ISSN: 2707-1146
e-ISSN: 2709-4189

DOI: https://doi.org/10.36719/2707-1146/61/4-10

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Use of Mind Maps in the Teaching of Natural Sciences

Abstract

The characteristic and general aspects of teaching natural sciences in secondary general education schools have been studied. It has been noted that the most common feature of the natural sciences, which include chemistry, biology, physics, and geography, is their close connection and interrelation with natural phenomena. It has been shown that, as exact sciences, the natural sciences and the corresponding fields of study consist of both theoretical and practical components, and the similarity of their research methods and objects makes it possible to use the mind map method in the teaching of these subjects, including chemistry. It has been determined that the common aspects of the natural sciences, the similarity of research objects, and their methodological proximity indicate the necessity of a unified approach in their teaching. From this perspective, as in the process of teaching chemistry, the mutual integration of theoretical and practical components in biology, physics, and geography lessons is of great importance. Such an approach enables the integrative study of natural sciences, the establishment of interconnections between different scientific disciplines, and the correlation of knowledge with real life. This contributes to the development of students' logical, critical, and creative thinking, the formation of scientific reasoning, and the enhancement of their ability to analyze problems from multiple perspectives. The use of mind maps in teaching natural sciences creates conditions for the systematization of scientific concepts, the establishment of logical connections between topics, and the more visual, interactive, and sustainable assimilation of lessons.

Keywords: *didactics, mind map, natural sciences, visual, audial, kinesthetic, digital, education, upbringing*

Introduction

The issues related to the use of mind maps in teaching chemistry in secondary general education schools have been extensively discussed in the sources (Babayev & Babayeva, 2021), where it has been shown that the main principles of educational reform in our Republic are aimed at the formation and development of student-centered education and interactive learning. The theory of teaching and education (Babayeva & Babayev, 2020) — *didactics* — considers education as the result of teaching and teaching as the means leading to education. From this perspective, the teaching method should be chosen correctly so that its result — that is, the effectiveness of the education provided to students — is high. In other words, what matters is not how much we know, but how much we are able to convey to others (Mammadova, 2017). Despite the diversity of forms and methods applied in the education system, the most important factor for students is their ability to retain what they read and learn, and to increase their learning efficiency.

Throughout the history of humanity, among the various types of diagrams and maps used for different purposes over millennia, mind maps occupy a special place due to their distinctive method

ISSN: 2707-1146
e-ISSN: 2709-4189

of creation and direction of use. Sometimes referred to as "the key to memory," mind maps are valuable because their creation and use develop imagination and creative thinking, strengthen memory, and ensure the joint activity and harmony of the brain hemispheres. For these reasons, they serve as both a learning and teaching tool suitable for use in almost all areas of human activity, including the educational process (Babayeva, 2022).

It should be noted that at the end of each topic or a specific completed section taught in chemistry lessons in secondary general education schools, a corresponding mind map is constructed. The constructed mind map essentially serves as an effective repetition of the lesson. The initiators of the mind map method have also approached it as a pedagogical aid and an engaging motivational tool for students in mapping the topics covered. Through this method, learning does not lag behind traditional and interactive teaching methods based on the use of textbooks and teaching aids — in some cases, it even surpasses them. This is because the material being studied is divided into smaller portions through branching using main and derived keywords in the relevant mind map, allowing students to easily verify the correctness of each question and its corresponding answer.

In general education schools, the existence of a specific "language of chemistry," consisting of chemical symbolism, terminology, and nomenclature, distinguishes the chemistry subject from all other disciplines (Abishov, 2022). At the same time, the science of chemistry has the broadest connections with all other scientific fields. Thus, in research related both to living organisms and to the inorganic world, the symbolic language of chemistry and its applications are widely used. Another characteristic feature is that the written form of the chemical language is more significant and richer than its oral form.

In secondary general education schools, the language of chemistry is a didactically developed version adapted to the goals and content of instruction, taking into account students' age characteristics and psychological factors. It is aimed at mastering the school chemistry course, as well as fostering students' development and education. Unlike the scientific language, the school chemistry language is simpler, more comprehensible for students, free from complex linguistic structures, and features simplified terminology and nomenclature.

The language of chemistry is applied at all stages of chemistry teaching and research.

