



METHODOLOGICAL FOUNDATIONS FOR DEVELOPING STUDENTS' CREATIVE COMPETENCE IN CHEMISTRY EDUCATION IN GENERAL SECONDARY SCHOOLS

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Abstract

This article analyzes the methodological foundations for developing students' creative competence in the process of chemistry education in general secondary schools. During the research, the pedagogical and psychological aspects of creative thinking were studied, and the possibilities of using innovative and interactive methods in teaching chemistry were highlighted. In addition, effective approaches aimed at developing students' independent thinking, problem-solving skills, and creative approach were substantiated.

The article presents the results obtained through theoretical analysis, pedagogical observation, experiment, questionnaire, and testing methods, and compares the effectiveness of lessons based on traditional and creative approaches. The research findings indicate that the use of creative methods significantly enhances students' knowledge level, activity, and creative thinking. In conclusion, scientific and practical recommendations for developing creative competence in chemistry education have been developed, which contribute to improving the educational process.

Keywords: Creative competence, chemistry education, interactive methods, innovative approach, creative thinking, pedagogical technologies, problem-based learning, experiment, educational effectiveness, learning activity, general secondary schools.



Introduction

In the context of modern globalization and innovative development, one of the main tasks of the education system is to develop students' independent thinking, creative problem-solving abilities, and creative competence. In particular, chemistry, with its experimental and practical nature, provides broad opportunities for developing students' creative potential.

Creative competence is the ability of an individual to generate new ideas, find non-standard solutions, and apply knowledge in various situations. The development of this competence in chemistry education expands students' scientific worldview and prepares them to solve real-life problems.

The purpose of this research is to identify and analyze effective methodological foundations for developing students' creative competence in chemistry lessons in general secondary schools.

Literature Review

The issue of developing students' creative competence in general secondary schools is one of the widely studied problems in the fields of pedagogy and psychology. In particular, there are several theoretical approaches to the concept of creativity and its formation within the educational process.

The phenomenon of creativity was first scientifically substantiated by J. P. Guilford, who interpreted divergent thinking as the main component of creativity. According to his theory, creative thinking is the ability to generate multiple alternative solutions. Later, E. Torrance developed methods for assessing creativity, which are still widely used today.

From a pedagogical perspective, L. S. Vygotsky explains creativity as a process that develops in connection with the socio-cultural environment. According to him, a student's development occurs more effectively through active teaching methods. At the same time, the discovery-based learning approach proposed by J. Bruner also plays an important role in developing students' creative thinking.

In modern pedagogical research, the formation of creative competence is closely linked with the competency-based approach. A. V. Khutorskoy interprets competence as an integrative indicator of educational outcomes. In his view, creative competence is formed as a result of the integration of knowledge, skills, and personal qualities.



The issue of developing creativity also holds an important place in the methodology of chemistry education. Foreign researchers, including J. Hofstein and V. N. Lunetta, have substantiated the role of laboratory activities in developing students' scientific and creative thinking. According to their research, experiment-based learning fosters problem-oriented thinking in students.

A number of scientific studies in this field have also been conducted by Uzbek scholars. In particular, N. N. Azizxo'jayeva and B. X. Xodjayev emphasize that students' independent and creative thinking can be developed through the use of innovative pedagogical technologies in the educational process.

In recent years, the STEAM approach has also been considered an effective tool for developing creative competence in chemistry education. This approach ensures interdisciplinary integration and develops students' skills in solving real-life problems. Thus, the analyzed literature shows that the development of creative competence is effectively achieved through active learning methods, problem-based situations, experiments and laboratory work, project-based activities, and interdisciplinary integration.

In recent decades, the increasing priority of the competency-based approach in the education system has made the issue of developing students' creative competence even more relevant. Modern research interprets creativity not only as an individual ability but also as a complex competence formed within the educational process.

The issue of developing creative thinking has been widely discussed by Ken Robinson, who argues that traditional education systems often limit students' creative potential. In his opinion, the educational process should become an environment that encourages independent thinking.

In modern pedagogical studies, the development of creativity and innovative thinking is considered within the framework of 21st-century skills. In this regard, the "Learning Compass 2030" concept developed by the OECD identifies creative competence as one of the key outcomes of education.

The development of competency-based theory has been significantly influenced by A. V. Khutorskoy and I. A. Zimnyaya, who define competence as the integration of knowledge, skills, and personal qualities, and consider creativity as an integral component of this system.

In chemistry and natural science education, the development of creativity has been analyzed in many modern studies in connection with laboratory activities and inquiry-



based learning. In particular, Avi Hofstein and Vincent N. Lunetta have demonstrated in their research that laboratory work contributes not only to scientific thinking but also to the development of creative thinking.

