Implementation And Expansion Of Specialized Chemistry Education In Secondary Schools With The Formation Of Environmental Awareness

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Abstract: This study is aimed at a systematic analysis of the pedagogical foundations of specialized chemistry education in grades X–XI, as well as the processes of its implementation and dissemination. The subject of Chemistry provides students not only with fundamental scientific knowledge but also with opportunities for the development of intellectual, moral-ethical, and environmental thinking. The study examines the content, structure, and management models of specialized education, including project-based, target-oriented programmatic, and direct administrative management models.

Specialized chemistry education ensures differentiated instruction that takes into account students' individual interests, abilities, and professional orientations. Laboratory and practical experiments, problem-based tasks, project activities, and initiatives aimed at solving local environmental issues contribute to the deepening of students' environmental awareness, responsibility, and culture.

The study also identifies key pedagogical, resource-related, and methodological conditions necessary for the implementation and dissemination of specialized chemistry education. This process requires innovative, systemic, and comprehensive changes within the educational system. As a result, specialized chemistry education is presented as an effective form of education under modern conditions, aimed at developing students' creative potential as well as their scientific and environmental thinking.

Keywords: Chemistry, specialized education, grades X–XI, environmental awareness, laboratory experiments, practical activities, differentiation of instruction, individualized education, pedagogical models, educational innovations.

INTRODUCTION

At present, issues of sustainable societal development, environmental protection, and ensuring environmental safety have become particularly relevant within the education system. Under these conditions, there is a growing need to form environmental awareness among secondary school students from an early age. The subject of Chemistry is especially significant, as explaining the impact of chemical processes on the environment contributes to the development of environmental consciousness.

Specialized chemistry education in secondary schools provides opportunities to organize the educational process in accordance with students' individual interests, abilities, and future professional orientations. In this context, it is important to identify the scientific and didactic foundations for the systematic and in-depth formation of environmental awareness.

The implementation and expansion of specialized chemistry education contribute to the differentiation of learning activities, increased interest in the subject, and the identification of students' future professional trajectories. This form of education makes it possible to deepen the environmental component of knowledge and link it with practical activities.

Specialized education is aimed at adapting educational content to students' individual interests and abilities. The main didactic principles of implementing specialized chemistry education include scientific rigor, systematicity, accessibility, practical orientation, and integration. Adherence to these principles creates favorable conditions for combining chemical knowledge with the environmental aspects of education.

MATERIALS AND METHODS

Within the framework of specialized chemistry education, considerable attention is paid to the environmental consequences of industrial and technological processes, the safety of chemical substances, sources of environmental pollution, and methods for reducing their negative impact. Such content ensures a systematic and consistent formation of students' environmental awareness.

The development of environmental awareness is achieved through the integration of theoretical knowledge with practical activities during chemistry lessons. Laboratory work, practical experiments, problem-based tasks, and project-based activities promote the development of students' environmental thinking, analytical skills, and responsible attitudes toward nature.

Particular emphasis is placed on tasks related to local environmental issues, which strengthens students' personal responsibility for the condition of the surrounding environment. The systematic incorporation of environmental content into specialized chemistry education deepens students' scientific understanding and contributes to the formation of environmental culture.

The dissemination of specialized education and its pedagogical significance require strengthening the material and technical base of educational institutions, improving teachers' methodological preparedness, and providing adequate teaching and learning resources. In this process, the availability of environmentally oriented educational materials plays a crucial role.

The widespread implementation of specialized chemistry education increases students' interest in chemistry and ecology and actively involves them in research activities. As a result, students develop environmental knowledge, practical skills, and responsible behavior.

The application and development of various instructional management technologies by teachers represent a natural and objective process in modern education. This section analyzes domestic and international research on specialized education, examines the educational process and its key component—the professional activity of the teacher—and considers the didactic foundations for the implementation and dissemination of specialized chemistry education in grades X–XI through instructional technologies and quality management systems.

Specialized chemistry education in grades X–XI is viewed as a form of individualized learning that takes into account students' abilities, professional interests, aspirations, and

the requirements of future professional activity through changes in the internal structure, content, and organization of the educational process.

