

ANALYSIS OF SCIENTIFIC RESEARCH ON THE DEVELOPMENT OF SCIENTIFIC LITERACY IN GENERAL SECONDARY EDUCATION

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Abstract:

This article scientifically and pedagogically analyzes modern methodological approaches aimed at developing students' scientific literacy in the general secondary education system. In particular, based on the analysis of scientific research conducted by scholars of our republic, effective methodological mechanisms for organizing the teaching process of natural sciences on an integrative, practice-oriented, and innovative basis are revealed. The article also substantiates the didactic opportunities for developing students' scientific thinking, problem-solving skills, evidence-based reasoning, and the ability to apply knowledge in practical situations.

Keywords: Scientific literacy, natural sciences, integrative approach, competency-based approach, scientific thinking, research competence, interdisciplinary integration, innovative educational technologies, problem-based learning, functional literacy, practical skills, international assessment programs.

Introduction

In the modern education system, the formation and development of students' natural-scientific literacy skills is considered one of the most important pedagogical tasks. In particular, during the teaching of natural sciences at the level of general secondary education, it is of special importance to develop students' abilities to explain natural phenomena on a scientific basis, conduct observations and experiments, analyze obtained results, and apply knowledge in practical situations.

In this process, organizing the educational content while taking into account students' age and psychological characteristics, integrating learning activities with research and practical work, and using effective methodological approaches are considered important factors. Therefore, improving the methodology of teaching natural sciences, developing students' scientific thinking, and conducting scientific research aimed at forming natural-scientific literacy skills are recognized as one of the key directions in pedagogical science. Below, scientific research conducted in this field and their results are analyzed.

In the Republic, several scholars have conducted scientific research on the development of students' knowledge and skills in natural sciences. For instance, in her research titled "Methodology for Using Assessment Programs in Monitoring Students' Natural-Scientific Literacy (Based on PISA and TIMSS)", M.T.Ergasheva thoroughly examines the theoretical and pedagogical foundations of monitoring students' natural-scientific literacy based on international assessment programs, their methodological mechanisms, and the possibilities of integrating them into the educational process. The study scientifically investigates not only the assessment of students' knowledge through PISA and TIMSS tasks, but also the identification, analysis, and development of their functional competencies. The approaches proposed by the researcher emphasize teaching natural sciences on the basis of integrative "Science," using assessment as a monitoring tool, and developing students' functional literacy.

In our view, the scientific approaches proposed by M.T. Ergasheva demonstrate the necessity of fundamentally improving the assessment system in the development of students' natural-scientific literacy. In particular, it is important to organize the assessment process not only as a control tool, but also as a didactic mechanism for developing students' scientific thinking, to systematically integrate PISA and TIMSS tasks into the educational process, and to strengthen interdisciplinary connections.

Furthermore, in school practice, it is necessary to move away from relying solely on test-based results and to increase the proportion of tasks aimed at analysis and conclusion-making based on various forms of data presentation such as texts, tables, graphs, and experimental results. This enables students not only to acquire knowledge, but also to develop competencies in applying knowledge in different situations, solving problem-based tasks, and making scientifically grounded decisions.

In her research titled "Development of Teachers' Methodological Preparation in Teaching Natural Sciences (Science)", B.A. Amirullayeva scientifically addresses the improvement of teachers' professional and methodological training based on interdisciplinary integration and a constructive approach. The study develops mechanisms for improving teachers' methodological competencies through integrative "Science" teaching models, the 5E model, problem-based learning, and project-based educational technologies. The researcher proposes a didactic model, a practical-technological system, and integrated methodological approaches within the system of continuous professional development for teachers. In addition, based on the research findings, curricula, methodological manuals, and professional development course content were improved and implemented in practice.

Based on the analyses conducted, it can be noted that the approaches proposed by A. Amrullayeva constitute an important methodological foundation for the systematic development of teachers' professional competencies in teaching natural sciences, the organization of the educational process on an integrative and practice-oriented basis, and the development of students' scientific thinking and functional literacy.

