
RESEARCH ON THE FEATURES OF TEACHING NATURAL SCIENCES IN DISTANCE LEARNING

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INTRODUCTION

The modern development of education is closely related to the widespread use of digital technologies. This became especially noticeable during the pandemic and martial law, when schools were forced to switch to distance learning. In such circumstances, the question of high-quality organization of teaching arose, in particular, natural science subjects, which usually involve practical work¹.

Physics, chemistry, biology and geography form scientific thinking and research skills in schoolchildren. However, these subjects require laboratory classes, which are difficult to organize remotely, which creates a number of pedagogical, methodological and technical difficulties.

At the same time, the distance format opens up new opportunities – interactive platforms, virtual laboratories, multimedia and digital tools. This requires new approaches from the teacher, adaptation of materials, development of digital skills and the ability to maintain student motivation².

The relevance of the work is due to the need to study the specifics of distance teaching of natural sciences, to identify effective teaching methods and to develop recommendations for improving its quality.

Students' understanding of science is an important prerequisite for learning in schools, for example, as a basis for a high degree of independence in research-based learning, as well as an educational goal that allows students, among other things, to critically evaluate information.

Empirical research in education has always focused on the characteristics that make up good teaching. Over the past century, the field has undergone

¹ Державний стандарт базової середньої освіти. Затверджено постановою Кабінету Міністрів України від 30 вересня 2020 р. № 898. <https://mon.gov.ua/osvita-2/zagalna-serednya-osvita/nova-ukrainska-shkola-2/derzhavniy-standart-bazovoi-serednoi-osviti> (дата звернення: 05.04.2026).

² Биков В. Ю. Дистанційне навчання: теорія і практика : монографія. Київ : Юрінком Інтер, 2008. 352 с.

a paradigm shift. For much of the 20th century, high-quality teaching was characterized by a teacher-centered approach. Educational research has also focused on the corresponding qualities that good teachers should possess. Since the 1970s, a shift towards learner-centered teaching has begun. This has been due to increasingly vocal voices in education and educational research demanding that learners, as subjects, be at the center of teaching and learning. As teaching methods have shifted towards a more learner-centered approach over the past decades, the concept of learner-centeredness has become established in pedagogy and didactics. It has become apparent that it is a conceptually vague construct, described under different names in different models. Research in school practice largely agrees that student-centeredness is now one of the central principles on which teaching is based³.

Contemporary considerations regarding the design of effective higher education increasingly focus on the choice of an appropriate learning format, that is, on how and to what extent learning should (continue to) take place digitally.

The goal is to investigate the features of teaching natural sciences in distance learning and to identify effective approaches to organizing this process.

Tasks:

- analyze the essence of distance learning;
- characterize the specifics of natural sciences;
- identify appropriate methods and technologies;
- investigate the organization of practical and laboratory work;
- identify key problems and propose ways to solve them.

The object of research is the process of teaching natural sciences in educational institutions.

Methods used: literature analysis, generalization of experience, comparison, systematization and observation.

Practical value of the work – the results obtained can be used by teachers to increase the effectiveness of distance learning.

1. Theoretical basis of teaching natural disciplines

1.1. The concept and structure of natural disciplines

Natural sciences occupy an important place in school education, as they help students form a scientific understanding of the world, natural phenomena and the role of man in nature. The main ones are physics, chemistry, biology and geography – each of which has its own subject of study, but together they create a holistic picture of the world around us.

³ Кухаренко В. М., Рибалко О. В., Сиротенко Н. Г. Дистанційне навчання: умови застосування. Харків : НТУ «ХПІ», 2002. 320 с.

Physics studies the movement, interaction of matter and energy, is a fundamental science and the basis of modern technologies. Without physical knowledge, it is impossible to understand the principles of electronics, transport, energy and space exploration. Physics develops logical and abstract thinking in students, the ability to model situations and solve non-standard problems⁴.

Chemistry studies the composition, structure, properties of substances and their transformations. Its achievements are actively used in industry, medicine, agriculture and everyday life. The study of chemistry forms in students an understanding of the material world, develops a caring attitude towards the environment and safe behavior in everyday life.

Biology is the science of living organisms, their structure, development and interaction with the environment. It covers a wide range of areas: from molecular genetics to the ecology of entire ecosystems. Biology educates environmental responsibility, promotes awareness of the value of health and forms a culture of sustainable environmental management.

Geography studies natural and socio-economic processes on Earth, forming an idea of the climate, natural resources, population and economy. It develops spatial thinking, teaches to analyze maps, statistical data and navigate in modern geopolitical processes.

