# DEVELOPING SCIENTIFIC LITERACY IN STUDENTS THROUGH IN-DEPTH TEACHING OF CHEMISTRY BASED ON A VARIABLE CURRICULUM

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**Annotation:** This article considers the issues of developing scientific literacy in students through in-depth teaching of chemistry based on a variable curriculum. The theoretical and practical aspects of teaching chemistry in accordance with the individual abilities and level of preparation of students in the modern education system, the formation of conceptual concepts, scientific experience foundations and problem-solving competencies are analyzed. The role of the variable approach in the development of scientific literacy, the methodology for using educational materials at different levels and the expected results are described based on the analysis of scientific and pedagogical literature.

**Keywords:** chemistry education, alternative curriculum, scientific literacy, conceptual understanding, problem solving, competence, in-depth learning

**Introduction:** Developing scientific literacy in students is one of the important tasks in modern chemistry education. International research shows that there is a need to move from traditional approaches to approaches aimed at developing scientific literacy in teaching chemistry. Alternative curricula play an important role in this process of change. As Talanquer noted, “central ideas in chemistry define fundamental concepts and shape the curriculum, teaching and assessment” [1]. These ideas form the basis of alternative curricula, allowing them to meet the needs of students at different levels. Sjöström and Eilks distinguish three different visions of scientific literacy: "the first level emphasizes the acquisition of chemical knowledge and practices, the second level emphasizes the understanding of the usefulness of chemical knowledge, and the third level emphasizes complexity and responsibility" [2]. The importance of teaching chemistry through systems thinking has been emphasized by Mahaffy and colleagues: "Is it possible for chemistry to be a central subject without systems thinking?" They show the role of chemistry in solving societal problems and interdisciplinary connections by asking the question [3]. This approach serves as an important principle in the development of alternative curricula. Janssen and colleagues propose the concept of chemical perspectivism, arguing that "theoretical perspectives unify knowledge and skills and can be developed as tools for thinking" [4]. This approach allows students to analyze chemical problems from different perspectives. Dewi and colleagues use an ethnochemistry approach to "develop students' scientific literacy by incorporating local knowledge related to cultural practices into the curriculum."[5]. The importance of visualization tools has been studied by Zhang and Linn: “dynamic visualizations significantly improve students’ understanding of chemical reactions” [6]. This is an effective tool for a variational approach, especially in explaining complex chemical processes. Çalık and Coll emphasize the importance of developing scientific thinking habits and write that “forming scientific thinking habits in the context of socio-scientific problems increases students’ critical thinking skills” [7]. Schwartz and colleagues developed a taxonomy for assessing chemical literacy, stating that “students’ chemical literacy level can be assessed in four aspects: chemical knowledge, knowledge in the context of chemistry, higher-order cognitive skills, and affective aspects” [8]. This taxonomy serves as an important guideline for developing variational curricula. Guerrero and Sjöström analyzed the concept of critical scientific literacy and concluded that “critical scientific literacy is essential for solving global problems such as climate change "includes knowledge and skills that are" [9]. Nimatulloyeva, reviewing innovative pedagogical approaches to differentiated education, writes that "a variable approach allows for improving the quality of education, taking into account the individual capabilities of students" [10]. This approach is of particular importance in in-depth teaching of chemistry.

