

Pedagogical And Psychological Features of Developing Students' Creative Thinking and Creative Competence

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	Abstract The article examines, from theoretical and experimental perspectives, the pedagogical and psychological features of developing the creative thinking and creative competence of general secondary school students in the process of chemistry education. The essence of the concepts of “creative thinking” and “creative competence”, their structural components (motivational-value, cognitive-divergent, operational-activity and reflective-evaluative) and development criteria are clarified. Based on the PISA framework for assessing creative thinking and I.E. Shernazarov’s scientific views on the development of functional literacy, a system of context-based, problem-search and open-ended creative tasks for chemistry lessons has been developed. The results of the pedagogical experiment showed that the proposed methodology leads to a statistically significant increase in the proportion of students with high and medium levels of creative competence.
Keywords: Creative thinking, creative competence, divergent thinking, chemistry education, functional literacy, PISA, creative task, pedagogical and psychological conditions, reflection.	

Introduction

In the context of globalization, digital transformation and the knowledge economy, the priority task of the education system is no longer limited to transmitting ready-made knowledge; it increasingly consists in developing students' ability to think independently, critically and creatively, to generate new ideas in non-standard situations and to put them into practice. The fact that the Organisation for Economic Co-operation and Development (OECD) introduced creative thinking as a separate assessment domain for the first time in the PISA 2022 study [24; 25] clearly demonstrates the importance of this quality within the system of 21st-century skills. Today, creativity is interpreted not as a special talent confined to the arts or literature, but as a competence that can be purposefully developed and assessed in every student.

The Law of the Republic of Uzbekistan “On Education” [1] and the Concept for the Development of the Public Education System until 2030, approved by Presidential Decree No. PF-5712 of 29 April 2019 [2], set as strategic goals the development of students' independent and creative

thinking and real-life problem-solving skills, the alignment of education quality with the requirements of international assessment programmes, and the country's entry into the top 30 countries of the PISA ranking by 2030. This necessitates a revision of the content and teaching methods of all subjects of general secondary education, including the natural sciences, on the basis of a creative approach.

Chemistry has considerable didactic potential for developing students' creative thinking. Activities such as understanding the relationship between the structure and properties of substances, modelling chemical processes, putting forward hypotheses, planning experiments and interpreting results are inherently exploratory and creative. However, in educational practice, chemistry lessons are still dominated by reproductive, algorithmic problems oriented towards a single correct answer. As noted in I.E. Shernazarov's studies on international assessment, students perform relatively well when reproducing knowledge in standard situations, yet experience serious difficulties when completing open-ended tasks that are set in a real-life context and admit several solutions [6; 11; 17].

Although the concepts of "creative thinking" and "creative competence" are often used as synonyms in the scientific literature, there is an important distinction between them. Creative thinking is a cognitive process aimed at generating new, original and useful ideas, whereas creative competence denotes the readiness and ability to carry out this process consciously within a particular field of activity, that is, an integral unity of knowledge, skills, motivation, values and reflection. In other words, creative thinking is the core of creative competence, and competence is its personal and activity-based manifestation. Taking this distinction into account shows that chemistry education should focus not only on increasing the number of ideas students produce, but also on shaping their attitude towards creative activity and their ability to regulate it.

This situation gives rise to a scientific and pedagogical problem: on the one hand, society and international educational standards require a high level of creative competence from students; on the other hand, the pedagogical and psychological features of developing this quality in chemistry education, namely the age characteristics of adolescence, intrinsic motivation, a psychologically safe creative environment, the facilitating role of the teacher and assessment mechanisms, have not been sufficiently systematized. Therefore, the aim of the study is to identify the pedagogical and psychological features of developing students' creative thinking and creative competence in chemistry education and, on this basis, to develop an effective methodology and test it experimentally. To achieve this aim, the following objectives were set: to clarify the psychological and pedagogical essence of the concepts of creative thinking and creative competence; to define the structural components, criteria and indicators of creative competence; to design a system of creative tasks for chemistry lessons; and to substantiate the effectiveness of the proposed methodology through a pedagogical experiment.