The purpose of specialized education is to create modern learning conditions for senior students that reflect their interests, abilities, and inclinations and are oriented toward lifelong learning and professional development. This system includes a specific educational model focused on individualization, consideration of students' real needs, and conscious career choice **[18]**.

In the Kyrgyz Republic, this system is currently at the stage of formation. For example, there are no specialized secondary schools in the city of Batken. At the same time, the Iskhak Razzakov Lyceum in Kyzyl-Kiya and the "Semetey" Lyceum in Kadamzhai (Batken region) implement specialized education for grades X–XI and demonstrate high academic achievements. Since specialized education meets modern educational requirements, its experience is widely applied in secondary schools of developed countries. Educators publish scientific articles on this topic and develop new approaches to improve the system.

An important task in organizing specialized education is determining its structure, directions, and profiling models. This process requires consideration of students' individual interests, abilities, inclinations, and preferences. It is also necessary to address factors that hinder the educational process, including the approval of an adapted general education standard, the development of a list of specialized textbooks, and the provision of qualified teaching staff.

In specialized chemistry education, three main directions are distinguished: natural science, physics-mathematics, and humanities. The materials of specialized courses often include new scientific fields that are not covered in basic curricula and are mainly presented in the works of foreign authors **[8]**. The main objective of advanced and specialized chemistry education is the development of students' creative thinking and environmental awareness. To achieve this objective, educational content should include not only selected theoretical material but also practice-oriented tasks, environmentally focused activities, and collaborative forms of learning. In collaborative learning, knowledge acquisition is most effective through the combination of teacher-guided instruction and students' active independent work, including the development of responsible attitudes toward the environment.

Students' activity involves solving chemistry problems of varying levels of complexity, independently or with teacher support, as well as analyzing these problems within an environmental context. Teaching materials should be sufficiently challenging while remaining accessible to learners. Simplified curricula do not meet the demands of modern society and should be replaced by extended or specialized courses with integrated environmental content.

The content of chemistry education is an integral component of natural science education. It reflects complex relationships such as "human–substance–life" and "substance–material–practical activity" and their impact on the environment. The formation of a chemical worldview and environmental awareness among students contributes to the development of scientific thinking, environmental culture, and appropriate behavior.

The subject of Chemistry provides students not only with fundamental natural science knowledge but also with significant educational potential for intellectual and moral development, as well as opportunities for forming environmental awareness. Chemistry education is a key condition for developing environmentally literate thinking and ensuring safe and responsible behavior. In accordance with modern educational requirements, the concept of specialized education is implemented in schools, within which environmental content is integrated into chemistry-biological, chemistry-mathematics, and physics-chemistry profiles.

Since chemistry is an experimental science, curricula place significant emphasis on laboratory and practical work, and demonstration experiments are conducted in diverse and enhanced forms. These experiments facilitate students' understanding of the impact of chemical phenomena on the environment and deepen their environmental awareness.
Specialized chemistry education in grades X–XI serves as a means of differentiation and individualization, enabling educators to consider students' interests, inclinations, and abilities and to create learning conditions aligned with their professional intentions and plans for continuing education. This process also contributes to the formation of environmental thinking, responsibility, and ecological culture. Specialized schools serve as an institutional form of achieving this goal, although other forms of specialized education may also be effective in certain contexts.
The core idea of updating general secondary education programs is to ensure an individualized, functional, and effective educational process. The transition to specialized education provides students with opportunities for in-depth study of selected subjects and individualized mastery of content, including the formation of environmental awareness.
The specialized education process takes into account students' interests, abilities, and preferences, allows for the selection of individual educational pathways, promotes in-depth acquisition of environmentally oriented knowledge, develops social skills and environmental responsibility, prepares graduates for informed career choices, fosters careful attitudes toward the environment, and ensures continuity of specialized education.
Numerous domestic and international studies have examined the content and structure of specialized education, the deepening of educational content, instructional differentiation, and support for individual development. Dissertation research by I.B. Bekboev, E.M. Mambetakunov, S.K. Kaldybaev, and E.E. Sindin addresses pedagogical conditions for effective management of the educational process, while G.B. Abakirova's work explores the influence of the credit system and staff training on educational effectiveness. The works of V.N. Averkyn, V.I. Bochkarev, K.Ya. Vazina, A.I. Kamyshnikov, A.M. Moiseev, M.M. Potashnik, A.N. Tikhonov, and T.I. Shamova also examine issues related to specialized education.
In addition, studies by T.P. Afanasyeva, N.V. Nemova, and I.D. Chechel focus on specific aspects of educational system management associated with specialized education. However, the limited number of such studies, as well as the complexity and specificity of implementing specialized education, indicate the need for further research.
It is necessary to clarify the terminology related to the management of specialized chemistry education. In particular:

- **Implementation of specialized chemistry education** refers to a system of measures aimed at establishing initial practices of specialized education within the educational system. This process involves the first application of the content, organization, and methodological foundations of a new specialized chemistry course in grades X–XI and creates conditions for the formation of students' environmental awareness.
- **Dissemination of specialized chemistry education** refers to a system of measures aimed at expanding the practice of specialized education throughout the educational system and introducing it in all schools, including those with limited resources. The large-scale nature of dissemination and differences in institutional preparedness complicate the process and may negatively affect educational outcomes. However, with expert support, established algorithms, and regulatory documentation, this process becomes more manageable and promotes the systematic and sustainable formation of students' environmental knowledge.
- **Transition to specialized chemistry education** is often used as a synonym for the concept of "implementation and dissemination of specialized education." In some cases,

the term "broad implementation of specialized education" is also applied, which is equivalent to the concept of "dissemination of specialized education."

The primary challenge in disseminating specialized chemistry education lies in its large-scale nature and the need to introduce new forms of instruction across all schools, including those with limited resources. At the same time, the dissemination process is simplified compared to initial implementation due to the availability of regional experience, methodological materials, and educational components with an environmental focus.

Following the completion of experimental implementation, it is necessary to achieve a widespread transition to specialized chemistry education in grades X–XI across all general education institutions in the country. The timelines, pace of implementation, prioritization of key objectives, student coverage, and specific regional models must be defined for each district and city.

At the national level, management of the implementation and dissemination of specialized chemistry education should be based not only on regulatory and legal frameworks but also on scientific and didactic principles. In all circumstances, effective management is essential, and the selection of scientific-didactic foundations must be deliberate and goal-oriented.

Within the general secondary education system of the Kyrgyz Republic, specialized education is divided into two main stages: the preparatory stage and the specialization stage. The internal structure of a profile includes three main components: the basic component, the specialized component, and elective courses. The basic and specialized components are determined by state educational standards for specific subjects, while elective courses are implemented according to the programmatic components of each school **[9]**.

According to this Concept, all specialized schools in the country provide complete compulsory education in core subjects. The development of subject-specific competencies at the specialized level allows students to strengthen key competencies in accordance with labor market requirements and higher education institutions **[19]**.

For grades X–XI, three primary scientific-didactic models have been identified for the implementation and dissemination of specialized chemistry education. Each model considers two key aspects of organizing specialized chemistry education within regional (municipal) education systems:

1. **Level of autonomy of specialized chemistry education** — the capacity to implement education independently at lower levels of the educational management hierarchy (municipal authorities relative to regional authorities, individual schools relative to municipal authorities).
2. **Activity and initiative of the management object** — that is, the initiative and responsibility of institutions involved in the organization of education.

Based on these characteristics, three new didactic models for the implementation and dissemination of specialized chemistry education are proposed:

- **Project-based (production) model** — organization of preparation, implementation, and dissemination of specialized chemistry education in grades X–XI through project design of corresponding activities.
- **Target-program model** — organization of preparation and implementation according to predefined programs and didactic objectives.
- **Direct administrative model** — organization of implementation and dissemination through direct management of the process and provision of the necessary resources.

