PROBLEMS IN THE ORGANIZATION AND MODERN OPPORTUNITIES FOR THE DEVELOPMENT OF PROJECT-BASED LEARNING (ON THE EXAMPLE OF CHEMISTRY)

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Abstract

This article examines the pedagogical features of organizing chemistry teaching based on project-based learning. Project-based learning is considered an effective educational approach that promotes students' research, analytical, and practical skills. Since chemistry involves experimental activities, laboratory work, and scientific modeling, project-based learning helps increase students' motivation and fosters scientific thinking. The paper analyzes the main pedagogical challenges, organizational issues, and development prospects related to the implementation of project-based learning in chemistry education.

Keywords: project-based learning, chemistry teaching methodology, research skills, educational project, practical learning, STEM education.

Introduction

In the modern education system, one of the most important pedagogical directions is the justification of the learning process of active cognitive activity of the student. In this sense, Project-Based Learning is considered as an effective pedagogical technology that allows students to develop their research, creative and analytical abilities [1, p. 15]. This approach is not limited to the theoretical assimilation of educational material by students, but is aimed at applying knowledge by solving specific practical tasks.

The subject of chemistry is a science that is experimental and exploratory in content. Laboratory experiments, chemical models and scientific observations occupy an important place in the teaching of chemistry. Therefore, the method of project-based learning is naturally combined with the content of the chemistry subject and creates conditions for the development of scientific thinking of students [2, p. 45].

During project-based learning, students study a specific scientific problem, collect information, conduct experiments, analyze the results and draw conclusions. This process allows students to develop critical thinking, independent decision-making, and teamwork skills [3, p. 45]. At the same time, the project method increases students ' interest in the subject and strengthens their learning motivation.

At the same time, the application of project-based learning in chemistry creates certain pedagogical and organizational difficulties. Among them, issues such as lack of time, lack of laboratory equipment, and different levels of teacher training can be noted [4, p. 40]. These conditions require the search for new methodological approaches to the effective organization of project-based learning.

In this regard, identifying the problems of using the project method in teaching chemistry and substantiating the directions of its development is one of the urgent problems of modern pedagogical research.

Main part

Project - Based Learning is considered in modern pedagogy as one of the most effective methods aimed at developing active cognitive activity of students. This approach allows you to master the content of learning through practical tasks and contributes to the development of research, analytical and creative abilities of students [1, p. 18]. Especially in natural sciences, including chemistry, project learning is naturally combined with elements of scientific research. This is because Chemical Science is based on experimental activity, observation, modeling, and experimental proof.

Project-based learning in chemistry allows students not only to master ready-made information, but also to independently build knowledge through the study of a scientific problem. For example, project topics such as" determining the level of water pollution"," composition of household chemicals"," environmentally safe reactions " direct students to the experimental study of chemical phenomena. In the course of such work, students develop the skills of observing chemical reactions, analyzing the results and drawing scientific conclusions [2, p. 52].

In foreign educational practice, project-based learning is widely used as an important element of the STEM education system. In the education system of countries such as the USA, Finland, Germany, the project method is considered in close connection with research teaching in the teaching of Natural Sciences [3, p. 45]. In these countries, chemistry classes are often organized through experimental research, laboratory

work, and research projects. Students study specific scientific problems, conduct an experiment and present the results obtained in the form of a scientific presentation or research report.

The introduction of project-based learning technology in Kazakhstan's education system has been actively considered in recent years. The updated content of education is aimed at developing students ' research skills. In this context, project work, laboratory experiments and practical tasks play an important role in Chemistry [4, p. 42]. However, as practice shows, in the process of Organizing Project-Based Training, certain difficulties are encountered. Among them, factors such as time limits, the size of the curriculum, insufficient laboratory equipment and a different level of methodological training of teachers can be noted.

One of the most important conditions for the effective organization of Project training in chemistry is the availability of a sufficient subject environment and material base. Chemistry classrooms, as a specially equipped laboratory space, allow you to organize the practical activities of students. Laboratory instruments, reagents, safety devices and demonstration equipment directly affect the quality performance of project work [5, p. 12]. If the chemistry room is equipped in accordance with laboratory requirements, students can implement their projects through experimental research. This contributes to the development of their scientific thinking and increased interest in the subject.

At the same time, the pedagogical role of the teacher in the organization of project-based learning is special. The teacher acts as an organizer and guide of the research process, and not just an informant. It helps students determine the subject of research, guides the use of scientific methods, and supports the analysis of the results obtained [6, p. 25]. Training in this format allows you to develop independent cognitive activity of students.

The use of the project method in teaching chemistry creates conditions for the formation of a research culture of students, the practical application of subject knowledge and the development of a scientific worldview. However, for the full implementation of project-based learning, it is necessary to comprehensively develop such factors as the material base, methodological support and professional training of teachers [7, p. 35].

