knowledge finds himself in a difficult situation in the sphere of interdisciplinary activity, which can cause him to have a negative attitude towards it. At the initial stages of inclusion in cognitive activity, interdisciplinary connections can lead to a discrepancy between the levels of students' skills and interests in different subjects. When solving interdisciplinary problems, students' skills begin to depend to a greater extent on the experience of transfer and mastering the methods of transfer, rather than on a previously formed, but still changeable interest in a certain subject.

Some students, under the influence of interdisciplinary connections, begin to show interest in subjects that previously did not attract them. However, their knowledge and skills remain at a low level. Other students, on the contrary, significantly improve their skills in transferring knowledge from one subject to another, but there are no noticeable changes in their subject interests. Their interests remain stable. This can be explained by the fact that interdisciplinary connections are not the only factor that shapes students' cognitive interests.

Experience limited to a certain area of knowledge does not allow one to see the familiar in a new light, which is necessary for creative solutions to interdisciplinary problems. In such cases, template thinking interferes. At the initial stages of cognitive activity based on interdisciplinary connections, a discrepancy arises between previously formed skills and interests of students. However, later this discrepancy is eliminated, and skills and interests become more closely connected on a qualitatively new, generalized basis.

Inclusion of interdisciplinary connections in the educational process on a regular basis has a positive effect on the expansion and deepening of students' knowledge and skills. This contributes to the development of students' intelligence and the formation of diverse cognitive interests, which is one of the indicators of personality development.

In the process of learning, a stable relationship is formed based on interdisciplinary connections: a wide range of cognitive interests; conscious perception of interdisciplinary tasks; the need to study interdisciplinary connections; a creative approach; systemic thinking; cognitive independence of the student.

**9. Developing interest in natural sciences among high school students and forming a holistic view of the world.**

The introduction of interdisciplinary connections into the educational process as a catalyst for cognitive activity [14] qualitatively transforms its other drivers. This happens because learning is a system in which all elements are interconnected and changing one of them disrupts this connection, which requires a systematic approach to organizing the entire process.

Including elements from other scientific disciplines in the lesson program enriches it and makes it more relevant. This allows you to take a fresh look at familiar material and combine new knowledge with old into a single system.

Thanks to the connections between different subjects, you can more deeply understand the essence of the phenomena being studied. For example, you can study cause-and-effect and physical-chemical relationships in biological processes, as we have already done in our scientific research.

This allows for a more detailed examination of the development of science, methods and results of modern scientific research, in which the interaction of various fields of knowledge and a systematic approach to studying the world are strengthened. By deepening the content of lessons, interdisciplinary connections activate the learning process based on the constant application of knowledge. The practical significance and usefulness of knowledge in all subjects becomes obvious.

We are convinced that understanding the value of knowledge helps maintain interest in its deepening and expansion. The learning process, enriched with interdisciplinary connections, stimulates thinking activity and becomes a source of sustainable interest for students. In our natural science lessons, interdisciplinary connections enhance the generalizing nature of the educational material, which requires a change in teaching methods.

Interdisciplinary connections activate all aspects of cognitive interest related to educational activities: they create problem situations, elements of research and creativity, diversify forms of independent work and stimulate the acquisition of new skills. Interdisciplinary connections not only transform teaching methods, but also influence the change in organizational forms. There is a need for collective forms of organizing educational work that best facilitate the solution of interdisciplinary problems and create conditions for the manifestation of students' knowledge and interests in other subjects.

We create conditions for our students in which everyone can achieve success. As is known, success in an activity is a powerful motivator that stimulates activity and interest in it. In the process of collective educational work, stimuli of cognitive interest associated with the relationships between the participants are actively manifested. This is an emotional mood, faith in the cognitive abilities of students, mutual support in activities, elements of rivalry, encouragement and other factors.