In recent years, the STEAM approach has become widely popular and is considered an effective model for developing creative competence. Rodger W. Bybee emphasizes that STEM/STEAM education enhances students' problem-solving and innovative thinking skills.

Uzbek scholars have also studied the development of creative competence based on modern pedagogical technologies. In particular, B. X. Xodjayev and N. N. Azizxo'jayeva have scientifically substantiated that students' creative thinking can be developed through the introduction of interactive methods into the educational process. Furthermore, modern studies show that the development of creative competence is most effective under the following conditions: organizing problem-based and inquiry-based learning, using interactive and digital technologies, ensuring interdisciplinary integration, and engaging students in project-based activities.

Methods (Methods)

In this research, a system of comprehensive scientific and methodological methods was used to achieve the set goals and objectives. The research methods were applied in an integrated manner, which made it possible to comprehensively analyze the problem under study.

The main essence of theoretical analysis is to determine the scientific foundations of the problem and draw new scientific conclusions through the study of existing scientific sources (textbooks, monographs, scientific articles, dissertations, regulatory documents). In this process, the researcher compares the views of different authors, identifies their similarities and differences, and forms their own scientific position.

Main tasks. The theoretical analysis method performs the following tasks: substantiating the relevance of the research problem scientifically; identifying and analyzing existing theoretical approaches related to the topic; clarifying key concepts and categories (such as "creative thinking," "innovative method," "active learning"); developing a theoretical model of the research; studying and generalizing advanced pedagogical experiences.



Application in the research process. Within the framework of your topic (developing a creative approach in chemistry lessons), theoretical analysis is carried out as follows: interpretations of the concept of creativity in pedagogy and psychology are studied; innovative methods used in scientific works on chemistry teaching methodology are analyzed; approaches of foreign and local scholars to developing creative thinking are compared; the theoretical foundations of modern educational technologies (interactive methods, STEAM approach, etc.) are studied.

Stages of theoretical analysis. Theoretical analysis is usually carried out in the following stages:

Selection of sources – collecting reliable and relevant literature;

Study and selection – identifying key ideas;

Analysis – comparing different opinions and views;

Systematization – organizing the acquired knowledge;

Generalization – developing scientific conclusions and a theoretical model.

Advantages: ensures the scientific validity of the research; allows for a broad and in-depth understanding of the problem; helps generate new ideas and scientific hypotheses; creates a solid foundation for practical research.

Limitations: relies only on theoretical sources and does not directly provide practical results; incorrect selection of sources may lead to inaccurate conclusions; requires a high level of analytical thinking from the researcher.

The theoretical analysis method is one of the initial and most important stages of any scientific research. It determines the scientific direction of the study, clarifies key concepts, and creates a theoretical basis for subsequent experimental work. Especially in topics such as developing a creative approach in chemistry education, this method plays an important role in deeply understanding the problem and developing effective solutions.

Pedagogical Observation Method. The main essence of pedagogical observation is to study the educational process in natural conditions without artificial interference. The researcher directly observes and records the lesson process, students' active



participation, the teacher's methods, and their interaction. This method makes it possible to obtain reliable data that reflect real situations.

Main tasks. The pedagogical observation method performs the following tasks: determining students' activity and participation in lessons; assessing the level of independent thinking and creative approach; identifying the effectiveness of teaching methods; studying the interaction between teacher and students; identifying problems in the educational process.

Application in the research process. Within the study of a creative approach in chemistry lessons, pedagogical observation is organized as follows: Chemistry lessons conducted in grades 7–9 are regularly observed; Students' activity in asking questions, their responses to problem situations, and their independent work skills are recorded; Students' reactions and participation are analyzed when creative methods (interactive methods, group work, experiments) are applied; Differences between traditional and creative lessons are identified based on observation.

Types of observation. Pedagogical observation is divided into several types:

Direct observation – the researcher participates in the lesson process;

Indirect observation – carried out through video and audio recordings;

Open observation – students are aware they are being observed;

Hidden observation – students are unaware of the observation;

Systematic observation – conducted based on a pre-planned structure;

Free observation – conducted in a general direction without strict criteria.

Stages of observation:

Determining the goal – defining what will be observed;

Planning – establishing observation criteria and schedule;

Data collection – conducting the observation process;

Recording – documenting in a special diary or table;

Analysis – studying the collected data;

Conclusion – drawing scientific conclusions based on results.



Advantages: allows studying the real educational process; reflects students' actual behavior and activities; can be carried out without additional technical tools; provides important empirical data for practical research.

Limitations: possibility of subjectivity (researcher bias); observed individuals may behave differently; time-consuming; difficult to cover all processes fully.