An important feature of these subjects is their interconnectedness and integrated nature: biological processes cannot be understood without chemistry, geographical phenomena are often explained through physical laws, and environmental problems require knowledge from all natural disciplines at the same time. That is why integrated learning – the STEM approach, which combines natural sciences, technology, engineering and mathematics – is becoming increasingly widespread in modern education.

Teaching natural sciences has its own characteristics: it is based on experiment and observation, uses visualization and models, forms research skills and teaches how to apply knowledge in practice. Modern teaching methods also involve the use of digital tools – virtual laboratories, interactive simulations and educational platforms, which significantly expands the possibilities of cognition.

Therefore, natural science disciplines perform not only cognitive, but also developmental and educational functions, preparing students for conscious life in a technological society and contributing to the formation of a comprehensively developed personality.

⁴ Міністерство освіти і науки України. Офіційний сайт. URL: <https://mon.gov.ua> (дата звернення: 05.04.2026).

1.2. The essence of distance learning

Distance learning is a modern form of education based on the use of digital technologies and involves the interaction of teachers and students at a distance.

Its main feature is the lack of direct contact between participants in the educational process, which is compensated by video conferences, electronic platforms, online resources and educational applications.

There are three main forms of distance learning. Synchronous involves communication between teachers and students in real time – through online lessons and video conferences. Asynchronous allows you to work on materials and complete tasks at a convenient time without the simultaneous presence of all participants. Mixed combines traditional classroom lessons with online and independent forms of work⁵.

Among the advantages of distance learning are: flexibility in choosing time and place, wide access to information resources, the ability to individualize the learning process and the use of modern technologies.

However, there are also significant disadvantages: limited live communication between the teacher and students, difficulties in organizing practical classes, the need for high self-discipline, as well as technical problems associated with the Internet and equipment.

Therefore, distance learning can be effective if there is a competent combination of appropriate methods, tools and technologies.

1.3. Psychological and pedagogical features of distance learning

The organization of distance learning requires taking into account how students perceive information, how motivated they are and how capable they are of independent work.

One of the main changes is the nature of the interaction between the teacher and students. In the distance format, live emotional communication fades into the background, which can reduce the interest and activity of students. Therefore, it is important for the teacher to create a comfortable psychological atmosphere even in virtual space.

A serious problem remains the decline in learning motivation. Students often experience difficulties in organizing their own activities, which negatively affects learning outcomes. Interactive methods, involving students in active work and various forms of feedback help to overcome this.

At the same time, distance learning also has a positive impact – it develops independence, responsibility, self-control skills, planning and working with information.

⁵ Морзе Н. В., Кочарян А. Б. Інформаційно-комунікаційні технології в освіті : навчальний посібник. Київ : Академвидав, 2014. 302 с.

Other psychological and pedagogical features of this format include: the need for a clear structure of educational material, active use of visual and multimedia tools, taking into account the individual characteristics of each student and ensuring regular feedback⁶.

The issue of assessing knowledge deserves special attention. In conditions of distance learning, it is more difficult to achieve objectivity, therefore it is advisable to combine various forms of control – testing, project work, oral answers and creative tasks.

Therefore, the effectiveness of distance learning is largely determined by the extent to which the teacher takes into account the psychological and pedagogical characteristics of students and possesses the appropriate professional skills.

2. Features of teaching natural disciplines in distance learning

2.1. Features of natural disciplines (biology, chemistry, physics, geography) as academic subjects

Natural disciplines differ from humanitarian and social subjects in several key features:

1. Experimental component – most topics involve practical application of knowledge through laboratory work, experiments and observations.

2. Visualization of processes and phenomena – to master the material, students need to see the dynamics of processes, the structure of organisms, chemical reactions or physical phenomena.

3. Mathematical apparatus and accuracy of measurements – physics and chemistry require calculations, calculations and the use of formulas, which adds complexity to online learning.

4. Interdisciplinarity – geography, biology and chemistry are often integrated with ecology, technology and mathematics, which creates the need for an integrated approach.

5. Dependence on material resources – working with laboratory equipment, chemical reagents, microscopes and other devices requires physical presence, which complicates distance learning.

Thus, natural sciences have specific methodological requirements that must be taken into account when organizing online lessons.

2.2. Adaptation of curricula and content to the distance format

Adaptation involves changing the structure, methods and forms of presentation of educational material for effective learning in an online environment:

⁶ Положення про дистанційне навчання : Наказ Міністерства освіти і науки України від 25.04.2013 № 466 (зі змінами).

- Reduction or modification of the experimental component through the use of multimedia resources: presentations, graphs, 3D models, educational videos, interactive maps.

- Step-by-step structuring of the material: division into blocks with theoretical explanations, examples, interactive tasks and self-testing.

