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SCIENTIFIC AND THEORETICAL FOUNDATIONS OF ENSURING INTERDISCIPLINARY INTEGRATION IN GENERAL SECONDARY SCHOOLS AND IMPROVING ITS PEDAGOGICAL POTENTIAL

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Abstract. The article analyses the scientific and theoretical foundations of ensuring interdisciplinary integration in general secondary schools and substantiates ways of enhancing its pedagogical potential. Philosophical, psychological and didactic interpretations of the concept of integration are compared, and the levels and models of interdisciplinary connections are systematised. A four-stage integrative model aimed at developing pupils' holistic scientific worldview and functional literacy is proposed, together with the pedagogical conditions required for its implementation. The findings may serve as a basis for practical recommendations on designing integrated lessons, organising collaboration among subject teachers and assessing interdisciplinary learning outcomes.
Keywords: interdisciplinary integration, interdisciplinary connections, general secondary school, integrated lesson, competence-based approach, STEAM education, holistic worldview, pedagogical potential.

Annotatsiya. Mazkur maqolada umumta'lim maktablarida fanlararo integratsiyani ta'minlashning ilmiy-nazariy asoslari tahlil qilingan hamda uning pedagogik imkoniyatlarini takomillashtirish yo'llari asoslab berilgan. Integratsiya tushunchasining falsafiy, psixologik va didaktik talqinlari qiyosiy o'rganilib, fanlararo aloqalarning darajalari va modellari tizimlashtirilgan. Muallif tomonidan o'quvchilarda yaxlit ilmiy dunyoqarash va funksional savodxonlikni shakllantirishga yo'naltirilgan to'rt bosqichli integratsion model hamda uni amalga oshirishning pedagogik shart-sharoitlari taklif etilgan. Tadqiqot natijalari integratsiyalashgan darslarni loyihalash, fan o'qituvchilarining hamkorlikdagi faoliyatini tashkil etish va fanlararo ta'lim natijalarini baholash bo'yicha amaliy tavsiyalar ishlab chiqishga xizmat qiladi.
Kalit so'zlar: fanlararo integratsiya, fanlararo aloqalar, umumta'lim maktabi, integratsiyalashgan dars, kompetensiyaviy yondashuv, STEAM-ta'lim, yaxlit dunyoqarash, pedagogik imkoniyat.

Аннотация. В статье анализируются научно-теоретические основы обеспечения межпредметной интеграции в общеобразовательных школах и обосновываются пути совершенствования её педагогических возможностей. Сопоставлены философские, психологические и дидактические трактовки понятия интеграции, систематизированы уровни и модели межпредметных связей. Предложена четырёхэтапная интегративная модель, направленная на формирование у учащихся целостного научного мировоззрения и функциональной грамотности, а также определены педагогические условия её реализации. Результаты исследования могут служить основой для разработки практических рекомендаций по проектированию интегрированных уроков, организации совместной деятельности учителей-предметников и оцениванию межпредметных образовательных результатов.

Ключевые слова: межпредметная интеграция, межпредметные связи, общеобразовательная школа, интегрированный урок, компетентностный подход, STEAM-образование, целостное мировоззрение, педагогические возможности.

Introduction

In the twenty-first century scientific knowledge expands far more rapidly than any single school subject can absorb, while the challenges that school leavers are going to face – climate change, digital transformation, public health, the rational use of natural resources – seldom respect the borders between academic disciplines. A curriculum composed of isolated subjects therefore runs the risk of producing fragmented knowledge: a pupil may confidently solve a quadratic equation in an algebra lesson and yet fail to recognise the very same relationship when it describes the flight of a thrown ball in physics. Overcoming this fragmentation has become one of the key tasks of contemporary general secondary education.

In the Republic of Uzbekistan the renewal of school education is proceeding within a clearly defined legal framework. The Concept for the development of the public education system until 2030 sets the goal of bringing the content of schooling closer to international standards and of strengthening the practical orientation of learning[1], whereas the Law "On Education" consolidates the competence-based orientation of state educational standards[2]. At the international level, the OECD Learning Compass 2030 likewise underlines that learners need not only solid disciplinary knowledge but also the capacity to think across disciplines and to combine knowledge from different fields when solving new problems[3].

Nevertheless, in everyday school practice interdisciplinary integration is frequently reduced to occasional "binary" lessons or to incidental references to another subject. Teachers often lack a methodological instrument that would allow them to plan integration systematically, to coordinate expected learning outcomes across subjects and to evaluate what has actually been achieved. The purpose of this article is, therefore, to clarify the scientific and theoretical foundations of interdisciplinary integration in general secondary schools and to substantiate ways of enhancing its pedagogical potential.

Theoretical foundations of the problem

The conviction that knowledge ought to be taught as a connected whole has deep roots in the history of pedagogy. Jan Amos Comenius maintained that things which are linked in nature should also be linked in instruction, and he viewed the unity of the world as the natural basis for the unity of teaching[4]. Within the progressive tradition, John Dewey connected learning with the continuity of experience and argued that school subjects become meaningful for children only when they are related to the real problems children encounter[5].

[1] Decree of the President of the Republic of Uzbekistan No. PF-5712 of 29 April 2019 "On approval of the Concept for the development of the public education system of the Republic of Uzbekistan until 2030".

[2] Law of the Republic of Uzbekistan "On Education" No. ZRU-637 of 23 September 2020.