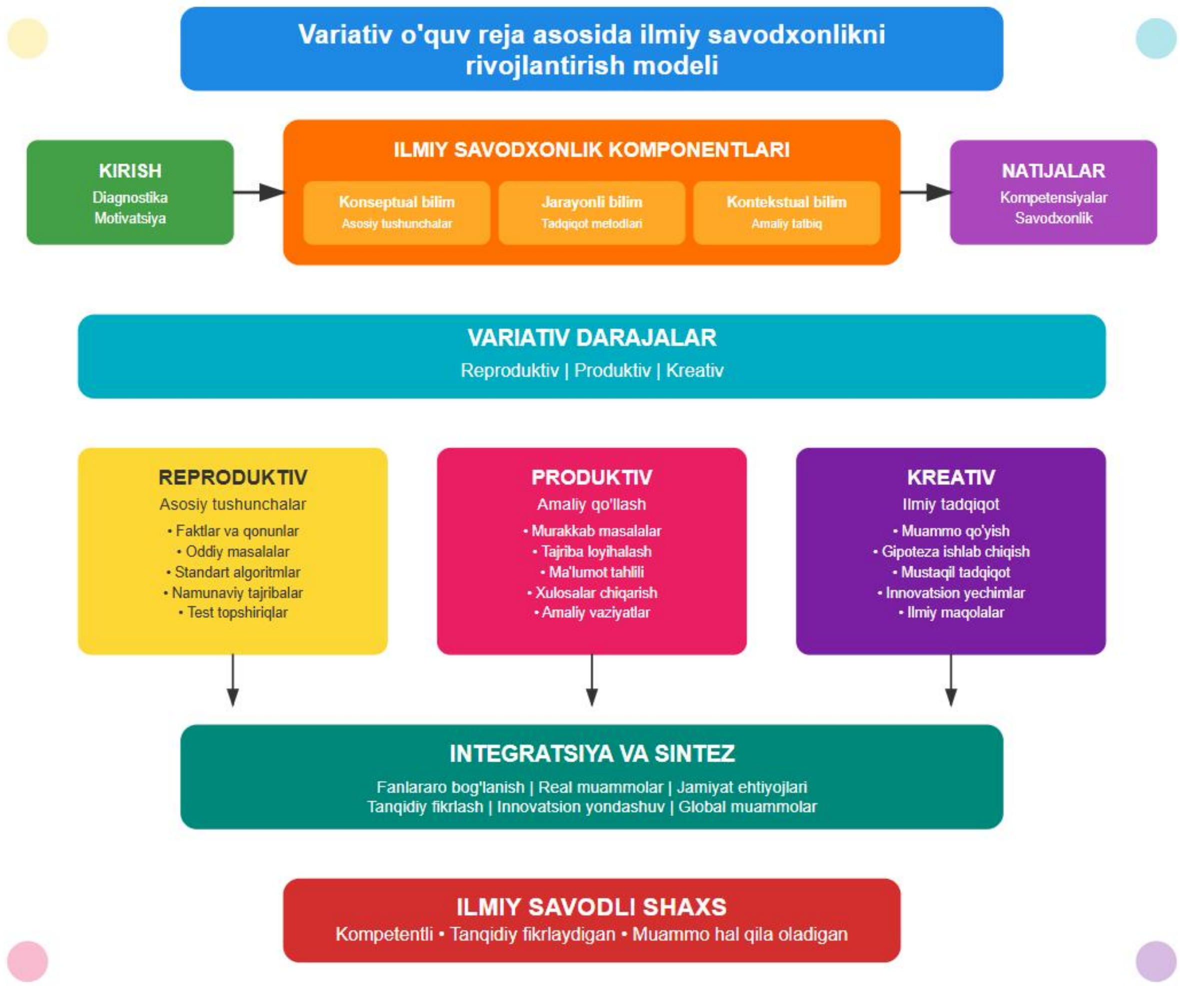


**Figure 1: Model for developing scientific literacy based on a variable curriculum**

In-depth teaching of chemistry based on a variable curriculum is an effective means of developing scientific literacy in students (Figure 1). Scientific literacy refers not only to knowing chemical facts and concepts, but also to being able to apply them in real-life situations, critically analyze and solve problems.

