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DEVELOPING DIDACTIC CONDITIONS AND EFFECTIVE PEDAGOGICAL MECHANISMS FOR ORGANIZING INTERDISCIPLINARY CONNECTIONS IN GENERAL SECONDARY SCHOOLS

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Abstract. This article examines the didactic conditions and pedagogical mechanisms that turn interdisciplinary connections into a productive component of teaching in general secondary schools. Based on a theoretical analysis of curriculum integration research, national education policy documents and generalized school practice, the study argues that links between subjects produce meaningful learning outcomes only when they are designed as a coherent system rather than introduced occasionally at a teacher's discretion. Four groups of didactic conditions are identified: normative and content-related, organizational and methodological, personnel-related, and diagnostic. Building on these conditions, the article proposes a set of pedagogical mechanisms, including coordinated thematic planning, integrated and binary lessons, interdisciplinary projects, problem-oriented case tasks and a criteria-based framework for assessing integrated learning results. It concludes that the proposed model can strengthen students' holistic worldview, functional literacy and capacity to transfer knowledge across subject boundaries.

Keywords: interdisciplinary connections; curriculum integration; didactic conditions; pedagogical mechanism; general secondary education; integrated lesson; project-based learning; functional literacy.

Introduction

Contemporary society places demands on school graduates that can hardly be met within the boundaries of a single academic subject. Real-world problems, whether environmental, technological, economic or social, are complex by nature, and solving them requires the ability to combine knowledge from several fields, to see relationships between phenomena and to apply what has been learned in unfamiliar situations. Against this background, the traditional subject-based organization of schooling, for all its advantages in ensuring systematic knowledge, often leaves students with a fragmented picture of the world in which physics, biology, history and literature appear as unrelated sets of facts.

International frameworks for the future of education emphasize that learners need not only disciplinary knowledge but also interdisciplinary, epistemic and procedural knowledge that allows them to act effectively in a changing environment [7]. In the Republic of Uzbekistan, the Concept for the Development of the Public Education System until 2030 sets the task of modernizing the content of general secondary education, introducing competence-based approaches and raising the quality of teaching in line with international standards [10]. Implementing these priorities naturally brings the question of interdisciplinary connections to the forefront of pedagogical theory and school practice.

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At the same time, school experience shows that interdisciplinary links are frequently realized in a spontaneous and fragmentary way. Teachers of different subjects plan their work independently, the timing of related topics in curricula is not always synchronized, and methodological guidance on designing integrated lessons remains limited. As a result, valuable opportunities for building students' coherent understanding are lost. This contradiction between the recognized importance of interdisciplinary integration and the insufficient development of the conditions and mechanisms for its implementation defines the relevance of the present study.

The aim of the article is to substantiate the didactic conditions under which interdisciplinary connections in general secondary schools become effective and to propose pedagogical mechanisms for their systematic organization.

Literature Review

The idea of connecting school subjects has a long history in pedagogy, yet its theoretical foundations were considerably refined in the second half of the twentieth century. J. T. Klein traced the evolution of interdisciplinarity as a concept and distinguished between borrowing methods from neighbouring disciplines, solving shared problems and building new integrative frameworks [6]. H. H. Jacobs proposed viewing interdisciplinary curriculum as a continuum of design options ranging from parallel discipline arrangements to fully integrated programs, stressing that the choice of option should depend on the educational goals rather than on fashion [5].

R. Fogarty described ten models of curriculum integration, among them the sequenced, shared, webbed, threaded and integrated models, each of which reflects a different degree of interaction between subjects [4]. J. A. Beane linked curriculum integration with learner-centred and democratic education, arguing that organizing content around significant problems and issues makes learning more meaningful for students [1]. S. M. Drake and R. C. Burns showed that integrated curricula can be aligned with educational standards and accountability requirements, which removes one of the main objections raised by practitioners [3]. A. F. Repko and R. Szostak, in turn, formalized the interdisciplinary research process, identifying stages such as defining the problem, drawing on relevant disciplinary insights, identifying conflicts between them and constructing a more comprehensive understanding [8].

The psychological basis for interdisciplinary learning is provided by cultural-historical theory, according to which higher mental functions develop through mediated activity and the generalization of concepts [9], as well as by research on the transfer of learning, which demonstrates that knowledge acquired in one context is transferred more successfully when learners understand its underlying principles and encounter it in varied situations [2]. Researchers in the post-Soviet and Uzbek pedagogical tradition have traditionally classified interdisciplinary connections by content (factual, conceptual, theoretical), by time (preceding, concurrent, subsequent) and by the methods of activity being transferred. Nevertheless, the literature still lacks a sufficiently operational description of the conditions and mechanisms that allow an ordinary school to implement interdisciplinary connections systematically, which is the gap this article seeks to address.

Materials and Methods

The study is theoretical and analytical in nature. Its methodological basis consists of the systemic and activity-based approaches, the competence-based approach and the principles of curriculum integration. The following methods were applied:

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analysis and synthesis of scholarly literature on interdisciplinarity and integrated learning; content analysis of normative documents regulating general secondary education; comparison of integration models described in international research; generalization of advanced pedagogical experience; and pedagogical modelling, which was used to construct the set of didactic conditions and pedagogical mechanisms presented below.

The analysis focused on three questions: which conditions must be in place at the level of the school and the teacher for interdisciplinary connections to function effectively; which pedagogical mechanisms translate these conditions into everyday classroom practice; and which criteria allow the results of integrated learning to be evaluated in a reliable way.