- Integration with online platforms (Google Classroom, Moodle, Kahoot, LearningApps) for organizing tasks, tests and discussions.

- Differentiation of tasks: adaptation of the complexity of the material according to the level of training of students, which allows for an individual approach in a distance format.

- The use of video demonstrations, interactive simulations and virtual laboratories.

Such measures ensure the preservation of the content of the discipline and allow for the preservation of interactivity of learning even without physical presence.

2.3. Organization of practical and laboratory work in distance learning conditions

Organization of practical work in natural sciences is one of the most difficult tasks of distance learning. Several approaches are used to solve it.

Virtual laboratories are online services that simulate real experiments without physical risks. Among the most common: PhET Interactive Simulations (simulations in physics, chemistry and biology), ChemCollective (virtual chemical laboratory), Labster (interactive 3D laboratories in biology, chemistry and medicine), ExploreLearning Gizmos (models for natural sciences) and Bioman Biology (interactive biological experiments).

Video demonstrations – a teacher or scientist conducts an experiment on camera, and students observe, analyze the results and complete the tasks. For this, resources such as Khan Academy, Crash Course on You Tube or Ukrainian educational platforms with video lessons in natural sciences are used.

Home experiments are simple experiments with safe materials under the online guidance of a teacher. For example, observing plant growth, studying chemical reactions by mixing safe solutions or measuring the speed of falling bodies.

Interactive simulations and modeling are digital tools that allow you to recreate the conditions of an experiment and change its parameters. Additionally, Molecular Workbench, Visible Body, Algodoo (for physics) and EarthViewer (for geography and ecology) are used.

Group projects and research tasks are joint work of students on data collection and analysis, discussion of results via video call or forums. Google Workspace, Padlet, Miro and Jamboard are used to organize cooperation.

The integrated use of these methods allows you to maintain the practical component of learning and form scientific research skills in students even in a distance format.

2.4. Formation of natural science competence of students online

Natural science competence includes the ability to analyze and interpret natural phenomena, apply knowledge in practice, conduct experimental research and work with scientific information.

In the conditions of online learning, its formation is ensured through several key approaches.

Interactive tasks and testing stimulate critical thinking and the ability to make independent decisions, encouraging students to actively process the material.

Project activities involve the development of experiments, observations, reports and scientific presentations in digital format, which develops research skills and the ability to structure the results of work.

Digital models and simulations allow you to test hypotheses and explore processes that are difficult or impossible to observe in real conditions.

Group discussions and forums develop communication skills, teach you how to argue your own position and defend scientific conclusions.

An interdisciplinary approach ensures the integration of knowledge from different natural sciences, which contributes to a deeper and more comprehensive understanding of phenomena and processes.

Therefore, the distance format is not an obstacle to the effective formation of natural science competence – provided that interactive methods, digital tools and scientific research activities are competently combined⁷.

3. Practical aspects and recommendations

3.1. Analysis of the experience of teaching natural sciences in a mixed format

Modern realities of school functioning require the organization of the educational process in a mixed format, combining face-to-face and distance learning. This approach ensures continuity of education, flexibility in teaching and the ability to adapt to different circumstances, including security ones.

In practice, teaching natural sciences is built on a combination of these two forms. Face-to-face classes are used mainly to explain complex topics, conduct laboratory work and directly communicate with students. The distance

⁷ Пометун О. І., Пироженко Л. В. Сучасний урок. *Інтерактивні технології навчання* : науково-методичний посібник. Київ : А.С.К., 2004. 192 с.

component covers consolidating the material, completing independent tasks and monitoring results.

To organize online learning, Google Classroom is used – for posting materials, tasks and assessments – and Meet for conducting lessons and consultations.

The work pays special attention to the use of multimedia materials, the combination of individual, group and project activities, as well as ensuring constant feedback with students. The blended format has proven effective for several reasons: face-to-face classes compensate for the limitations of distance learning, the online component expands access to educational resources, and in general, the individualization of the educational process is ensured.

However, certain difficulties were also revealed: uneven student activity during distance learning, difficulty synchronizing material between formats, and significant time spent preparing educational materials.

Despite these challenges, the blended learning format has confirmed its feasibility and effectiveness in teaching science subjects.

3.2. Results of pedagogical observation and questionnaires of teachers and students (empirical part)

To determine the effectiveness of distance learning of science subjects, pedagogical observation and questionnaires were conducted among teachers and students.

Research methodology:

Methods: questionnaires, pedagogical observation during online lessons, analysis of tasks completed by students.

Sample: 4 teachers of science subjects (biology, chemistry, physics, geography); 31 8th grade students.