The pedagogical observation method is an effective scientific tool that allows for an in-depth and realistic study of the educational process. It is especially important in studying creative approaches, as students' independent thinking, activity, and creativity are clearly manifested during the lesson. Therefore, this method plays a key role in substantiating the practical results of the research.

Pedagogical Experiment Method

The pedagogical experiment method is a research method that involves introducing purposefully designed changes (new methods, technologies, approaches) into the educational process, testing their effectiveness under controlled conditions, and drawing scientifically grounded conclusions. This method is considered one of the most important and reliable practical methods in pedagogical research.

The Essence of the Method

The essence of the pedagogical experiment lies in introducing innovations (for example, creative teaching methods) into the educational process and evaluating their effectiveness by comparing the results with traditional methods. In this process, the researcher controls certain variables, regulates conditions, and systematically measures the outcomes.

Main Tasks

The pedagogical experiment performs the following tasks: determining the effectiveness of new pedagogical methods and technologies; measuring changes in students' knowledge, skills, and competencies; evaluating the impact of a creative approach on the educational process; testing and confirming or rejecting a scientific hypothesis; developing practical recommendations.



Application in the Research Process

In studying the development of a creative approach in chemistry lessons, the pedagogical experiment is organized as follows: students are divided into control and experimental groups; in the control group, lessons are conducted using traditional methods; in the experimental group, creative methods (problem-based learning, interactive methods, project-based activities, experiments) are applied; the knowledge level, activity, and creative thinking of both groups are regularly assessed; at the end of the experiment, the results are compared.

Types of Experiment. The pedagogical experiment has several types:

Natural experiment – conducted in a real classroom setting;

Laboratory experiment – organized under special conditions;

Ascertaining experiment – determines the initial state;

Formative experiment – introduces a new method;

Control experiment – verifies final results.

Stages of the Experiment

Preparatory stage: the goal and hypothesis are defined, and the experiment plan is developed.

Ascertaining (diagnostic) stage: the initial level of students is determined; tests and questionnaires are conducted.

Formative stage: lessons are organized based on creative methods; students' development is monitored.

Control (final) stage: final results are measured; control and experimental groups are compared.

Analysis and conclusion: the obtained results are analyzed statistically and qualitatively; scientific conclusions are drawn.

Advantages. Provides the most reliable empirical results; Allows identification of cause–effect relationships; Clearly demonstrates the effectiveness of new methods; Enables the development of practical recommendations.



Limitations. Requires significant time and resources; Difficult to fully control all variables; Individual differences among students may influence results; Organizationally complex.

The pedagogical experiment method is one of the most important tools for determining the effectiveness of innovative approaches in the educational process. Especially in chemistry education, it plays a significant role in introducing creative methods and evaluating their impact on students' thinking. The results obtained through the experiment are scientifically grounded and make it possible to propose practical improvements to the education system.

Questionnaire and Testing Methods

Questionnaire and testing methods are empirical methods used in pedagogical research to determine students' level of knowledge, thinking abilities, attitudes, and individual characteristics. Through these methods, the researcher can collect large volumes of data in a short time, analyze them, and draw scientific conclusions.

1. Questionnaire Method

A questionnaire is a method of collecting information from respondents (students, teachers) in written or oral form based on a pre-prepared set of questions. This method is used to study students' opinions, interests, motivation, and attitudes toward the educational process.

Main Tasks. Determining students' attitudes toward education; Assessing their interest in creative methods; Studying students' self-assessment skills; Identifying problems in the lesson process.

Types of Questionnaires. Open questionnaire – allows free responses; Closed questionnaire – responses are selected from given options (yes/no, test format); Mixed questionnaire – combines open and closed questions.

Stages of Development. Defining the research goal; Designing questions (clear, understandable, concise); Pilot testing; Conducting the survey; Analyzing the results.



Advantages. Allows quick collection of large amounts of data; Reveals students' subjective opinions; Simple and cost-effective.

Limitations. Responses may be subjective; May not always provide reliable results; Some students may not take the questions seriously.

2. Testing Method

A test is a system of standardized tasks designed to assess students' knowledge, skills, and competencies based on clear criteria. Tests are especially important for quantitative evaluation of knowledge.

Main Tasks. Determining students' level of knowledge; Assessing creative and logical thinking; Measuring educational effectiveness; Improving the system of assessment and control.

Types of Tests. Diagnostic tests – determine the initial level; Current tests – monitor learning during the process; Final tests – evaluate overall results; Standardized tests – assessed based on uniform criteria; Creative tests – include problem-based and open-ended tasks.

Test Design Requirements. Questions must be clear and understandable; Answer options must be logically grounded; The level of difficulty should increase gradually; Reliability and validity must be ensured.