A **target program** refers to a set of actions and structures aimed at achieving a specific result (change) within predefined temporal, financial, and other resource constraints. Such a program defines the desired future state of the system, the initial state, and ensures the transition from the current to the target state. In other words, if the concept defines the idea, content, and direction of system development, the target program specifies concrete

practical measures to achieve these goals. The target program is considered a flexible and versatile mechanism applicable in various regional contexts **[12]**.

Specialized chemistry education represents a dedicated pedagogical process, ensuring purposeful and organized collaborative activity of students and teachers, as well as an educational format aimed at forming environmental awareness and thinking. Ultimately, this process facilitates rational use of time, effort, and resources to achieve shared objectives.

The implementation and dissemination program for specialized chemistry education in grades X–XI is medium-term in nature and typically spans 3–4 years. Upon program approval, the overall implementation scheme must be clearly defined, creating conditions for systematic formation of students' environmental knowledge.

The program-target model for implementing and disseminating specialized chemistry education represents a specific document detailing action plans, timelines, responsible parties, and required resources. Such measures may include lessons with environmental content, laboratory and practical work, and the execution of environmental projects.

The program provides not merely a plan of action but ensures systematic, project-based, target-program, and strategic planning. It also allows for concise analytical justification, definition of desired objectives, and key parameters for transitioning from the current state to the target state, including criteria and indicators for the formation of students' environmental awareness.

The subject of the program is the mass transition to specialized chemistry education in grades X–XI. When developing and approving regional and municipal programs, the following features should be considered:

1. Implementation and dissemination of specialized chemistry education constitute a large-scale, complex, and systemic innovation. It affects not only the content, organization, and technologies of the educational process but also the school structure, resource provision (staff, teaching materials, legal and regulatory frameworks), and management of educational and ancillary processes. Consequently, monitoring of specialized chemistry education implementation should be viewed as a comprehensive process encompassing multiple interconnected changes.
2. Program implementation must be aligned with broader socio-economic processes. Linking regional educational programs with wider socio-economic initiatives enhances the effectiveness of implementation and dissemination.
3. Sociological studies indicate that specialized chemistry education in grades X–XI enjoys popularity among students and parents. This factor provides public support for the program and creates opportunities for effective implementation of regional initiatives.
4. Implementation and dissemination of specialized chemistry education are closely related to other components of education modernization: changes in the state assessment system, national quality assessment systems, reorganization of rural and urban school networks, and introduction of new teacher remuneration systems.
5. Successful program implementation depends on establishing a system of program-methodological, resource, and personnel support. Under these conditions, opportunities are created for broad and effective dissemination of specialized chemistry education.

The following aspects define the characteristics of regional and municipal programs, as well as the approach to specialized chemistry education in grades X–XI:

1. **Innovative nature of specialized chemistry programs** in grades X–XI. This requires consideration of previous experience and established practices in program development during implementation.

2. **Integration with regional and municipal educational programs**, as well as with major innovative initiatives in education, is essential for the implementation and dissemination of specialized chemistry education in grades X–XI.
3. **Ensuring broad public participation** in the development and discussion of programs is an important factor, enhancing the likelihood that programs meet societal needs and expectations.
4. **Engagement of the entire scientific and pedagogical potential of the region** in program development contributes to the quality and effectiveness of specialized chemistry education.
5. **Emphasis on preliminary resource provision and precise calculation of timelines and transition speed** for specialized education, taking into account regional capabilities, is a necessary condition for successful implementation.
6. **Formation of public awareness** regarding the depth and scale of changes associated with the transition to specialized chemistry education in grades X–XI is a key aspect.

To enhance the status of specialized chemistry education and improve program resource capacity, it is necessary to include programs in the list of priority regional initiatives and to ensure their approval by relevant governmental authorities.

The organization of specialized chemistry education in grades X–XI requires the creation of a dedicated collegial body, including specialists from educational authorities responsible for implementation and dissemination, representatives from municipal and school levels, and stakeholders from all participants in the educational process.

The **project-based model** of specialized chemistry education in grades X–XI presupposes a pre-planned management logic focused on specific innovative outcomes. Implementation and dissemination of the project-based model create conditions for establishing precedents of innovative practice at both municipal and school levels.

