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A FRAMEWORK FOR ASSESSING SCIENTIFIC LITERACY IN BILINGUAL EDUCATION

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Abstract. This article analyzes the contemporary scientific and methodological foundations for assessing the scientific literacy of students in general secondary schools. It examines the concept of scientific literacy assessment, its role within the competency-based approach, and the assessment practices adopted in international educational systems. A comparative analysis of the views of foreign scholars demonstrates that scientific literacy should be assessed not only through subject knowledge but also through scientific reasoning, communicative competence, and a system of values. Based on the findings of the study, the theoretical foundations for developing assessment criteria and indicators grounded in a three-component model of scientific literacy—subject knowledge, language competence, and axiological values—are presented. The proposed framework contributes to improving the quality of natural science education, enhancing assessment practices, and supporting the effective implementation of competency-based education.
Keywords: scientific literacy, assessment, indicator, criterion, competency-based approach, CLIL, bilingual education, subject knowledge, language competence, axiological values.

Introduction. In recent years, profound reforms in education systems worldwide have shifted the focus from students' acquisition of theoretical knowledge to the development of competencies that enable them to think independently, solve problems scientifically, and make evidence-based decisions in real-life situations. Consequently, educational quality is increasingly evaluated not by the amount of information students can recall, but by their ability to apply acquired knowledge in practical contexts. This transformation has also introduced new methodological requirements for the teaching of natural sciences.

Scientific literacy is regarded as one of the key competencies of contemporary education. It refers to an individual's ability to explain natural phenomena scientifically, analyze scientific evidence, evaluate experimental results, and draw well-reasoned conclusions about ecological, biological, physical, and chemical issues encountered in everyday life. This competency plays a significant role in developing scientific worldviews, fostering innovative thinking, and promoting the sustainable development of society.

The transition to competency-based education has also required a fundamental reconsideration of assessment practices. Whereas traditional assessment primarily focused on measuring students' theoretical knowledge, contemporary educational approaches emphasize the assessment of knowledge application, scientific reasoning, problem-solving skills, communicative competence, and personal attitudes. Therefore, improving the criteria for assessing scientific literacy has become one of the most important scientific and methodological challenges in the field of educational methodology.

Extensive reforms have also been implemented in Uzbekistan to improve the content of general secondary education based on the competency-based approach, enhance students' performance in international assessment programs, and improve the quality of natural science education. However, classroom observations indicate that the assessment of scientific literacy is still largely focused on measuring reproductive knowledge. Comprehensive assessment criteria capable of evaluating essential competencies such as scientific reasoning, logical inference, the appropriate use of scientific terminology, and students' responsible attitudes toward nature have not yet been sufficiently developed.

From this perspective, an in-depth examination of the theoretical foundations of scientific literacy assessment, the analysis of existing assessment approaches, and the development of assessment criteria that meet the requirements of contemporary education constitute an important scientific and methodological challenge.

Theoretical Foundations of Scientific Literacy Assessment. A review of the literature indicates that the concept of scientific literacy has evolved considerably over time. Initially, it was interpreted primarily as the acquisition of knowledge related to the natural sciences. Subsequently, its scope expanded to include scientific reasoning, problem-solving abilities, evidence-based thinking, and civic responsibility. Contemporary perspectives define scientific literacy as an individual's ability to apply scientific knowledge in everyday life, critically evaluate scientific information, demonstrate responsible attitudes toward environmental issues, and make scientifically justified decisions. Therefore, assessing scientific literacy should extend beyond measuring knowledge acquisition and should encompass the evaluation of complex cognitive processes.

Within a competency-based approach, assessment should consider not only students' theoretical knowledge but also their practical performance, communicative skills, research abilities, and personal attitudes. Accordingly, the assessment of scientific literacy is most effective when organized as a multidimensional system that captures these complementary aspects of learning.

Theoretical analyses further suggest that assessment criteria should be based on indicators that are clear, objective, observable, and measurable. Otherwise, assessment results cannot accurately reflect students' actual competencies. This requirement is particularly important in bilingual and CLIL-based natural science education, where the assessment framework should evaluate not only subject knowledge but also students' language competence, since both dimensions are developed simultaneously throughout the learning process.

Development of Assessment Criteria and Indicators for Scientific Literacy. Assessing scientific literacy is a fundamental component of contemporary competency-based education. The primary objective of this process is not to determine students' ability to reproduce acquired knowledge, but rather to evaluate their competence in applying scientific knowledge to real-life situations, analyzing scientific problems, drawing evidence-based conclusions, and engaging in scientific communication. Therefore, the assessment system should be based on comprehensive criteria and indicators that reflect students' overall development.