Literature review

The tradition of the scientific study of the psychological nature of creative thinking began with the research of J.P. Guilford. In his structure-of-intellect model, he distinguished between convergent thinking (directed towards a single correct solution) and divergent thinking (directed towards the search for multiple solutions), linked creativity specifically with divergent thinking and identified its parameters of fluency, flexibility, originality and elaboration [18]. E.P. Torrance

created a system of verbal and figural tests designed to measure these parameters, which remain among the most widely used tools for diagnosing creativity today [19].

In subsequent research, creativity came to be interpreted not merely as a cognitive process but as the outcome of a complex interaction between the individual and the environment. The “investment theory” of R. Sternberg and T. Lubart identifies six resources of creativity: intellectual abilities, knowledge, styles of thinking, personality, motivation and environment [20]. In T. Amabile’s componential model, domain-relevant skills, creativity-relevant processes and intrinsic motivation are recognized as the key factors, and it has been shown that external control and fear of evaluation reduce creative activity [21]. M. Csikszentmihalyi describes creativity as a systemic relationship between the individual, the domain and the field, that is, the community of experts [22]. From an educational point of view, the “Four C” model of J. Kaufman and R. Beghetto is particularly significant: it recognizes personal discoveries in everyday and learning activities (the mini-c and little-c levels) as legitimate forms of creativity [23]. This substantiates the view that, for a school student, the very process of creating something subjectively new has developmental value.

In the Russian school of psychology, L.S. Vygotsky considered imagination and creativity to be inseparable from human experience, emphasized that the richness of a child’s creativity depends directly on the richness of his or her experience, and, through the idea of the zone of proximal development, substantiated the possibility of pedagogically guiding creative development [26]. Ya.A. Ponomarev described the psychological mechanism of creative thinking as a unity of logical and intuitive stages [27]. D.B. Bogoyavlenskaya proposed “intellectual activity” as the unit of creativity, that is, an individual’s ability to continue exploration beyond the limits of a given task without external stimulation [28]. A.V. Khutorskoy, in his concept of heuristic learning, developed the idea of the student’s creative self-realization, independent creation of educational products and, on this basis, the acquisition of key competences [29].

In the PISA 2022 framework developed by the OECD, creative thinking is defined as the competence to engage productively in the generation, evaluation and improvement of ideas, which can result in original and effective solutions, advances in knowledge and impactful expressions of imagination [24]. The assessment covers four domains, namely written expression, visual expression, social problem solving and scientific problem solving, and three ideation processes: generating diverse ideas, generating creative ideas, and evaluating and improving ideas [24; 25]. The scientific problem solving domain is directly related to chemistry education, as it requires students to propose hypotheses, design experiments and seek alternative explanations in situations of uncertainty.

In the national pedagogical literature, the development of creativity has been addressed mainly in the context of innovative educational technologies and interactive methods. N.A. Muslimov and co-authors investigated pedagogical innovations, teacher creativity and the design of educational technologies [30], while R.J. Ishmuhamedov and M. Yuldashev developed practical ways of using interactive methods in teaching and upbringing [31].

Within chemistry teaching methodology, this problem has been systematically developed in the research of I.E. Shernazarov. In his works, he regards creative thinking as a component of functional literacy and substantiates a methodology for developing functional literacy through creative thinking tasks [4; 5]. In his study on developing 21st-century skills through the assessment

of students' creative thinking, the assessment of creativity is interpreted as an important tool for managing the learning process [3]. His works on developing functional literacy in general secondary school students [6], on forming types of functional literacy in future chemistry teachers [7; 8], and on the concept and pedagogical model for assessing functional literacy in chemistry [9] particularly emphasize the role of context-based tasks grounded in real-life situations. I.E. Shernazarov has also studied in depth the organization of the educational process on the basis of the competence-based approach [10], the objectives and implementation of international assessment studies in Uzbekistan [11], the preparation of future chemistry teachers for international assessment studies [12; 13; 14], the use of the STEAM approach in chemistry education [15], and the development of students' research skills and scientific literacy through experimental work [16]. In his doctoral dissertation, a methodology for developing the scientific literacy of future chemistry teachers on the basis of international assessment studies was developed as an integrated system, in which literacy oriented towards creative activity is treated as a separate structural component [17].