International and Kazakhstan experience in Organizing Project-based learning

Project-based learning technology has been widely used in many educational systems around the world. Especially in the teaching of Natural Sciences, this approach is considered one of the most effective methods aimed at the formation of students ' research skills. In foreign practice, the teaching of chemistry is largely based on experimental activity, elements of scientific research and laboratory work. And in Kazakhstan, project-based learning technology has been actively implemented in recent years within the framework of the updated content of Education [1, p. 20; 2, p. 48].

The table below shows the main features of the application of the project method in the study of chemistry in the practice of Kazakhstan and abroad in comparison.

Table 1.

Organization of chemistry on the basis of Project Training: Experience of Kazakhstan and abroad

Indicators	Kazakhstan experience	Foreign experience
Training format	Project work is used in certain sections of the curriculum	Project learning is one of the main teaching approaches in many schools
Laboratory work	There is a limited supply of equipment in some schools	Laboratory experiments are organized on a regular basis
STEM integration	It has been introduced in recent years	STEM is the main element of the education system
The role of the teacher	Teacher guide and organizer	Teacher scientific supervisor and research coordinator
Research activities of students	Project work is often carried out at the subject level	In most cases, interdisciplinary research projects are implemented
Assessment system	Project work is often evaluated through a formative assessment	The result of the study, the presentation and the result of the experiment are evaluated comprehensively

As shown in the table, in the system of Foreign Education, Project-Based Learning has become a constant element of teaching chemistry. This approach is aimed at creating a culture of scientific research in students. Although the project method is actively being implemented in Kazakhstan's practice, the material base and laboratory capabilities may still be limited in some schools. Therefore, it is important to improve the practical infrastructure for the development of project-based learning in chemistry.

Picture 1. Chemistry classrooms at school (school of the Republic of Kazakhstan on the right, school of Finland on the left)

One of the most important factors in the effective organization of project training in chemistry is the availability of specially equipped chemistry classrooms. Since chemistry is an experimental science, the research activity of students is largely carried out through laboratory work. The chemistry room must have laboratory tools, reagents, safety equipment and demonstration equipment [3, p. 39].

In this regard, it is important to consider in comparison the possibilities of chemistry classrooms in the implementation of Project training.

Table 2.

Equipment level of the chemistry room and project-based learning opportunities

Room position	Ability to organize project work	Example of projects
Fully equipped laboratory	The possibility of conducting an experimental study is high	Analysis of water composition, study of reaction rate
Medium equipped room	Organization of simple experiments and control work	Household chemicals research
Minimally equipped room	Theoretical or model projects	Environmental chemistry, models of chemical processes
Cabinet equipped with digital resources	Using virtual laboratories and simulations	Modeling of chemical reactions

As can be seen from the table, the material and technical condition of the chemistry room directly affects the content and format of Project training. In the case of a fully equipped laboratory, students can conduct real experiments, and in the case of limited resources, projects can be organized theoretical or model in nature. In recent years, virtual laboratories and digital simulations have also become important tools in project learning.

Implementation stages of Project-Based Learning in chemistry

The effective organization of project-based learning in chemistry requires a certain pedagogical consistency and periodization structure. Project activity is not a set of randomly organized tasks, it is a complex pedagogical process aimed at the gradual development of students ' research skills. Therefore, the implementation of project-based learning is carried out through several interrelated stages. At each stage, the specific actions of the teacher and students are determined, and the purpose and results of the research work are gradually formed. Such a phased organization allows students to develop scientific thinking and apply chemical knowledge in practical terms.