An analysis of current assessment practices indicates that natural science education continues to place greater emphasis on evaluating theoretical knowledge. In contrast, competencies such as scientific reasoning, observation and experimental skills, the appropriate use of scientific terminology, environmental awareness, and collaborative learning are not assessed sufficiently. Consequently, accurately determining students' actual level of scientific literacy remains a significant challenge. To address this issue, a three-component model for assessing scientific literacy was developed within the framework of this study. This model enables a comprehensive evaluation of students' learning in natural science by integrating knowledge, skills, and values. It consists of the following three components:

- Subject knowledge**;**
- Language competence**;**
- Axiological values**.**

Each component is assessed using a set of specific criteria and measurable indicators.

Subject Knowledge Component. Subject knowledge represents the core dimension of scientific literacy. This component reflects students' understanding of concepts related to biology, physics, chemistry, geography, and ecology, their ability to recognize relationships among these disciplines, and their competence in explaining natural phenomena from a scientific perspective.

The assessment of this component is based on the following indicators:

- accurate explanation of scientific concepts;
- appropriate use of scientific terminology;
- identification of cause-and-effect relationships in natural phenomena;
- analysis of experimental and observational data;
- formulation of evidence-based scientific conclusions;
- application of acquired knowledge to everyday situations.

These indicators are designed to measure not merely students' ability to recall information but, more importantly, their capacity to apply scientific knowledge in practical contexts.

Language Competence Component. In a bilingual educational environment, the development of scientific literacy cannot be separated from language competence. During the learning process, students use scientific terminology, interpret experimental findings, explain graphs and diagrams, and participate in scientific discussions. For this reason, language competence was identified as an independent component of the assessment framework.

This component includes the following indicators:

- appropriate use of natural science terminology;
- comprehension of scientific texts;
- interpretation of diagrams, tables, and illustrations;
- oral and written presentation of experimental results;
- logical responses to scientific questions;
- active participation in group discussions.

These indicators make it possible to evaluate students' ability to communicate scientifically and to express natural science concepts effectively through language.

Axiological Values Component. One of the essential dimensions of scientific literacy is the development of students' conscious attitudes toward nature, the environment, and society. For this reason, the axiological values component was incorporated into the assessment framework.

This component reflects students' environmental awareness, interest in scientific inquiry, and sense of responsibility for environmental conservation.

Assessment is based on the following indicators:

- demonstrating a responsible attitude toward nature;
- understanding environmental issues;
- adopting a healthy lifestyle;
- collaborating effectively in group activities;
- showing interest in scientific inquiry;
- demonstrating environmental responsibility.

These indicators make it possible to evaluate students' personal qualities and value systems as integral aspects of scientific literacy.

The assessment criteria developed in this study provide a comprehensive framework for evaluating students' scientific literacy. Unlike conventional approaches that primarily assess theoretical knowledge, the proposed framework also evaluates students' scientific reasoning, communicative competence, and personal attitudes. The proposed criteria and indicators can be effectively applied in formative, interim, and summative assessment in natural science classes, enabling teachers to monitor students' learning progress systematically. Furthermore, this assessment framework provides teachers with valuable diagnostic information for analyzing the teaching and learning process, identifying learning gaps, and planning subsequent instruction more effectively.

Thus, the proposed assessment criteria and indicators constitute a comprehensive methodological framework for evaluating scientific literacy. The distinguishing feature of this framework is its integration of subject knowledge, language competence, and axiological values, allowing these three dimensions to be developed and assessed in a coherent and interconnected manner.

Conclusion. The findings of this study demonstrate that the effective assessment of scientific literacy should extend beyond measuring students' theoretical knowledge. It should comprehensively evaluate their ability to apply scientific knowledge in real-life contexts, employ scientific reasoning, communicate scientific ideas effectively, and demonstrate appropriate axiological values. From this perspective, the assessment criteria and indicators developed in this study, based on the three components of subject knowledge, language competence, and axiological values, provide a comprehensive framework for evaluating students' scientific literacy.

The proposed assessment system contributes to improving the effectiveness of competency-based natural science education by fostering scientific reasoning, scientific communication skills, and responsible attitudes toward nature. Furthermore, the proposed criteria and indicators can be employed in

formative, interim, and summative assessment, enabling teachers to assess learning outcomes objectively, monitor students' developmental progress, and continuously improve the teaching and learning process.

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