The literature review shows that, although psychological theories of creativity and international assessment frameworks have been elaborated in sufficient depth, their integration into chemistry teaching practice in general secondary schools, and in particular the mechanisms for the stage-by-stage development and assessment of creative competence that take into account the psychological characteristics of adolescence, have not been adequately covered. Filling this gap constitutes the scientific novelty of our study.

Research methodology

The methodological basis of the study comprised the systemic activity-based, competence-based, learner-centred and context-based approaches. In this study, creative competence was defined as an integrative quality encompassing an individual's value-based attitude towards creative activity, the harmony of divergent and convergent thinking, experience in generating, evaluating and improving new ideas, and the ability to regulate one's own creative activity reflectively. Based on this definition, a four-component structure of creative competence was developed (Table 1).

Table 1 Structural components, criteria and indicators of students' creative competence

Component	Content	Main indicators
Motivational-value	Intrinsic interest in creative activity; awareness of the personal and social significance of chemical knowledge	Cognitive interest, initiative, absence of fear of making mistakes, striving for independent inquiry
Cognitive-divergent	Application of chemical concepts and laws in non-standard situations; multi-variant thinking	Fluency, flexibility, originality, elaboration; ability to draw analogies and associations
Operational-activity	Implementation of ideas in the form of a practical solution, model, experiment or project	Putting forward hypotheses, planning experiments, building models, presenting project outcomes
Reflective-evaluative	Critical evaluation and improvement of one's own and others' ideas; awareness of the creative process	Evaluating ideas against criteria, analysing errors, improving solutions

The study employed theoretical methods (analysis of psychological, pedagogical and methodological literature, comparison, generalization and modelling), empirical methods (pedagogical observation, questionnaires, interviews, analysis of students' creative products, expert assessment and a pedagogical experiment) and mathematical-statistical methods (Pearson's χ^2 test and Student's t-test).

The pedagogical experiment was conducted in the 2025–2026 academic year in ascertaining, formative and control stages with the participation of grade 8–9 students from four general secondary schools in Tashkent city and Tashkent region. The experimental group included 124 students and the control group 118 students. In the experimental group, chemistry lessons were organized according to the developed methodology, whereas in the control group they followed the existing conventional methodology.

The diagnostic instruments included verbal tasks from the Torrance tests adapted to chemical content, context-based tasks of the scientific problem solving type designed on the basis of the PISA 2022 creative thinking framework, a questionnaire measuring intrinsic motivation towards chemistry, and reflective journals. Each component was scored on a 10-point scale, and the overall creative competence index was calculated using the formula $K = (M + Kd + O + R) / 4$, where M, Kd, O and R are the mean scores for the motivational-value, cognitive-divergent, operational-activity and reflective-evaluative components, respectively. Depending on the index value, low (0–4.0 points), medium (4.1–7.0 points) and high (7.1–10 points) levels were distinguished. Open-ended tasks were assessed by three independent experts; the coefficient of concordance of the experts' ratings (Kendall's W) was 0.81, indicating a sufficiently high reliability of the assessment results.

Results

The results of observations and questionnaires conducted at the ascertaining stage made it possible to identify a number of pedagogical and psychological factors hindering the development of creative thinking. Most of the surveyed students reported that they were anxious about “giving a wrong answer” in chemistry lessons, that the tasks mostly required a single correct answer, and that they had few opportunities to put forward their own ideas. This is a manifestation in school practice of the phenomenon described by T. Amabile, namely the pressure of external evaluation and the resulting weakening of intrinsic motivation [21].