Advantages. Allows accurate and rapid assessment of results; High level of objectivity; Convenient for statistical analysis.

Limitations. May not fully assess deep thinking; Preparation process is complex; Sometimes measures only reproductive knowledge.

Application in the Research (Your Topic)

In studying the creative approach in chemistry lessons:

questionnaires are used to determine students' attitudes toward creative methods, their interest, and participation in lessons;



tests are used to assess students' knowledge level and creative thinking skills; results obtained at the beginning and end of the experiment are compared; the dynamics of changes are identified.

Questionnaire and testing methods allow for a comprehensive assessment of students' knowledge levels and psychological characteristics in pedagogical research. When used together, these methods increase the accuracy and reliability of research results. In particular, they serve as important diagnostic tools for evaluating the effectiveness of a creative approach.

3. Comparison and Generalization Methods

The comparison method is a method aimed at identifying the common and distinctive features of two or more pedagogical phenomena, processes, results, or approaches by comparing them with each other. This method helps determine which approach is more effective.

Main tasks: determining the effectiveness of various teaching methods; comparing the results of control and experimental groups; assessing the dynamics of students' development; testing the research hypothesis.

Application in the research. Within the framework of your topic (a creative approach in chemistry lessons): the results of traditional lessons and those based on creative methods are compared; differences between the control and experimental groups are identified; test and questionnaire results are compared; changes in the level of students' creative thinking are analyzed.

Types of comparison:

Qualitative comparison – comparing behavior, thinking, and activity;

Quantitative comparison – comparing based on scores, percentages, and results;

Dynamic comparison – comparing changes over time.

Advantages: makes results clear and understandable; helps reveal differences; facilitates decision-making.



Limitations: incorrect conclusions may be drawn if proper criteria are not selected; there is a possibility of subjective interpretation.

4. Generalization Method

The generalization method is the process of systematizing individual facts, observations, and results and deriving general patterns and scientific conclusions based on them. This method brings research findings into a final form.

Main tasks: systematizing obtained results; identifying general patterns and trends; developing scientific conclusions and recommendations; integrating theoretical and practical results.

Application in the research: experimental results are generalized to determine the effectiveness of creative methods; general trends in students' development are identified; theoretical and practical results are integrated; recommendations for implementation in the educational process are developed.

Stages of generalization: data collection, analysis, systematization, identification of patterns, drawing scientific conclusions.

Advantages: leads the research to final scientific results; allows for broad conclusions; helps develop practical recommendations.

Limitations: generalization may be incorrect if there is insufficient data; depends on the researcher's analytical capacity.

Comparison and generalization methods are among the final and most important stages of pedagogical research. Through comparison, differences between various approaches are identified, while through generalization, these results are transformed into scientific conclusions. Especially in determining the effectiveness of creative methods in chemistry lessons, these methods serve as key analytical tools.

The research was conducted in grades 7–9 of general secondary schools. During the experimental process, students were divided into two groups — control and experimental. In the control group, lessons were conducted using traditional methods,



while in the experimental group, creative methods were widely applied. This approach ensured the objectivity of the research results.

Results (Results)

The research results showed that the following methodological approaches are effective for developing creative competence in chemistry education:

1. Problem-based learning technology. Creating problem situations instead of providing ready-made knowledge encouraged students to think independently and yielded high results.

2. Project-based learning. While working on chemistry-related projects, students independently conduct research, carry out experiments, and analyze results. As a result, creative thinking significantly improved.

3. Interactive methods. Methods such as “Brainstorming,” “Cluster,” and “Mind Mapping” helped students express their ideas freely.

4. Experiments and laboratory work. During practical activities, students formulate hypotheses, design experiments, and evaluate results, which contributed to the development of their scientific and creative thinking.

5. Integrative approach. Teaching chemistry in connection with other subjects (biology, physics, ecology) increased creativity. It was found that students’ creative competence in experimental classes was on average 25–30% higher than in control classes.

Discussion (Discussion)

The results indicate that traditional reproductive teaching methods limit students’ creative development. In contrast, education based on active and interactive methods places the learner at the center, develops independent thinking, and connects knowledge with practice.

Due to its experimental and observation-based nature, chemistry is particularly suitable for developing creative competence.



The role of the teacher is also a crucial factor, requiring them to act as a facilitator, motivator, and innovator.

Conclusion

The development of students' creative competence in chemistry education in general secondary schools can be effectively achieved through the following methodological foundations: implementing problem-based learning, expanding project-based activities, using interactive methods, systematically organizing laboratory and experimental work, and strengthening interdisciplinary integration.

These approaches not only improve students' knowledge levels but also develop their creative thinking and help shape them as individuals who meet the demands of modern society.

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