Tools: online questionnaire for teachers and a separate questionnaire for students, observations during Google Meet lessons, analysis of the results of laboratory and practical tasks.

Student survey results:

Clarity of theoretical material:

74% of students noted that online lessons explain the material well;

19% – partially clear;

7% – difficult to understand.

Online practical and laboratory tasks:

61% of students believe that video demonstrations and simulations help to understand the experiment;

26% – partially help;

13% – difficult to perform without visual equipment.

Motivation for learning:

68% of students feel interested during interactive tasks;

32% – sometimes lose motivation.

Resources used:

PhET – 42% of students;

Labster – 19%;

Kahoot / Quizizz – 61%;

LearningApps – 55%;

YouTube video lessons (Khan Academy, CrashCourse) – 48%.

Results of the teacher survey (4 respondents):

Evaluation of the effectiveness of distance learning:

Theory: 3 teachers-effective, 1 – partially effective;

Practice/laboratory work: 2 – partially effective, 2 – effective if virtual laboratories are used.

Problems with distance learning:

limited access of students to fast Internet – 3/4;

complexity of organizing laboratory work – 4/4;

insufficient digital competence of students – 2/4;

uneven motivation of students – 3/4.

Tools and methods that increase efficiency:

Virtual labs (PhET, Labster, ChemCollective) – 4/4;

Online tests and quizzes (Kahoot, Quizizz) – 3/4;

Simulations and modeling – 3/4;

Home safe experiments – 2/4;

Project activities and group assignments – 3/4.

Conclusions: Distance learning of natural sciences for 8th grade students is effective when using interactive methods, virtual laboratories and video demonstrations.

Main problems: difficulty in conducting laboratory work without visual equipment, unequal access to digital resources and the Internet, partial loss of student motivation.

The use of various digital tools (simulations, tests, videos) has a positive effect on understanding the material and the development of natural science competence.

3.3. Methodological recommendations for the effective organization of distance learning in natural sciences

Based on the analysis of experience and empirical data, the following recommendations are offered:

1. Apply a blended learning format: online theory + face-to-face or virtual laboratory work.
2. Use interactive services and simulations:
 - PhET, Labster, ChemCollective – laboratory experiments;
 - LearningApps, Kahoot – knowledge testing;
 - Google Forms, Classtime – results control and testing.
3. Develop step-by-step instructions for home experiments with safe materials.
4. Support student communication and collaboration through group chats, forums, video conferences and project activities.
5. Provide differentiation of tasks: separate tasks for students with different levels of training and digital skills.
6. Constant feedback: comments, assessments, explanations of errors for the formation of natural science competence.
7. Improving the digital literacy of students and teachers, including training in working with online laboratories and services for interactive learning.

Following these recommendations allows you to increase the effectiveness of distance teaching of natural sciences, preserve their practical component, and ensure the development of students' scientific thinking.

CONCLUSIONS

A comprehensive study of the features of teaching natural sciences in distance and blended learning was carried out.

The analysis showed that natural sciences play an important role in shaping students' scientific worldview, developing their logical thinking and practical skills. In conditions of distance and blended learning, there is a need to transform traditional approaches to teaching, taking into account modern educational challenges. It was established that the effectiveness of the educational process largely depends on the use of interactive methods, digital platforms, multimedia resources, as well as on a rational combination of face-to-face and distance learning. Video lectures, simulations and virtual laboratories play a special role, which partially compensate for the limitations of students' practical activities. As a result of the study, practical recommendations were also developed for teachers on the effective organization of teaching natural sciences in distance and blended learning formats.

The purpose of the study, which was to study the features of teaching natural sciences in distance and blended learning, was achieved. In the process of work, all the tasks were completed: the theoretical foundations of teaching natural sciences were analyzed, the essence and forms of distance learning were considered, the main methods and technologies of teaching were determined, the

features of the organization of practical and laboratory work were investigated, key problems were identified and ways to solve them were proposed. The practical part of the work, based on my own pedagogical experience, confirmed the feasibility of using a blended learning format as an effective model of organizing the educational process. The developed recommendations for teachers complement the theoretical provisions and have practical value.

Prospects for further scientific research lie in an in-depth study of the possibilities of improving blended learning, in particular in the aspects of increasing student motivation, developing their research competencies, and providing quality feedback. The development of new digital tools and methods for conducting practical and laboratory work in a distance format is also relevant. The issue of objective assessment of student academic achievements and the impact of digital technologies on the quality of education in general requires further research.

SUMMARY

Therefore, the results of the study confirm that the introduction of modern pedagogical approaches and digital technologies in teaching natural sciences contributes to increasing the efficiency of the educational process and ensures its adaptation to the conditions of blended learning.

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