In the process of developing students' cognitive interest, interdisciplinary connections (content, operational-activity, organizational-methodical) perform various functions. First of all, they serve as motivation for students, encouraging their interest in classes. This effect is enhanced by other positive stimuli related to content, activity, and relationships.

Educational activities based on interdisciplinary connections arouse keen interest in the students. With a systematic approach, it becomes the basis for the formation of stable cognitive interests of schoolchildren. Such skills are formed by establishing connections between various subjects, such as physics, chemistry, biology, with history, geography, social studies. The teacher offers students tasks that require critical analysis, proof, justification and argumentation of conclusions. Evaluation of learning outcomes stimulates the interest and activity of students.

As a result of our research, we came to the conclusion that education based on a variety of interdisciplinary connections contributes to the formation of stable and broad cognitive interests, which are of great importance for the comprehensive development of the personality of a high school student.

The ideological orientation of cognitive interests is the student's constant desire to comprehend and explain the deep interconnections that explain the relationship between the individual and society, nature and society, man and labor.

In the process of forming a system of views and beliefs that determine the direction of our knowledge, several stages can be distinguished:

(1) The emergence of interest and the desire to use interdisciplinary connections to understand general subject concepts with the help of problematic elements;

(2) Formation and deepening of interest in the study of philosophical concepts, development of the ability to think independently when solving problems that require knowledge from different fields;

(3) Development and strengthening of interest in philosophical issues through constant activity and independent work of students (including creative assignments and extracurricular activities of an interdisciplinary nature).

Consequently, the formation of high school students' ability for independent cognition in the process of activities based on interdisciplinary connections occurs simultaneously with the development of their worldview and value orientations that determine their social activity.

**10. Conclusion.**

Thus, as the authors [15] rightly noted, our work is about the didactic organization of the entire educational process, about the constructive development of a system of pedagogical work. Here, the interdisciplinary connections we have presented are the principle of constructing a powerful didactic system.

To advance our idea, we continue to explore how interdisciplinary connections influence the development of systems thinking in secondary school students in both science and humanities classes.

Based on these theoretical considerations, we can identify three key categories of interdisciplinary connections:

(1) Substantive and informational;

(2) Operational and activity-based;

(3) Organizational and methodological.

Based on the analysis of our previous research works presented in this article, we highlight a number of aspects that demonstrate how subjects in the natural sciences and humanities can interact with other disciplines, taking into account the discussion of the pros and cons of using an interdisciplinary approach in teaching.

By exploring the potential for integration between various fields of knowledge within the general education program, such as physics, mathematics, chemistry, computer science, information and communication technologies, biology and others, as well as disciplines in the natural sciences and humanities, we create a basis for developing professional skills in future specialists in any scientific field.

**References:**

1. Miftakhova, R.G. (2024). Continuous education in Russia. // *Scientific journal "Innovations in*

*education"*, №5, Moscow: Publishing house "Association of electronic learning", 2024, pp.4-11, EDN AJWBZJ.