On the basis of the identified factors, the following pedagogical and psychological features of developing students' creative competence, together with the corresponding conditions, were substantiated. First, adolescents aged 13–15 have a strong need for self-expression, independence and recognition by peers; therefore, group creative activity, presentation of ideas and peer assessment channel this need into creative activity. Second, creativity manifests itself only in a psychologically safe environment, that is, in conditions where mistakes are accepted as a source of development and every well-grounded idea is respected. Third, to strengthen intrinsic motivation, chemical content should be presented in connection with students' everyday lives, health, environmental problems and the industrial potential of the region; this corresponds to the context-based approach substantiated by I.E. Shernazarov [6; 9]. Fourth, the stages of divergent and convergent thinking should alternate consistently: attention should first be paid to the quantity and diversity of ideas, and then to their evaluation and the selection of the most effective one.

Fifth, formative assessment and reflection enable students to become aware of and regulate their own creative process.

To implement these conditions, a system of creative tasks for chemistry lessons was developed. The system is based on the three ideation processes of the PISA 2022 framework [24] and on I.E. Shernazarov's idea of developing functional literacy through creative thinking tasks [4] (Table 2).

Table 2 System of creative tasks used in chemistry lessons

Type of task	Quality developed	Example with chemical content
Divergent tasks	Fluency, flexibility	Using materials available at home, propose as many ways as possible to determine the hardness of water.
Context-based problem situations	Transfer of knowledge to real-life situations, justification	How does spreading table salt on roads in winter affect cars and soil? Propose alternative substances and justify their advantages and disadvantages.
Inverse (open-ended) tasks	Originality, flexibility of chemical thinking	Sodium chloride and water were formed as a result of a reaction. Find all possible variants of the starting substances and reaction conditions.
Modelling tasks	Imaginative thinking, elaboration	Using available materials, build spatial models of methane and water molecules and explain the reason for the difference in their shapes.
Evaluating and improving ideas	Critical and reflective thinking	Evaluate the "natural indicator" project proposed by your classmate against the criteria and give two suggestions for improving it.
STEAM projects	Integrative thinking, practical and productive activity	Create a pH scale based on red cabbage juice, determine the acidity or alkalinity of household products and present the results as an infographic.

The tasks were integrated into different stages of the lesson: problem questions at the motivation stage, divergent and modelling tasks when studying new material, context-based problems at the consolidation stage, and projects and inverse tasks as homework. Interactive methods such as Brainstorming, Synectics, Six Thinking Hats and Cluster were used. At the end of each lesson, students wrote answers in their reflective journals to questions such as "What new idea did I propose today?" and "Which of my ideas did I improve, and how?"

The practical content of the methodology can be illustrated by a grade 8 lesson on the topic "Oxygen. Combustion and Oxidation". At the motivation stage, students were asked the problem question: "Why can a fire be extinguished with water, while it is dangerous to pour water on burning oil?" Students first put forward hypotheses without restrictions using the Brainstorming method, and then analysed them in small groups on the basis of their knowledge of the density of substances, boiling points and the conditions of combustion. At the stage of learning new material, the "fire triangle" model (fuel, oxygen and ignition temperature) was not presented by the teacher in ready-made form but was "discovered" by the students themselves from the results of the experiments they had observed.

At the consolidation stage, the groups were given a context-based task: “Draw up a fire safety leaflet for the school canteen and justify, from a chemical point of view, at least four different ways of stopping combustion.” After the groups presented their products, at the “evaluating and improving ideas” stage each group assessed another group’s work against pre-agreed criteria (scientific validity, originality, practical applicability and safety) and offered suggestions for improvement. In the reflection at the end of the lesson, most students noted that they had realized that a new conclusion could be drawn even when their hypothesis turned out to be wrong. Such a structure simultaneously ensures the consistent alternation of divergent and convergent thinking, a psychologically safe environment and the development of the reflective-evaluative component. At the end of the experiment, the levels of students’ creative competence were determined again. The results are presented in Table 3.

