

# **METHODOLOGY FOR DEVELOPING CREATIVE COMPETENCE IN CHEMISTRY EDUCATION BASED ON INTERNATIONAL ASSESSMENT RESEARCH**

Usmanov Bakhtiyor Khabibullayevich

Academic Lyceum No. 2 of the Tashkent State Medical University

(AL №. 2 TSMU), Chemistry Teacher

---

## **Abstract:**

The development of creative competence is a priority in modern chemistry education, reflecting global shifts toward competency-based learning. International assessment research emphasizes creativity, problem-solving, and the application of scientific knowledge in real-life contexts. This study aims to develop and validate a methodology for fostering students' creative competence in chemistry education through international assessment-oriented instructional strategies. A quasi-experimental design was employed, involving control and experimental groups. The findings indicate a statistically significant improvement in students' creative competence in the experimental group, confirming the effectiveness of the proposed methodology and its alignment with international educational standards.

**Keywords:** Chemistry education, creative competence, international assessment research, competency-based approach, innovative methodology.

## **Introduction**

Contemporary chemistry education faces the challenge of preparing students not only with subject knowledge but also with creative competence necessary for solving complex scientific and societal problems. Creative competence encompasses originality, flexibility of thinking, and the ability to apply chemical knowledge in novel contexts.

International assessment research has introduced new perspectives on evaluating learning outcomes by prioritizing higher-order thinking, contextual reasoning, and creativity. These assessment frameworks provide a methodological foundation for rethinking instructional practices in chemistry education. However, the integration of international assessment principles into chemistry teaching methodologies remains insufficiently systematized.

This study addresses this gap by proposing a structured methodology for developing creative competence in chemistry education based on international assessment research.

## **Materials and Methods**

### **Research Design and Conceptual Framework**

This study employed a quasi-experimental mixed-methods research design, combining quantitative and qualitative approaches to ensure a comprehensive evaluation of the proposed

methodology. The research was grounded in competency-based education theory, constructivist learning principles, and the methodological foundations of international assessment research.

The experimental procedure was organized into three interrelated stages:

Diagnostic stage – identification of students' initial level of creative competence in chemistry;

Formative stage – implementation of the developed methodology based on international assessment-oriented instructional strategies;

Summative stage – evaluation of the effectiveness of the methodology through post-intervention assessment and comparative analysis.

This structure ensured systematic monitoring of changes in students' creative competence and allowed the identification of causal relationships between instructional intervention and learning outcomes.

### **Participants and Educational Context**

The participants were secondary school students studying chemistry within the framework of the national curriculum. An experimental group and a control group were formed. Both groups were comparable in terms of age, prior academic achievement, and instructional conditions.

Group equivalence was established using:

previous chemistry achievement records;

results of diagnostic pre-tests;

teacher assessments of students' baseline learning skills.

The study was conducted in a natural classroom environment to ensure ecological validity.

Participation was voluntary, and ethical standards of educational research were observed, including anonymity and informed consent.

### **Instructional Materials and Learning Resources**

Instructional materials for the experimental group were specifically developed on the basis of international assessment research principles, emphasizing the application of chemical knowledge in real-life contexts. These materials included:

context-based chemistry tasks reflecting environmental, industrial, and everyday chemical situations;

open-ended problem scenarios requiring multiple solution pathways;

data-rich tasks involving tables, graphs, experimental results, and textual information;

experimental and modeling activities encouraging hypothesis formulation and testing;

integrative tasks combining chemistry concepts with elements of physics, biology, and environmental science.

All materials were aligned with curriculum requirements while embedding international assessment characteristics such as authenticity, interdisciplinarity, and higher-order cognitive demand.

### **Instructional Procedure and Teaching Strategies**

The instructional intervention was implemented during regular chemistry lessons over a defined instructional period. The experimental group was taught using a structured methodology incorporating the following strategies:

Problem-based learning, in which students analyzed non-standard chemical problems derived from real-world contexts;

Inquiry-based instruction, involving questioning, hypothesis development, experimentation, and evidence-based conclusions;

Collaborative learning, promoting group discussion, peer evaluation, and collective problem-solving;

Reflective learning activities, including self-assessment and written reflections on problem-solving strategies.