In this context, for effective implementation and dissemination of specialized chemistry education, it is necessary to carefully study experiences at the national level and in analogous regions. Based on these insights, all types of implementation and dissemination—including financial, material-technical, legal, scientific-methodological, staffing, and informational aspects—can be carried out efficiently.

Within the project-based model, the didactic foundations of specialized chemistry education in grades X–XI are considered as a project-program document for management at regional and municipal levels. This document reflects the overall educational concept and the anticipated social outcomes. Its structure is modular: each module covers both substantive and organizational-administrative aspects of specialized education and may be assigned to different executors (municipal districts, educational institutions, scientific organizations, education management departments, state-public bodies).

Implementation and dissemination of specialized chemistry education in grades X–XI require broad participation from governmental, public, and social structures. For example, in the city of Batken, one of the key mechanisms for transitioning to specialized education is the establishment of stable and effective communication between producers and consumers. The interests and needs of the local community—including business entities, entrepreneurs, parents, and the social environment—are considered through city boards of trustees, parent committees, student councils, and other public structures.

The development of governmental and public engagement in specialized chemistry education is evidenced by the successful annual enrollment of students from the Batken Regional Gymnasium-Boarding School into higher education institutions and their high performance in nationwide assessments. To ensure effective feedback, agreements, special studies to evaluate the social and economic efficiency of education, and activities aimed at developing the system are actively applied.

In the scientific study, **two models for the implementation and dissemination of specialized chemistry education in grades X–XI** were developed:

1. **Transition model** – focuses students on in-depth study of chemistry.
2. **Mixed model** – integrates the content of specialized education with the general education program, including adapted practical solutions for schools.

Conclusion

Specialized chemistry education in grades X–XI represents a form of individualized learning that takes into account students' personal interests, abilities, and professional inclinations. This form of education promotes the development of creative thinking, scientific and environmental awareness, as well as the acquisition of practical skills and responsible behavior.

Chemistry education provides the foundation for the formation of environmental consciousness, understanding the impact of chemical substances on the environment, and ensuring safe conduct. Within specialized education, laboratory work, practical experiments, project assignments, and activities aimed at addressing local environmental issues contribute to the systematic and in-depth development of environmental thinking, ecological culture, and student responsibility.

The implementation and dissemination of specialized chemistry education transform the content, organization, and technologies of the educational process and impose new requirements on school resources, personnel, and program-methodological support. One of the key objectives of this process is the systematic and sustainable development of students' environmental knowledge. In several lyceums in the Kyrgyz Republic, the experience of implementing specialized education has been successful, with effectiveness reinforced by scientific and didactic foundations at both regional and municipal levels.

Specialized chemistry programs in grades X–XI allow for differentiated knowledge acquisition, increase student interest in the subject, and help determine future professional orientations. They also foster the development of environmental thinking through laboratory work, practical experiments, and project assignments with environmental content.

Program-target and project-based models play a crucial role in ensuring the effectiveness of education, supporting the processes of implementation and dissemination with specific activities and resources. These models create conditions for deepening environmental knowledge, developing practical skills, and fostering responsible attitudes toward the environment.

Recommendations

1. **Expansion of specialized education:** Implement specialized chemistry education in grades X–XI across all general education schools, including those with limited resources, ensuring the necessary conditions for effective implementation.
2. **Integration of environmental content:** Systematically incorporate environmental aspects into laboratory and practical work, project assignments, and problem-based tasks in chemistry lessons.
3. **Methodological support:** Enhance teachers' methodological training for specialized chemistry education and provide accessible teaching materials with environmental content.
4. **Development of regional and municipal models:** Organize education and monitor progress using project-based, program-target, and direct administrative models of specialized chemistry education.
5. **Personnel and resource provision:** Ensure the program is supported by qualified teachers, administrative staff, and adequate material and technical resources for successful implementation.

6. **Public participation:** Increase the effectiveness of specialized education through collegial bodies, including students, parents, and local community representatives.
7. **Development of environmental culture:** Implement programs aimed at fostering environmental thinking, responsibility, and sustainable lifestyles among students within chemistry lessons.

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