2. Yakuta, A.A., Korneev, V.T., Korneeva, G.D., Kochergina, E.D., Podlesnyj, D.V., Saushkina, T.V., & Shitikova, K.M. (2023). *Physics, advanced level. Implementation of the requirements of the Federal State Educational Standard of Secondary General Education: a methodological manual for a teacher*, Moscow: Publishing House "Institute for Education Development Strategy", 2023, 114 p., EDN WTJNBJ.
3. Zagranichnaya, N.A. (2022). *Chemistry (advanced level). Implementation of the requirements of the Federal State Educational Standard of Basic General Education: a methodological manual for a teacher*, Moscow: Publishing House "Institute for Education Development Strategy of the Russian Academy of Education", 2022, 97 p., EDN PNMGWV.
4. (2024). *Askino Secondary School №1, Republic of Bashkortostan, Russian Federation. Official website of the educational organization*, Retrieved 20.10.2024 from https://askino.02edu.ru
5. (2024). *Municipal budgetary educational institute named after I.Sh.Muksinov, Yanaul city, Republic of Bashkortostan, Russian Federation. Official website of the educational organization*, Retrieved 20.10.2024 from https://gimnaziayanaul.edusite.ru
6. Miniakhmetov, A.A., Khamzina, E.A., & Aslyamova, I.F. (2023). Natural scientific aspects of graphic solution of physical and mathematical problems on the educational topic "Mechanical oscillation" when preparing graduates for the USE (on the basic of "Growth points" Askino secondary school №1 Republic of Bashkortostan). // *International Scientific Journal "Theoretical & Applied Science"*, №01(117), pp.418-426, EDN YLIFOX.
7. Makeeva, S.G., & Shutkina, I.V. (2021). Formation of readiness for the implementation of interdisciplinary connections in training as a component of professional training. // *Scientific journal "Yaroslavl Pedagogical Bulletin"*, №6(123), Yaroslavl: Publishing House "Yaroslavl State Pedagogical University named after K.D. Ushinsky", 2021, pp.81-89, EDN BQWQSI.
8. Miniakhmetov, A.A., Akhmadullina, G.F., Borisova, E.N., & Lutfullina, E.G. (2023). General theoretical and methodological techniques for the comparative description of the description of autumn in the poems of A.A.Fet and F.I.Tyutchev from the cycle "The gilded wealth of the silver period" (on the basic of "Growth points" Askino secondary school №1 Republic of Bashkortostan). // *International Scientific Journal "Theoretical & Applied Science"*, №10(126), pp.277-285, EDN OHBBIY.
9. Slabkaya, D.N. (2023). Modern learning technologies. // *Scientific journal "Pedagogical journal"*, V.13, №5-1, Noginsk: Publishing house "Analytics Rodis", 2023, pp.693-698, EDN BRSSIU.
10. Miniakhmetov, A.A., Masnavieva, Z.T., Borisova, E.N., & Lutfullina, E.G. (2024). General theoretical and methodological techniques for studying the relationship of ethnicity and nature in the ancient Bashkir epic "Ural-Batur" (on the basis of "Growth points" Askino secondary school №1 Republic of Bashkortostan). // *International Scientific Journal "Theoretical & Applied Science"*, №03(131), pp.29-37, EDN IQDIBA.
11. Miniakhmetov, A.A., & Akhmetov, R.G. (2024). Some aspects of theoretical and methodological techniques for teaching geography course in high school on the basis of a general education organization (using the example of classroom and extracurricular activities). // *International Scientific Journal "Theoretical & Applied Science"*, №08(136), pp.1-13, EDN VFPZNG.
12. Snegireva, I.V. (2022). Principles of pedagogical technology of a modern lesson from the point of view of the formation of meta-subject skills. // *Scientific journal "Methodist"*, №9, Moscow: Publishing house "Publishing house Methodist", pp.25-27, EDN QXPHJR.
13. Miniakhmetov, A.A., Khakimova, G.R., & Akhmatgalieva, L.M. (2023). The study of the trials in the USSR and the Russian Federation dedicated to the disclosure of the circumstances of the peaceful soviet citizens during the Great patriotic war of 1941-1945 (on the basic of "Growth points" Askino secondary school №1 Republic of Bashkortostan). // *International Scientific Journal "Theoretical & Applied Science"*, №08(124), pp.201-211, EDN LYKGRI.
14. Najdan, A.N. (2021). The role of natural science subjects in the education system. // *Scientific journal "Pedagogical Journal"*, V.11, №1-1, Noginsk: Publishing house "Analytics Rodis", pp.11-15, EDN OTNCGO.
15. Perminova, L.M. (2021). Didactic foundations for constructing an integrated lesson. // *Scientific journal "Pedagogy"*, V.85, №5, Moscow: Publishing house "Limited Liability Company Pedagogy", pp.17-27, EDN AEYTFQ.