Table 3 Distribution of students’ creative competence levels in the experimental and control groups

Group and stage	High		Medium		Low	
	n	%	n	%	n	%
EG (n=124), before	12	9.7	48	38.7	64	51.6
EG (n=124), after	35	28.2	63	50.8	26	21.0
CG (n=118), before	11	9.3	46	39.0	61	51.7
CG (n=118), after	16	13.6	51	43.2	51	43.2

Note: EG – experimental group, CG – control group.

Before the experiment, no significant difference was observed between the experimental and control groups in the distribution of levels ($\chi^2 = 0.01$; $p > 0.05$), which indicates that the initial state of the groups was equivalent. After the experiment, the proportion of students at the high level in the experimental group increased from 9.7% to 28.2%, while the proportion at the low level decreased from 51.6% to 21.0%. In the control group, the corresponding changes were considerably smaller: the high level increased from 9.3% to 13.6%, and the low level decreased from 51.7% to 43.2%. The statistical significance of the difference between the groups at the end of the experiment was confirmed: the calculated value $\chi^2 = 16.32$ exceeds the critical value (5.99) at 2 degrees of freedom and a significance level of 0.05.

The dynamics of the mean scores for the parameters of the cognitive-divergent component of creative thinking are shown in Table 4.

Table 4 Mean scores for divergent thinking parameters (10-point scale)

Parameter	EG before	EG after	CG before	CG after	t (before)	t (after)
Fluency	4.12±1.41	6.48±1.37	4.08±1.45	4.71±1.43	0.22	9.83
Flexibility	3.86±1.38	6.15±1.40	3.91±1.36	4.42±1.39	0.28	9.64
Originality	3.27±1.30	5.94±1.46	3.31±1.33	3.79±1.35	0.24	11.88
Elaboration	3.95±1.35	6.02±1.42	3.89±1.37	4.36±1.40	0.34	9.15

Note: $M \pm \sigma$ – mean and standard deviation; the critical value of the t-test is 1.97 ($p = 0.05$).

The table shows that before the experiment the differences between the groups were not significant for any parameter ($t < 1.97$), whereas after the experiment a statistically significant difference in favour of the experimental group emerged for all parameters ($t > 1.97$; $p < 0.001$). The greatest growth was recorded for originality: the efficiency coefficient was 1.82 in the experimental group and 1.15 in the control group. For fluency, flexibility and elaboration, the efficiency coefficients in the experimental group were 1.57, 1.59 and 1.52, respectively.

The questionnaire results for the motivational-value component also showed positive changes: in the experimental group, the proportion of students who preferred to express their ideas freely in chemistry lessons increased considerably, and the reflective journals showed a higher level of awareness of the creative process and richer content in entries on improving ideas.

Discussion

The results show that the development of creative competence is not limited to the use of a special set of tasks but requires a fundamental change in the pedagogical and psychological climate of the learning process. In our view, the fact that originality showed the highest growth rate is explained by the psychologically safe environment and by the abandonment of the “single correct answer” stereotype in the evaluation of ideas. This confirms T. Amabile’s conclusion that intrinsic motivation is a decisive factor of creativity [21] and D.B. Bogoyavlenskaya’s idea that intellectual activity is associated with going beyond external requirements [28].

The effectiveness of context-based chemical tasks is consistent with the pattern identified in I.E. Shernazarov’s research: tasks based on real-life situations simultaneously develop both scientific literacy and creative thinking [3; 4; 6]. In this sense, creative competence and functional literacy appear as mutually complementary qualities: functional literacy provides the basis for applying knowledge in life, while creative competence makes it possible to transform and apply this knowledge in new, unusual situations. Likewise, the role of STEAM projects and experimental tasks in developing the operational-activity component is consistent with the author’s conclusions on STEAM education and experimental work [15; 16].