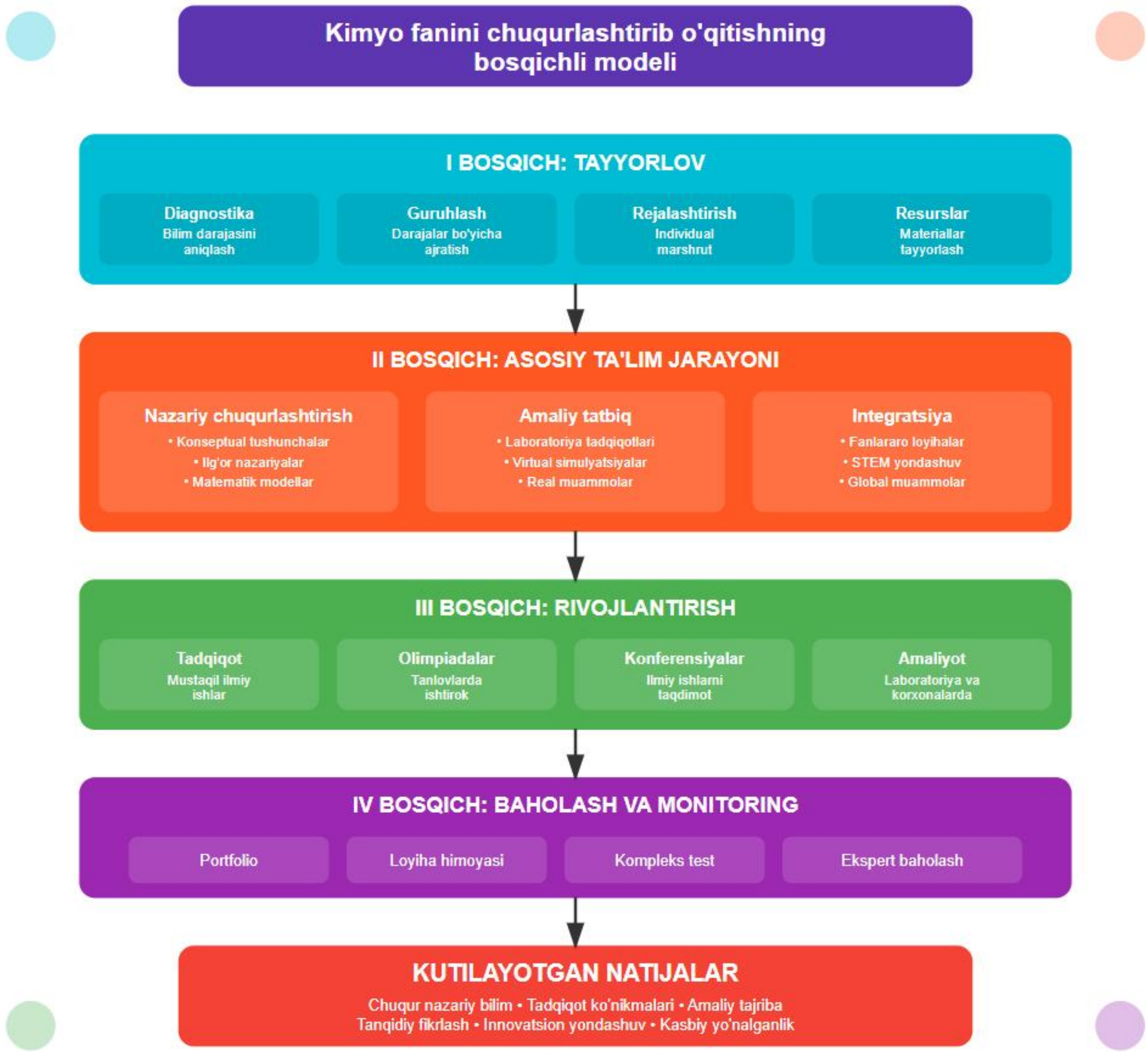


**Figure 2: A step-by-step model of in-depth teaching of chemistry**

A variable approach allows for individualization of the educational process, taking into account the different levels of preparation, interests, and learning speed of students (Figure 2). This approach includes the following main components: in-depth study of conceptual concepts, practical application of scientific research methods, problem-based learning, and interdisciplinary integration. In mastering conceptual concepts, students are provided with materials of different levels - from the basic level to the advanced level. While the basic level includes basic chemical concepts that meet the minimum state requirements, the advanced level covers complex chemical processes, research projects, and innovative solutions. Laboratory work, virtual experiments, and modeling play an important role in forming the foundations of scientific experience. Students become subjects who not only receive ready-made knowledge, but also independently search for and create knowledge. The context of real-life situations and socio-scientific problems is used to develop problem-solving competencies.