In his dissertation entitled "Improving the Mechanism for Organizing the Assessment of the Quality of Basic Secondary Education Based on the Requirements of the PISA International Programme," A. A. Ismailov presented the results of scientific research aimed at assessing

natural science literacy. The analysis of test results obtained within the framework of the two-stage study conducted by the researcher demonstrated that the development of the components of students' natural science literacy was characterized by different dynamics. The study substantiated the theoretical and organizational aspects of integrating the methodological foundations of the PISA programme, the competency-based approach, and international assessment mechanisms into the national education system¹.

The analysis of the research findings demonstrates that this approach constitutes an important scientific and methodological foundation for aligning the educational quality assessment system with international standards, identifying and developing students' functional literacy, and effectively managing the educational process.

In the dissertation entitled "Methodology for Organizing Student Project Work in General Secondary Schools Based on the STEAM Approach (with Reference to the Teaching of Natural Sciences)," researcher Z. M. Sangirova examines the implementation of modern pedagogical technologies, particularly the STEAM approach, in the process of teaching natural sciences in general secondary schools, with a focus on engaging students in practical and innovative activities. The study develops methodological approaches aimed at fostering students' critical thinking, problem-solving skills, and ability to work collaboratively. The author emphasizes that teaching natural sciences on an integrative basis contributes not only to the development of students' natural science, technical, environmental, and economic literacy, but also to the development of their critical and creative thinking. Furthermore, interdisciplinary integration creates opportunities for students to perceive nature as an integrated system and to develop a unified scientific understanding of the natural world in their cognitive framework².

The research conducted by Z. R. Khamidova under the title "Improving the Methodology of Teaching Natural Sciences to 6th-Grade Students through STEAM Educational Technologies" developed the theoretical and methodological foundations of the STEAM approach to teaching natural sciences, as well as a methodological system based on interdisciplinary integration and the competency-based approach. The study substantiated mechanisms for developing students' scientific thinking and natural science literacy through the 5E and 3C+2E models, project-based learning, and problem-based situations. The research findings demonstrate that the educational process organized on the basis of STEAM technologies significantly improved students' abilities to integrate interdisciplinary knowledge, solve problems, engage in scientific reasoning, and apply competencies in practical activities³.

The analysis of the research findings allows us to conclude that the approaches proposed by Z. M. Sangirova and Z. R. Khamidova constitute an important methodological foundation for ensuring interdisciplinary integration through STEAM technologies in teaching natural sciences, organizing the educational process on a practical and competency-oriented basis, and

¹ A.A. Ismailov "Tayanch o'rta ta'lim sifatini baholashning tashkil etish mexanizmini PISA xalqaro dasturi talablari asosida takomillashtirish" ped.fan. PhD diss. avtoreferat Toshkent 2022-53b

² Z.M.Sangirova "Ummumta'lim maktablarida STEAM yondashuvi asosida o'quv loihalarini tashkil etish metodikasi". ped.fan. PhD diss. Chirchiq 2022-117-b

³ Z.R.Xamidova STEAM ta'lim texnologiyalari vositasida 6-sinf tabiiy fanlarni o'qitish metodikasini takomillashtirish ped.fan. PhD diss. avtoreferat Toshkent 2025-59b

developing students' critical thinking, problem-solving skills, and scientific thinking. At the same time, these approaches represent a systematic pedagogical mechanism aimed at the comprehensive development of students' natural science literacy and improvement of the effectiveness of the educational process.