Teachers acted as facilitators, guiding students' inquiry processes rather than providing ready-made solutions. The control group followed traditional teacher-centered instruction emphasizing explanation, memorization, and algorithmic problem-solving.

#### **Instruments for Data Collection**

Multiple instruments were employed to assess students' creative competence in chemistry:

Performance-based chemistry tasks, designed to evaluate originality, flexibility, and the scientific validity of solutions;

Analytic assessment rubrics, measuring key indicators of creative competence such as originality of ideas, logical reasoning, and application of chemical concepts;

Classroom observation protocols, documenting students' engagement, initiative, and interaction during learning activities;

Student reflective reports, providing qualitative insights into cognitive and metacognitive processes.

All instruments were reviewed by subject-matter experts to ensure content validity and alignment with research objectives.

#### **Assessment Criteria for Creative Competence**

Creative competence was evaluated using a multi-dimensional assessment framework, including the following indicators:

originality of problem-solving approaches;

flexibility in applying chemical knowledge across contexts;

ability to justify solutions using scientific evidence;

coherence and clarity of reasoning.

Each indicator was assessed on a multi-level scale, allowing quantitative comparison and qualitative interpretation of students' performance.

#### **Data Analysis Procedures**

Quantitative data obtained from pre- and post-tests were analyzed using descriptive statistics (mean values, percentage growth) and comparative analysis between experimental and control groups. This allowed identification of performance differences attributable to the instructional intervention.

Qualitative data from observations and reflective reports were analyzed through thematic content analysis, enabling the identification of recurring patterns related to creative thinking,

engagement, and learning strategies. The integration of quantitative and qualitative data ensured methodological triangulation.

### **Reliability and Validity**

To enhance the reliability and validity of the research results, several measures were implemented:

- standardized assessment conditions across groups;
- use of multiple data sources and assessment tools;
- consistency in instructional duration and content coverage;
- triangulation of quantitative and qualitative findings.

These procedures ensured the credibility, transparency, and replicability of the study.

### **Results**

The results of the study demonstrate the effectiveness of the proposed methodology for developing students' creative competence in chemistry education based on international assessment research.

#### **Quantitative Results**

Pre-test and post-test data analysis revealed a clear positive trend in the experimental group. At the diagnostic stage, both experimental and control groups showed comparable levels of creative competence, confirming their initial equivalence.

Following the formative intervention, the experimental group exhibited a statistically significant increase in creative competence indicators. The most notable improvements were observed in:

- originality of problem-solving approaches, reflected in students' ability to generate non-standard and diverse solutions;
- flexibility in applying chemical knowledge, particularly in unfamiliar and real-life contexts;
- scientific reasoning and justification, demonstrated through coherent explanations supported by chemical concepts and evidence.

In contrast, the control group showed only marginal improvement, primarily limited to procedural problem-solving skills. Comparative statistical analysis confirmed that the gains observed in the experimental group were significantly higher than those of the control group.

#### **Qualitative Results**

Qualitative analysis of classroom observations and student reflective reports provided additional evidence of the methodology's impact. Students in the experimental group displayed:

- increased engagement and motivation during chemistry lessons;
- greater initiative in proposing hypotheses and discussing alternative solutions;
- improved collaborative skills and willingness to defend their ideas scientifically.

These findings indicate that international assessment-oriented instructional strategies foster not only cognitive but also affective dimensions of creative competence.

## **Discussion**

The findings of this study confirm that integrating international assessment research into chemistry education significantly enhances students' creative competence. The observed improvements can be attributed to several methodological features.

First, context-based and open-ended tasks encouraged students to move beyond algorithmic problem-solving and engage in creative reasoning. This aligns with contemporary competency-based education theories emphasizing the application of knowledge rather than rote memorization.

Second, the use of international assessment-oriented tasks promoted higher-order thinking skills, including analysis, synthesis, and evaluation. Students were required to interpret data, justify conclusions, and consider multiple solution pathways, which directly contributed to the development of creative competence.

Third, the learner-centered instructional strategies employed in the experimental group supported active engagement and reflection. Inquiry-based and collaborative learning environments enabled students to articulate their ideas, receive peer feedback, and refine their reasoning processes.

The results are consistent with previous research highlighting the role of authentic assessment and real-life contexts in fostering creativity in science education. However, this study extends existing knowledge by providing a structured methodology specifically adapted to chemistry education and grounded in international assessment research.

