# DEVELOPING STUDENTS' COGNITIVE ACTIVITY THROUGH INDEPENDENT LEARNING IN AN INNOVATIVE CHEMISTRY EDUCATIONAL ENVIRONMENT

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**Abstract.** This thesis examines the methodological foundations of developing students' cognitive activity through independent learning in an innovative educational environment, with particular attention to inorganic chemistry instruction at technical universities. Drawing on the dissertation's conceptual model and reported pedagogical experiment involving 302 students, the discussion considers problem-based interactive tasks, metacognitive reflection, inquiry-based learning, the flipped classroom and self-directed learning. It also highlights the role of electronic educational resources in supporting independent study. The dissertation reports improvements of 16% in cognitive and procedural criteria and 17% in the integrative criterion. The analysis argues that a coherent combination of instructional strategies, reflective learning tasks and purposeful digital support can strengthen future chemistry specialists' independent reasoning and application of scientific knowledge.

**Keywords:** cognitive activity; independent learning; inorganic chemistry education; innovative educational environment; metacognitive strategies; inquiry-based learning; self-directed learning.

## INTRODUCTION

The development of students' cognitive activity is a significant pedagogical challenge in technical higher education, where knowledge of inorganic chemistry must be accompanied by the ability to interpret scientific information, explain chemical processes and independently solve professional problems. The transition toward an innovative educational environment creates opportunities to

move beyond the reproduction of ready-made knowledge. However, digital resources and interactive activities become educationally meaningful only when they support students' purposeful, self-regulated intellectual work.

This thesis is grounded in the dissertation abstract of Z. Sh. Usmanova (2026), "Methodology for developing students' cognitive activity through independent learning in an innovative educational environment (using the example of teaching chemistry in technical universities)." Its central concern is the methodological organization of independent learning for future chemistry specialists. Accordingly, the discussion focuses on the development of metacognitive abilities, critical and creative thinking, digital and media literacy, and the application of chemical knowledge to educational and professionally oriented situations. The objective is to explain how the components identified in the dissertation form a coherent pedagogical system rather than a collection of unrelated teaching techniques.

**MAIN BODY**

The dissertation approaches independent learning as an essential condition for developing cognitive activity in inorganic chemistry. This is particularly relevant to the study of chemical elements, substances and reactions, where students must connect observable phenomena with explanations involving microscopic structures and chemical regularities. Independent work therefore cannot be reduced to homework completion or reading assigned materials. It requires students to identify learning problems, search for and assess information, compare alternative explanations, formulate reasoned conclusions and reflect on the quality of their decisions. Such activities link disciplinary knowledge with the intellectual autonomy expected of future technical specialists. The conceptual difficulty of chemistry is consistent with Johnstone's (1991) analysis of multilevel scientific reasoning and Millar's (1991) account of abstraction in science learning.

One of the dissertation's principal contributions is the improvement of an adaptive system of problem-based interactive learning. Its reported instruments include Quest, Labyrinth, Blitz Survey, case-based tasks, brainstorming and activities organized with reference to Bloom's taxonomy. Their pedagogical value lies in the differentiation of cognitive demands. Short diagnostic questions can reveal gaps in prerequisite knowledge; cases require the analysis of contextualized problems; and more complex investigative tasks encourage comparison, inference and justification. The effectiveness of these techniques depends not on their novelty alone but on the extent to which each task activates a clearly defined cognitive operation. The value of explicitly structured problem solving in chemistry is also supported by Bunce, Gabel and Samuel (1991).

A second methodological direction concerns metacognitive strategies. The dissertation emphasizes search-oriented and reflective approaches to scientific cognition and connects them with critical, creative and analytical thinking. In practice, this means that a student should be able to explain not only what conclusion has been reached but also how the evidence was selected, why a particular solution was preferred and whether the result is consistent with chemical principles. Reflective questions after independent tasks may therefore address the reliability of information sources, the logical sequence of reasoning and the possibility of transferring an explanation to a new chemical situation. Zimmerman (2002) similarly identifies goal setting, monitoring and self-evaluation as central processes in self-regulated learning.

The innovative educational model described in the abstract integrates inquiry-based learning, the flipped classroom and self-directed learning. These approaches serve complementary functions. Self-directed learning emphasizes personal responsibility for planning and monitoring study; the flipped classroom makes preliminary engagement with instructional content possible before contact sessions; and inquiry-based learning organizes the subsequent

investigation of questions and problems. Within inorganic chemistry teaching, their integration allows theoretical preparation, interactive problem solving and reflective consolidation to operate as successive, mutually reinforcing stages. The dissertation identifies methodological, content-related, organizational-methodological and result-oriented components as the structural basis of this model.

Digital educational support is another source-grounded element of the methodology. The dissertation reports the development of the textbook “Inorganic Chemistry (for independent study of students)” and an electronic educational resource for independent study of inorganic chemistry, registered under certificate DGU 48500. Such resources can help organize access to learning materials and enable students to revisit difficult topics at an individual pace. Nevertheless, the methodological emphasis should remain on the quality of learning tasks: access to an electronic resource does not by itself establish deeper comprehension, whereas carefully designed search, comparison and self-assessment activities can make digital study cognitively productive.

The empirical component reported in the dissertation abstract involved 302 students from Fergana Polytechnic Institute, Namangan Engineering and Construction Institute and Jizzakh Polytechnic Institute. The abstract presents the results of pedagogical experimentation in terms of cognitive, procedural and integrative criteria. It reports effectiveness increases of 16% for the cognitive criterion, 16% for the procedural criterion and 17% for the integrative criterion. These figures are cited here as findings reported by the dissertation author; the abstract alone does not provide sufficient individual-level data for an independent reanalysis of the statistical calculations. The reported pattern nevertheless suggests that the proposed methodology was evaluated across both knowledge-oriented and application-oriented dimensions.

## CONCLUSION

The dissertation materials indicate that the development of cognitive activity in technical university chemistry education requires a systematically organized independent learning environment. The strongest feature of the proposed approach is the integration of problem-based interactive tasks, metacognitive reflection, inquiry-based learning, flipped classroom organization and self-directed study within a unified pedagogical model. In this framework, digital educational resources support the learning process but do not replace intellectual effort, scientific reasoning or purposeful teacher guidance.

The reported improvements in cognitive, procedural and integrative criteria provide a basis for considering the approach pedagogically promising. At the same time, these results should be interpreted within the scope of the dissertation abstract rather than presented as independently verified evidence. Further implementation should prioritize well-defined learning outcomes, authentic chemistry problems, transparent assessment criteria and opportunities for students to explain and evaluate their own reasoning. These conditions can contribute to the preparation of future chemistry specialists capable of independent knowledge acquisition and informed professional decision-making.

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