In the research conducted by L. M. Qaraxonova entitled "Improving the Methodological Foundations for Developing Students' Research Competence in Biology Lessons at General Secondary Schools," the theoretical and methodological foundations, pedagogical and psychological conditions, and didactic opportunities for developing students' research competence in biology education are examined. The study developed mechanisms for organizing research activities based on the competency-based approach and for developing students' scientific thinking and practical skills through scientific inquiry and interdisciplinary integration. The research findings demonstrate improvements in students' abilities to identify problems, search for and analyze information, conduct experiments, and substantiate and defend their findings. In addition, the educational process organized through small-scale research activities and project work produced effective results in developing students' research competence⁴.

The analytical findings indicate that this approach serves as a key methodological factor in developing students' research competence in biology education, directing them toward independent scientific thinking, and ensuring the integration of theory and practice.

In K. T. Suyarov's dissertation entitled "Developing Students' Learning and Research Skills through Physical Experiments," issues related to developing students' independent thinking, increasing their interest in scientific inquiry, and fostering their ability to identify and effectively solve problems are comprehensively analyzed⁵.

In the research conducted by Sh. T. Rakhmonov entitled "Preparing Students in Grades 7–9 of Specialized General Secondary Schools for International PISA Studies (with Reference to Natural Sciences)," the theoretical and methodological foundations, pedagogical conditions, and methodological mechanisms for preparing students for the PISA international assessment programme are examined. The study developed approaches aimed at fostering students' competencies in applying knowledge to real-life situations, scientifically explaining chemical phenomena, analyzing information, and engaging in creative thinking. The research findings demonstrate improvements in students' abilities to solve problems in non-standard situations, analyze evidence, interpret experimental results, and apply their knowledge in practice. Furthermore, the use of varied educational and methodological materials developed on the basis of PISA tasks, together with modern pedagogical technologies, produced positive results in improving the effectiveness of the educational process.⁶

⁴ L.M. Qaraxonova, "Umumiy o'rta ta'lim maktablari biologiya darslarida o'quvchilarning tadqiqotchilik kompetensiyasini rivojlantirishning metodik asoslarini takomillashtirish": ped. fan. bo'yicha falsafa doktori (PhD) dis. ... avtoref. – Toshkent, 2023. – 67 b.

⁵ Suyarov K.T. Fizik eksperimentlar asosida o'quvchilarda kuzatuvchanlik va tadqiqotchilik ko'nikmalarini rivojlantirish: ped. fan. (PhD) diss. – Chirchiq, 2019. – 124 b.

⁶ Raxmonov, Sh.T. "Ixtisoslashtirilgan umumiy o'rta ta'lim maktablari 7–9-sinf o'quvchilarini xalqaro PISA tadqiqotlariga tayyorlash (tabiiy fanlar misolida)": pedagogika fanlari bo'yicha falsafa doktori (PhD) dissertatsiyasi avtoreferati. – Samarqand: Islom Karimov nomidagi Toshkent davlat texnika universiteti, 2023. – 47 b.

The analytical findings demonstrate that experiment-based and PISA-oriented methodological approaches not only enhance students' natural science literacy but also develop their independent thinking, foster problem-solving skills, and strengthen their competencies in applying knowledge in practical activities. From this perspective, it is necessary to widely introduce elements of experiments and international assessment tasks into the teaching process in general secondary schools, enrich the content of educational and methodological materials, and improve the assessment system based on competency-oriented criteria.

In conclusion, developing students' natural science literacy within the general secondary education system is one of the priority areas of modern education. The findings of the analyzed studies demonstrate that the use of integrative, competency-based, STEAM, and PISA-oriented methodological approaches in teaching natural sciences provides effective opportunities for developing students' scientific thinking, research skills, problem-solving abilities, and competencies in applying knowledge in practice. At the same time, tasks developed in accordance with international assessment programmes, as well as educational technologies based on experimental and project-based activities, serve as important didactic tools for developing students' functional literacy. From this perspective, organizing the teaching of natural sciences in general secondary schools on the basis of innovative pedagogical technologies, strengthening interdisciplinary integration, improving the assessment system according to competency-based criteria, and directing students toward independent scientific activities are important factors in developing natural science literacy.

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