Research

The purpose of the present study is to explore the didactic potential of using the mind map method in the teaching of natural sciences in secondary schools and to identify its characteristic features. It is known that didactics — a specialized branch of pedagogy — examines the most important problems of teaching and learning, determines the optimal boundaries of students' education and upbringing by taking into account the achievements of scientific and technological progress as well as students' age characteristics, and scientifically substantiates the content and objectives of the teaching process.

In addition, didactics defines, in accordance with the intended goals, the forms and methods of teaching, the principles of selecting theoretical and practical lessons, and the relevant tasks that need to be addressed in the process of acquiring the knowledge and skills necessary for future development. At the same time, it is required to demonstrate the transition in the teaching process from learning the subject to generalizing it. In this process, students' individual characteristics must be taken into account, and the teaching process should be made engaging and dynamic.

General Characteristics of Natural Sciences and Subjects

The fields of study that examine the natural factors influencing human beings from the external environment are called natural sciences, while the corresponding school disciplines are referred to as natural science subjects. Everything that surrounds us is related in one way or another to the natural sciences. The foundation of natural sciences is their connection and interrelation with natural phenomena. Over time, the natural sciences have developed into distinct scientific directions.

The basis of the development of every process or phenomenon lies in the unity and struggle of contradictions (opposites). This concept also applies to modern natural science. In natural sciences, two mutually opposing yet unified tendencies are characteristic — one represents analyticity in the process of development, and the other represents syntheticity. Through the analytical approach, new

 ISSN: 2707-1146
e-ISSN: 2709-4189

branches of science and new laws are discovered. The objects of such research become more specific, and specialized scientific methods are applied.

In secondary general education schools, natural science subjects include biology, chemistry, physics, and geography. Geography is classified as a natural science subject because its object of study is the Earth — the habitat of all living beings, including humans. The branch of physical geography develops and expands by relying on the laws discovered by other natural sciences.

Physics belongs to the natural sciences and studies the quantitative regularities of natural phenomena at both macroscopic and microscopic levels. The laws of physics, based on experimentally obtained facts and certain quantitative relationships, are expressed in the language of mathematics. Purely chemical qualitative and quantitative analysis methods can no longer fully meet the increasing demands of modern science, technology, and industry. Therefore, the use of physical research methods based on deeper structural levels of matter is of decisive importance. The research objects of physics are diverse, including solid-state physics, atomic physics, plasma physics, nuclear physics, and others.

The next natural science is chemistry. Chemistry is important for humanity because it enables the production of essential materials and products for society from natural raw resources through chemical transformations.

The principal natural science is biology. Biology is the science of living organisms, and their main characteristics are growth and development, movement, response to stimuli, reproduction, and metabolism (nutrition, respiration, excretion). Biology, which studies living organisms, is divided into various fields such as botany, zoology, mycology, and others.

Various methods — primarily observation, experimentation, and measurement — are used to study living organisms:

- Observation is based on studying an object or phenomenon through the senses. It can be conducted both in natural and laboratory conditions, often using various instruments, devices, and equipment.
- The experimental method is used to test, confirm, or refute hypotheses formulated as a result of observations.
- Measurement is applied in many cases during the performance of observations and experiments.

Thus, by applying these research methods, the researcher succeeds in obtaining certain scientific knowledge about the object or phenomenon under study.

The discussions conducted show that the natural sciences study the world from a materialistic point of view and require society to approach nature with respect for its laws. Naturalism is a system based on studying and utilizing the laws of nature without applying human-made laws to natural processes. The emergence of the natural sciences is the result of a philosophical approach to scientific research. Since the methodology of mathematics differs significantly from that of the natural sciences, it is not classified among them. Mathematics is considered the foundation or basis of certain natural sciences.

In the natural sciences, scientific results are generally based on objectivity and precision, taking experimental and observational outcomes as their foundation. The natural sciences are not static; they are constantly undergoing processes of refinement and clarification.

In all natural sciences, a mathematical apparatus is used to describe observed natural phenomena. The natural sciences require the precise representation and formulation of natural laws. In this way, explanations of natural phenomena are expressed in the form of mathematical equations. Subsequently, by means of these mathematical formulas, any hypothesis can be re-examined, refined, or supplemented.