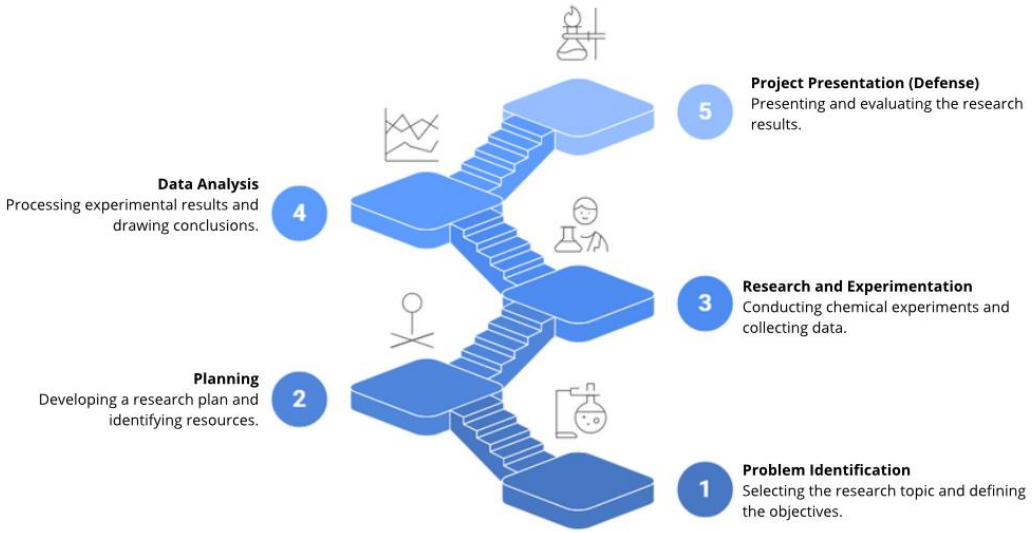

Diagram 1. Stages of implementation of Project-based learning in chemistry

The proposed phased model allows you to systematically organize project-based training in chemistry. Especially the period of experimental research plays an important role in the formation of a culture of scientific research of students. During the implementation of the project, students acquire such important skills as analyzing information, conducting experiments and drawing scientific conclusions. At the same time, the stage of project protection contributes to the development of students' communication skills and skills of evidence-based presentation of scientific results. Thus, Project training not only deepens the content of teaching chemistry, but also creates conditions for the development of the research and creative potential of students.

The main problems in the organization of teaching chemistry on the basis of Project training

The organization of chemistry on the basis of project-based learning is one of the pedagogical approaches that provides a great opportunity for the development of research and practical skills of students. However, in the process of full-fledged introduction of this method into educational practice, a number of organizational, material and methodological difficulties are encountered. These problems often arise due to the material and technical condition of schools, professional training of teachers and the peculiarities of the organization of the educational process.

First of all, one of the main problems in the organization of chemistry on the basis of Project training is insufficient laboratory equipment. In many schools, chemistry classrooms are not fully equipped according to laboratory requirements. The lack of laboratory utensils, measuring instruments, reagents and safety equipment limits the ability of students to conduct experimental work. As a result, project work often remains theoretical in nature, and the elements of experimental research are not fully realized.

At the same time, the issue of the material and technical base in rural schools requires special attention. Compared to urban schools, the quantity and quality of laboratory equipment is often limited in rural educational institutions. This situation creates inequality in the organization of project-based learning and reduces students ' ability to conduct experimental research.

Another important problem when carrying out design work in chemistry is the complete absence of reagents and precursors. Some chemicals are not used in school laboratories due to safety requirements or regulatory restrictions. This makes it difficult to carry out certain chemical reactions or research. As a result, some projects are implemented only at the level of theoretical modeling or demonstration experiments.

The lack of time in the organization of project training is also an important factor. Since the curriculum of chemistry is voluminous, teachers often have to give priority to mastering theoretical material. And for the organization of project work, additional time is required. The stages of conducting experiments, data analysis and project protection require certain time resources.

At the same time, the presence of methodological training of teachers on project-based learning technology at different levels also creates certain difficulties. The project method differs from traditional teaching approaches in that the teacher in this case acts not as an informant, but as an organizer and scientific supervisor of the research process. Therefore, an important role is played by the professional training of teachers in the organization of research work, the use of experimental methods and the assessment of project work.

Another important point is compliance with safety requirements. In the process of conducting chemical experiments, safety techniques are of particular importance. In some schools, insufficient safety equipment or lack of special equipment for laboratory work force the restriction of experimental work.

The problems encountered in the process of organizing chemistry on the basis of project training are largely related to the material base, methodological support and organizational factors. The solution of these problems indicates the need to provide chemistry classrooms with modern equipment, increase the professional training of teachers and develop methodological resources for project training.

Conclusion

Project-based learning is an effective pedagogical approach that promotes the development of students' research, analytical, and creative abilities in chemistry education. The experimental nature of chemistry naturally aligns with project-based learning, fostering scientific thinking and practical application of knowledge.

In the process of performing project work, students acquire such important skills as studying a scientific problem, analyzing information, conducting an experiment and drawing conclusions based on the results obtained. At the same time, this approach increases students' interest in the subject and contributes to the development of their ability to work independently, cooperate in groups and present research results.

At the same time, in the process of organizing project training in chemistry, there are a number of difficulties. These include insufficient laboratory equipment, limited reagents and necessary materials, time constraints of the curriculum, and varying levels of methodological training of teachers. Especially in rural schools, the problem of the material and technical base can create certain obstacles to the full implementation of project work.

In this regard, for the effective development of project-based learning in chemistry, it is important to improve the material and technical base of schools, provide chemistry classrooms with the necessary laboratory equipment, improve the professional skills of teachers and introduce digital laboratories and virtual simulations into the educational process.

Overall, project-based learning significantly enriches chemistry education and contributes to the development of students' scientific worldview and research culture.

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