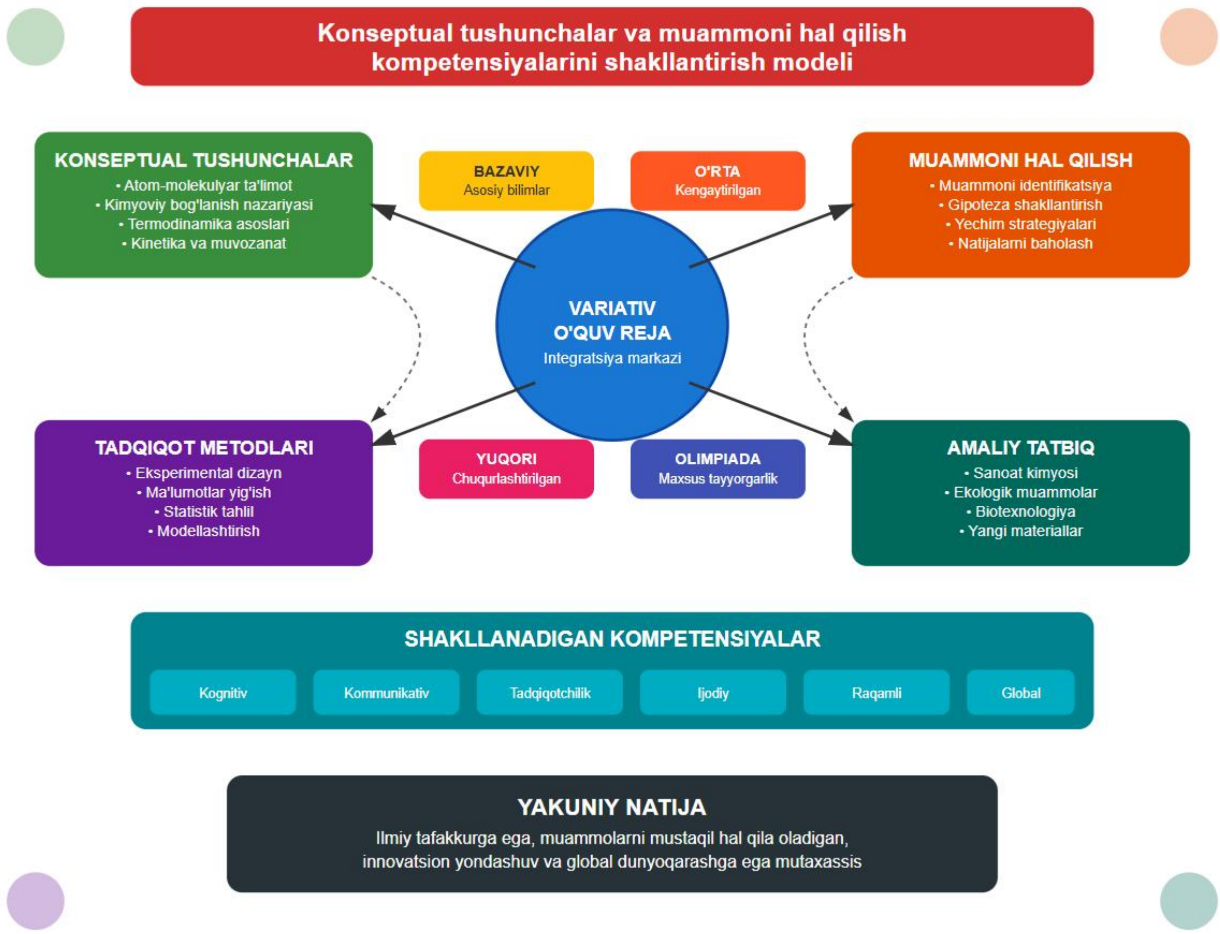


**Figure 3: A model for developing conceptual understandings and problem-solving competencies**

Students learn to apply chemical knowledge to solve environmental, economic, and social problems. A flexible curriculum allows for the flexible use of different teaching methods and tools (Figure 3). Diagrams and infographics are provided for visual learners, discussions for auditory learners, and practical experiences for kinesthetic learners. The assessment system is also based on a flexible approach - formative and summative assessment, self-assessment, and peer assessment methods are used. This allows students to manage and control their own learning process. As a result, students not only gain in-depth chemical knowledge, but also acquire scientific thinking, critical analysis, and problem-solving skills. They become scientifically literate individuals who can apply chemical knowledge in everyday life and in their future professional activities.

In-depth teaching of chemistry based on a variant curriculum is an effective way to develop scientific literacy in students. This approach allows students to develop conceptual understanding, scientific research skills, and problem-solving competencies, taking into account their individual characteristics. Through a variant approach, each student can receive education appropriate to their abilities and opportunities, develop scientific thinking and critical analysis skills. This, in turn, serves to educate a new generation of scientifically literate, innovative thinkers, and ready to solve global problems in society. In the future, improving this approach and applying it to other subjects will help improve the overall quality of the education system.

**References:**

1.Talanquer, V. (2016). Central ideas in chemistry: An alternative perspective. Journal of Chemical Education, 93(1), 3-8.

2.Sjöström, J., & Eilks, I. (2018). Reconsidering different visions of scientific literacy and science education based on the concept of Bildung. In Y. Dory, Z. Mevarech, & D. Baker (Eds.), Cognition, Metacognition, and Culture in STEM Education (pp. 65-88). Springer.

3. Mahaffy, P. G., Ho, F. M., Haack, J. A., & Brush, E. J. (2019). Can chemistry be a central science without systems thinking? Journal of Chemical Education, 96(12), 2679-2681.

4. Janssen, F. J., Westbroek, H. B., & van Driel, J. H. (2020). Scientific perspectivism in secondary-school chemistry education. Science & Education, 29(5), 1267-1291.

5. Dewi, C. A., Khery, Y., & Erna, M. (2019). An ethnoscience study in chemistry learning to develop scientific literacy. Journal Pendidikan IPA Indonesia, 8(2), 279-287.

6. Zhang, Z., & Linn, M. C. (2011). Can generating representations enhance learning with dynamic visualizations? Journal of Research in Science Teaching, 48(10), 1177-1198.

7. Çalık, M., & Coll, R. (2012). Investigating socio-scientific issues via scientific habits of mind: Development and validation of the scientific habits of mind survey. International Journal of Science Education, 34(12), 1909-1930.

8. Schwartz, Y., Ben-Zvi, R., & Hofstein, A. (2006). The use of scientific literacy taxonomy for assessing the development of chemical literacy among high-school students. Chemistry Education Research and Practice, 7(4), 203-225.

9. Guerrero, G., & Sjöström, J. (2024). Critical scientific and environmental literacies: A systematic and critical review. Studies in Science Education, 60(1), 45-78.

10. Nimatulloyeva, S. (2025). Differential Education: innovative pedagogical approaches. Journal of Preschool and School Education, 3(2), 12-24.