The conducted discussions make it possible to distinguish a number of common or similar characteristics among the natural sciences (subjects) under consideration:

1. Similarity or identity of research methods.
2. The inclusion of all natural sciences among the exact sciences.
3. Similarity or identity of research objects.

ISSN: 2707-1146
e-ISSN: 2709-4189

4. The existence of an original (written) language specific to each individual science or subject.
5. The structure of each science (or subject) consisting of both theoretical and practical components.

Taking into account these common features and several other factors, it can be confirmed that, alongside chemistry, the mind map method can also be successfully applied in the teaching of other natural sciences in secondary general education schools. As in other subjects, one of the most important aspects in teaching natural sciences is the development of students' ability to correctly comprehend and express the knowledge they acquire.

When differences in how individuals perceive and process information are considered in the teaching process, there arises a necessity to implement instructional strategies that support such individuality. From this perspective, the mind map method can serve as an effective tool to enhance the learning potential of students who possess diverse representational systems.

Representational Systems

In the teaching process, the dominant representational system of a student directly determines his or her learning style. Representational systems in education define how an individual symbolically interprets the surrounding world. The same external perceptions of the world can evoke very different reactions in different people. What makes one person happy may make another sad. This is because every individual filters the information that enters the brain through the lens of their past experiences, beliefs, and values. At this point, the information received from the external environment may also generate internal sensations. Through these internal sensations (representational systems), a person's experiences and thoughts can change and be influenced.

People usually make decisions because they seem logical to them and believe that their decisions are based on reason. However, in reality, these decisions are not necessarily based on logic; they are made because they make sense to the person in visual (sight), auditory (hearing), kinesthetic (feeling), or digital (analytical) terms. Later, individuals attempt to justify these decisions logically to others. In the field of personal development (NLP), these sensations are referred to as "representational systems." Every person has a representational system that predominates in the way they perceive and internalize information (Tokur, 2011).

Visual (Sight-Based) Learning

Visual learners understand information more effectively through images, graphics, colors, and diagrams. Their memory is built upon visual associations. Their learning style:

- It is beneficial to present information using colors, diagrams, and maps.
- The teacher's gestures and writings on the board help them learn.
- Looking at pictures and diagrams is more effective for them than reading text.
- The student "sees" and "recalls" information in their mind.

Auditory (Sound-Based) Learning

Auditory learners retain information more easily when they hear it. They prefer to learn through sound, rhythm, and tone. Their learning style:

- Listening to the teacher's speech, engaging in discussions, and sharing ideas in groups enhance their learning.
- Repeating information aloud is essential for memorization.
- Learning through rhythm, music, or poetry is highly effective.

Kinesthetic (Movement and Sensation-Based) Learning

Kinesthetic learners acquire knowledge through movement, touch, experience, and feeling. Their learning style:

- They learn by touching objects and working with models.
- Role-playing, conducting experiments, and engaging in active learning activities are important for them.
- Sitting still for long periods makes learning difficult for them.

ISSN: 2707-1146
e-ISSN: 2709-4189

Logical and Analytical (Digital) Learning

Analytical learners learn through logic, analysis, and systematic thinking. They internalize information not through feelings, but by understanding and identifying cause-and-effect relationships. Their learning style:

- They prefer to structure information, create plans, and explain it in logical sequence.
- "Why?" and "How?" questions are essential for them.
- Justification and evidence for information are important to them (Adler, 2005).

Every individual possesses all representational systems; however, during perception and assimilation of information, the mind automatically processes it according to the person's individual characteristics, prioritizing visual, auditory, kinesthetic, and digital systems in a specific order, and this plays a crucial role in shaping an individual's learning style. Pedagogical experience shows that different learning types demonstrate specific cognitive and behavioral patterns in processing information. Digital learners process information logically and draw analytical conclusions immediately after hearing it, visual learners prefer to organize information in written form before expressing their thoughts, kinesthetic learners respond more emotionally, and auditory learners tend to request that the information be repeated aloud.

Mind maps are a universal learning tool in the pedagogical process that integrate all representational systems. They help develop a student's logical, critical, and creative thinking, as well as their imagination, while increasing lesson productivity. Mind maps can also be successfully used in the teaching of natural sciences.