The consistent alternation of the divergent and convergent stages of thinking provides practical confirmation of the idea in J.P. Guilford’s theory [18] that the two types of thinking complement each other. When students first generated ideas without restrictions and then evaluated them against the criteria of chemical laws, safety and economic efficiency, the solutions they proposed became not only original but also scientifically grounded and feasible. This fully meets the requirement for “original and effective solutions” set out in the PISA 2022 framework [24].

The results also confirmed that students’ age characteristics have a significant impact on the development of creative competence. In adolescents aged 13–15, the active formation of abstract logical thinking, the desire to defend one’s own opinion and sensitivity to peers’ opinions manifest themselves simultaneously. Observations showed that students who were less active in individual work put forward more ideas in small-group creative activity, since the group served as a kind of “psychological protection” for them. At the same time, group work carries the risk of conformity, that is, blindly following the opinion of the leading student. It was found that writing down ideas individually first and then discussing them in the group (the brainwriting technique) is effective

in reducing this risk. This conclusion is consistent with the view that creativity results from a systemic relationship between the individual and the social environment [20; 22].

The role of the teacher also deserves special attention. During the experiment, it was found that an important condition is the teacher's transformation from a transmitter of knowledge into a facilitator and organizer of the creative process. In accordance with L.S. Vygotsky's idea of the zone of proximal development [26], the teacher should not give the student a ready-made solution, but should lead him or her to independent discovery through guiding questions and partial assistance. This demonstrates the need to develop creative thinking and functional literacy in the system of training future chemistry teachers, an issue extensively covered in I.E. Shernazarov's works on the training of future chemistry teachers [7; 8; 12; 17].

Some limitations of the study should also be noted. First, the experiment was conducted over one academic year with a relatively limited sample; longitudinal studies are needed to determine the long-term stability of creative competence. Second, the assessment of open-ended tasks involves a certain degree of subjectivity, which can be reduced by increasing the number of experts and refining the assessment rubrics. In future research, a promising direction is the creation of adaptive systems for developing and assessing creative thinking using digital technologies and artificial intelligence tools.

Conclusion and recommendations

Based on the results of the study, the following conclusions were drawn. First, creative competence is an integrative personal quality that combines the student's value-based attitude towards creative activity, the harmony of divergent and convergent thinking, experience in generating, evaluating and improving ideas, and the ability to regulate creative activity reflectively; it consists of motivational-value, cognitive-divergent, operational-activity and reflective-evaluative components.

Second, the main pedagogical and psychological features of developing creative competence in chemistry education were identified as taking into account adolescents' need for self-expression, creating a psychologically safe creative environment, strengthening intrinsic motivation through context-based content, consistently alternating the stages of divergent and convergent thinking, and systematically applying formative assessment and reflection.

Third, the system of creative tasks developed on the basis of the PISA 2022 framework and I.E. Shernazarov's scientific views on developing functional literacy, comprising divergent, context-based, inverse and modelling tasks, tasks on evaluating and improving ideas, and STEAM projects, makes it possible to develop all parameters of creative thinking simultaneously with the acquisition of chemical knowledge.

Fourth, the results of the pedagogical experiment confirmed the effectiveness of the proposed methodology: in the experimental group, the proportion of students with a high level of creative competence increased from 9.7% to 28.2%, and the difference between the groups was statistically significant ($\chi^2 = 16.32 > 5.99$).

Based on the results of the study, it is recommended to systematically include context-based and open-ended creative tasks in chemistry curricula and textbooks, to introduce special modules on creative pedagogy and the assessment of creative thinking into teacher professional development

courses, and to develop in future chemistry teachers the skills of designing creative tasks that meet the requirements of international assessment studies.

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