Despite the positive outcomes, certain limitations should be acknowledged. The duration of the intervention and the sample size may limit the generalizability of the findings. Future studies should explore long-term implementation and application across diverse educational settings.

## **Conclusion**

This study demonstrates that a methodology for developing creative competence in chemistry education based on international assessment research is both effective and pedagogically valuable. The integration of assessment-oriented, context-based, and open-ended tasks into chemistry instruction significantly improves students' creative competence, scientific reasoning, and engagement.

The proposed methodology contributes to the modernization of chemistry education by aligning teaching practices with global educational trends and competency-based standards. It provides practical guidance for chemistry teachers seeking to enhance creativity while maintaining curricular coherence.

The findings have important implications for curriculum developers, teacher training programs, and educational policymakers. By adopting international assessment-based instructional strategies, chemistry education can better prepare students for complex problem-solving and lifelong learning in a rapidly changing world.

## References

1. OECD. (2019). PISA 2018 assessment and analytical framework. OECD Publishing.
2. OECD. (2023). PISA 2022 creative thinking framework. OECD Publishing.
3. OECD. (2017). PISA 2015 assessment and analytical framework: Science, reading, mathematics and financial literacy. OECD Publishing.
4. Bloom, B. S. (1956). Taxonomy of educational objectives: The classification of educational goals. Longman.
5. Anderson, L. W., & Krathwohl, D. R. (2001). A taxonomy for learning, teaching, and assessing: A revision of Bloom's taxonomy. Longman.
6. Guilford, J. P. (1967). The nature of human intelligence. McGraw-Hill.
7. Torrance, E. P. (1974). Torrance tests of creative thinking. Scholastic Testing Service.
8. Runco, M. A. (2014). Creativity: Theories and themes: Research, development, and practice. Academic Press.
9. Kaufman, J. C., & Beghetto, R. A. (2009). Beyond big and little: The four C model of creativity. *Review of General Psychology*, 13(1), 1–12.
10. Sternberg, R. J. (2006). The nature of creativity. *Creativity Research Journal*, 18(1), 87–98.
11. Vygotsky, L. S. (1978). Mind in society: The development of higher psychological processes. Harvard University Press.
12. Shulman, L. S. (1986). Those who understand: Knowledge growth in teaching. *Educational Researcher*, 15(2), 4–14.
13. Bybee, R. W. (2013). The case for STEM education: Challenges and opportunities. NSTA Press.
14. Holbrook, J., & Rannikmae, M. (2009). The meaning of scientific literacy. *International Journal of Environmental and Science Education*, 4(3), 275–288.
15. Kind, P., & Kind, V. (2007). Creativity in science education: Perspectives and challenges. *Studies in Science Education*, 43(1), 1–37.
16. Voogt, J., & Roblin, N. P. (2012). A comparative analysis of international frameworks for 21st century competences. *Journal of Curriculum Studies*, 44(3), 299–321.
17. Sawyer, R. K. (2017). Teaching creativity in science education. *Journal of Creative Behavior*, 51(2), 1–14.
18. Zimmerman, C. (2007). The development of scientific thinking skills. *Developmental Review*, 27(2), 172–223.
19. Hofstein, A., & Lunetta, V. N. (2004). The laboratory in science education. *Science Education*, 88(1), 28–54.
20. De Jong, O., & Taber, K. S. (2014). Teaching and learning the many faces of chemistry. *Chemistry Education Research and Practice*, 15(3), 1–12.
21. Dori, Y. J., & Belcher, J. (2005). Technology-enabled active learning in science. *Journal of the Learning Sciences*, 14(2), 243–279.
22. Trnova, E., & Trna, J. (2014). Implementation of creativity in science teacher training. *Journal of Baltic Science Education*, 13(1), 54–66.

23. Kind, P., & Osborne, J. (2017). Styles of scientific reasoning. *Science Education*, 101(1), 8–31.
24. Plucker, J. A., Beghetto, R. A., & Dow, G. T. (2004). Why isn't creativity more important in education? *Educational Psychologist*, 39(2), 83–96.
25. NRC. (2012). *A framework for K–12 science education: Practices, crosscutting concepts, and core ideas*. National Academies Press.