Representational systems	**Correspondence to a mind map**	**Conclusion**
Visual	Images, colors, symbols, and branches strengthen visual memory and facilitate the assimilation of information.	The student learns the information by "seeing" it.
Auditory	During discussion and presentation, the student both listens and assimilates knowledge by comparing it with other ideas.	The student learns the information by "listening" to it.
Kinesthetic	The student draws the map, writes, makes connections, and learns the topic by feeling it through touch and movement.	The student learns the information by "feeling" it.
Digital	In a mind map, cause-and-effect relationships between concepts are visible, and information is perceived in a structured form.	The student learns the information by "understanding" it.

Such an approach creates conditions for the integrative study of natural sciences and for the development of students' logical, critical, and creative thinking. The use of mind maps in teaching natural sciences ensures a deeper understanding of scientific concepts and makes the learning process more visual, interactive, and continuous.

The main principles of natural sciences involve informed and developmental functions based on relevant observation, experimentation, and measurement. Selecting the main concepts and laws reduces the memorization load of the taught material, saves time, and implements the principle of small amounts of material providing more knowledge.

In general education schools, the teaching of natural sciences also demonstrates ways to master knowledge systematically. Through mental activity, students have the opportunity to rediscover the knowledge they acquire and experience the joy of learning. With purposeful mental activity, recall and comprehension lead to the creation of new scientific ideas and allow for various investigations.

Recent scientific achievements have shown that many natural phenomena are understood more clearly when studied within the framework of interconnected natural sciences rather than a single science. For example, many biological processes in the human body, in living organisms, and in

ISSN: 2707-1146
e-ISSN: 2709-4189

nature are based on chemical processes. Therefore, when explaining relevant topics, both chemistry and biology information is presented together so that students can understand them based on logic and experimental results.

Such integrative teaching both facilitates the establishment of interdisciplinary connections and allows students to understand natural sciences more comprehensively and systematically.

It should be noted that students' ability to overcome difficulties and the development of their thinking largely depend on their comprehension and understanding skills. Weak reading and comprehension skills in schools create difficulties in understanding and grasping chemistry topics, which students often carry with them to higher education. Chemistry, being a challenging subject, requires a strong foundation in reading and the language of chemistry. Therefore, improving achievements in chemistry at both secondary and higher education levels necessitates an increase in students' reading habits. Learners who are skilled at working with texts in their native language can also understand and analyze chemical problems more effectively (Alder & Berly, 2001).

It has been shown that the level of students' reading and comprehension skills directly correlates with their performance in chemistry. In secondary schools and during university entrance exams, where knowledge is often evaluated through tests, weaknesses in writing, reading, and comprehension continue to manifest in later stages of education and professional life (college, university, workplace, etc.). One source of these weaknesses is the influence of social networks, computers, mobile phones, and incorrectly written captions displayed on some private TV channels. Modern youth often spend a large portion of their free time on unsupervised mobile phone calls and messaging. Errors in writing, reading, and communication within their immediate environment, including family interactions, often become habitual and are carried over into university classrooms and workplaces, making correction more difficult.

However, writing, speech, and comprehension difficulties are usually addressed to some extent in university settings before graduates carry them into workplaces. In our view, effective measures include teaching *Business and Academic Communication in Azerbaijani* in most bachelor programs, conducting written exams and relevant colloquiums for professional courses, and ensuring interactive teaching methods to develop oral communication skills, in accordance with educational reform requirements. In these efforts, teachers must also demonstrate civic responsibility.

Experience in teaching chemistry at universities has shown that mastery of the language of chemistry first requires proficiency in Azerbaijani, the language in which the subject is taught and studied. This principle applies to all subjects, particularly natural sciences, and to the languages in which the subjects are learned.

Conclusion

Considering that natural sciences and their respective fields (chemistry, biology, physics, geography) share several common characteristics — such as being exact sciences, having identical research objects, and consisting of both theoretical and experimental components — and, most importantly, that they are closely related to and interconnected with natural phenomena, it can be concluded that mind maps, successfully used in teaching chemistry, can also be applied effectively in the teaching of other natural sciences.

ISSN: 2707-1146
e-ISSN: 2709-4189

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Received: 08.06.2025
Accepted: 17.09.2025