Results

The analysis made it possible to group the didactic conditions for organizing interdisciplinary connections into four interrelated blocks. Each block answers a specific question about what must be ensured before integration can become a regular feature of the educational process. The content of these blocks is summarized in Table 1.

Group of conditions	Content of the conditions	Expected effect
Normative and content-related	Identification of cross-cutting concepts and key ideas in curricula; synchronization of the timing of related topics across subjects; reflection of interdisciplinary outcomes in learning objectives	Logical coherence of content; removal of duplication and gaps between subjects
Organizational and methodological	Joint thematic planning by subject teachers; methodological associations working across subjects; timetable flexibility for integrated and binary lessons; availability of integrated teaching materials	Regular rather than occasional use of interdisciplinary links
Personnel-related	Teachers' readiness for integration: knowledge of related subjects, skills in co-designing lessons, motivation for collaboration; professional development programmes on integrated teaching	Competent and confident implementation of integrated learning

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Diagnostic	Criteria and indicators of interdisciplinary learning outcomes; tasks that require transfer of knowledge; monitoring and feedback on students' progress	Reliable evaluation of results and timely correction of the process

Table 1. Didactic conditions for organizing interdisciplinary connections in general secondary schools

The first block determines what should be integrated. Without a clear map of cross-cutting concepts such as energy, system, structure, change or interaction, teachers tend to connect subjects through superficial associations rather than through essential ideas. The second block determines how integration is organized: if teachers have no common time for planning and no institutional structure for cooperation, even well-designed content links remain on paper. The third block concerns who carries out integration, since the teacher's professional readiness is the decisive factor in transforming plans into practice. The fourth block ensures that integration is not an end in itself but is evaluated in terms of real changes in students' learning.

On the basis of these conditions, a set of pedagogical mechanisms was developed. In this study, a pedagogical mechanism is understood as a stable, reproducible sequence of actions by participants in the educational process that converts a didactic condition into a specific learning result. The following mechanisms proved to be the most significant.

Coordinated thematic planning. At the start of each academic term, teachers of related subjects jointly review their curricula, identify topics that overlap or support one another and agree on their sequence. The output of this work is an interdisciplinary thematic map, which shows, for example, that the study of solutions in chemistry should precede or coincide with the topic of osmosis in biology, and that the history of a scientific discovery can be discussed in history lessons while the corresponding law is studied in physics.

Integrated and binary lessons. An integrated lesson is built around a single problem examined through the lenses of two or more subjects, while a binary lesson is co-taught by two teachers. Such lessons are most effective at key points of the curriculum, when students need to generalize knowledge or apply it to a new situation. Their design requires a common goal, a clear distribution of roles between teachers and tasks that genuinely cannot be solved within one subject.

Interdisciplinary projects. Projects lasting from several days to several weeks allow students to investigate a real question, such as the water balance of their community, the energy efficiency of the school building or the cultural heritage of their region. Projects create a natural need for knowledge from mathematics, natural sciences, the humanities and information technology, and they develop the planning, cooperation and presentation skills that are central to the competence-based approach.

Problem-oriented case tasks. Case tasks present students with authentic situations described in an open-ended way. Unlike standard exercises, a case does not indicate which subject it belongs to, so learners must themselves decide which knowledge is relevant. This mechanism is particularly valuable for developing

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functional literacy, because it reproduces the conditions in which knowledge is used outside school.

Criteria-based assessment of integrated outcomes. Interdisciplinary results are assessed through criteria such as the ability to identify connections between phenomena studied in different subjects, the correct use of cross-cutting concepts, the transfer of methods of activity to new contexts and the quality of argumentation when solving complex problems. Rubrics shared by all participating teachers ensure that assessment is consistent and transparent for students.

The implementation of these mechanisms is advisable in three stages. At the preparatory stage, the school forms an interdisciplinary working group, analyses curricula and organizes professional development for teachers. At the main stage, integrated lessons, projects and case tasks are introduced into the educational process in accordance with the thematic map. At the reflective and corrective stage, the results are monitored, teachers share experience and the content and methods of integration are refined for the following academic year.

Discussion

The results are consistent with the view, widely shared in international research, that curriculum integration is effective only when it is purposeful and well structured [3; 5]. The proposed set of conditions shows that the main obstacles to interdisciplinary teaching are often organizational rather than conceptual: teachers usually recognize the value of integration, but they lack time for joint planning, synchronized programmes and appropriate assessment tools. For this reason, the organizational and methodological block of conditions deserves particular attention from school administrators.

It should also be emphasized that interdisciplinary connections do not replace subject-based teaching but complement it. A solid foundation of disciplinary knowledge remains a prerequisite for meaningful integration, since students cannot connect ideas they have not yet mastered [2; 8]. Therefore, the balance between subject lessons and integrated forms of work should be determined by the age of students, the nature of the content and the specific learning goals. The limitation of this study is its theoretical character; the effectiveness of the proposed mechanisms should be verified through experimental work in schools with different conditions.

Conclusion

The study has shown that the effective organization of interdisciplinary connections in general secondary schools depends on a combination of normative and content-related, organizational and methodological, personnel-related and diagnostic conditions. When these conditions are met, interdisciplinary links cease to be an occasional technique and become a systematic feature of the educational process.

The pedagogical mechanisms proposed in the article, namely coordinated thematic planning, integrated and binary lessons, interdisciplinary projects, problem-oriented case tasks and criteria-based assessment, provide a practical means of turning these conditions into concrete learning outcomes. Their consistent use can contribute to the formation of students' holistic worldview, functional literacy and ability to apply knowledge in real-life situations. Further research should focus on the experimental validation of the model and on the development of digital resources that support interdisciplinary teaching.

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