[3] OECD. The Future of Education and Skills: Education 2030. – Paris: OECD Publishing, 2018.

[4] Comenius J.A. The Great Didactic / transl. by M.W. Keatinge. – London: Adam and Charles Black, 1896.

[5] Dewey J. Experience and Education. – New York: Macmillan, 1938.

In the didactics of the second half of the twentieth century the issue was developed primarily through the notion of interdisciplinary (intersubject) connections. I.D. Zverev and V.N. Maksimova interpreted these connections as a didactic condition that guarantees the consistency of the content of different subjects and contributes to the formation of a systemic picture of the world in the minds of learners[6]. Maksimova subsequently distinguished informational, conceptual, methodological and organisational types of connections and demonstrated that each of them performs its own educational, developmental and upbringing functions[7].

The psychological basis of integration lies in the associative and systemic nature of human thinking. According to the cultural-historical theory of L.S. Vygotsky, scientific concepts do not develop in isolation but within a system of generalisations, and instruction that operates in the zone of proximal development stimulates the restructuring of this system[8]. When a pupil meets such concepts as “energy”, “function” or “system” in several subjects, he or she is compelled to generalise them at a higher level – and this is precisely the mechanism by which conceptual understanding becomes deeper and more flexible.

It is essential to draw a distinction between interdisciplinary connections and interdisciplinary integration. Connections characterise relationships between the content of separate subjects, each of which preserves its autonomy; integration, by contrast, presupposes a qualitatively new whole in which elements of different subjects are synthesised around a common idea, problem or competence. J.T. Klein shows that interdisciplinarity covers a broad spectrum – from the simple borrowing of methods to the construction of new integrative frameworks[9]. Accordingly, integration at school can be regarded both as a process, namely the purposeful establishment of links between subjects, and as a result, expressed in holistic knowledge and transferable skills.

Western curriculum theory offers several typologies of integration. R. Fogarty described ten models, ranging from the “fragmented” and “connected” to the “threaded”, “integrated” and “networked” curricula, ordered according to the degree to which subject boundaries are dissolved[10]. S.M. Drake and R.C. Burns propose a more compact three-level scheme – multidisciplinary, interdisciplinary and transdisciplinary integration – in which the starting point gradually shifts from subject content to real-life questions[11]. J.A. Beane insists that genuine integration should be organised around significant personal and social issues identified jointly by teachers and pupils[12], whereas H.H. Jacobs advocates a design-oriented approach in which interdisciplinary units are deliberately planned alongside discipline-based instruction rather than replacing it[13].

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[6] Зверев И.Д., Максимова В.Н. Межпредметные связи в современной школе. – М.: Педагогика, 1981.

[7] Максимова В.Н. Межпредметные связи в процессе обучения. – М.: Просвещение, 1988.

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[9] Klein J.T. Interdisciplinarity: History, Theory, and Practice. – Detroit: Wayne State University Press, 1990.

[10] Fogarty R. The Mindful School: How to Integrate the Curricula. – Palatine, IL: Skylight Publishing, 1991.

[11] Drake S.M., Burns R.C. Meeting Standards Through Integrated Curriculum. – Alexandria, VA: ASCD, 2004.

[12] Beane J.A. Curriculum Integration: Designing the Core of Democratic Education. – New York: Teachers College Press, 1997.

[13] Jacobs H.H. (Ed.) Interdisciplinary Curriculum: Design and Implementation. – Alexandria, VA: ASCD, 1989.

In Uzbek pedagogical science the problem of integration is examined in close association with innovative pedagogical technologies. R. Ishmuhamedov and M. Yuldashev emphasise that interactive methods and cooperative forms of learning create favourable conditions for combining the content of various subjects and for developing pupils' independent thinking[14]. In recent years the STEM/STEAM movement has also drawn the attention of national researchers and practitioners; as R.W. Bybee notes, its value lies not in introducing yet another subject but in connecting science, technology, engineering and mathematics through authentic problems[15]. Generalising these approaches, the main levels of integration applicable in general secondary schools can be summarised as shown in Table 1.

Table 1. Levels of interdisciplinary integration in general secondary school

Level	Essence	Example in school practice
Intra-subject (connected)	Links are established between topics and sections within a single subject	Relating linear functions to their graphs and to word problems in algebra
Multidisciplinary	A common theme is studied in parallel in several subjects, each keeping its own logic	The theme "Water" considered in geography, biology and chemistry during the same term
Interdisciplinary	Shared concepts, skills and methods are taught jointly and assessed together	The concept of "energy" developed in physics, chemistry and biology with a common assessment task
Transdisciplinary	Learning is built around a real-life problem that goes beyond subject boundaries	The project "Saving water in our mahalla" combining research, calculation, design and public presentation

Methods

The research relies on a complex of theoretical methods: analysis of philosophical, psychological and pedagogical literature on the problem; comparative analysis of national and foreign approaches to curriculum integration; examination of normative documents and state educational standards; systematisation and generalisation of advanced teaching experience; and pedagogical modelling. Taken together, these methods made it possible to identify the conceptual components of integration and to construct a model for its implementation in general secondary schools.

Results and discussion

The analysis undertaken allows four groups of foundations of interdisciplinary integration to be singled out. The philosophical foundations are formed by the ideas of the unity and interconnectedness of the world and of the systemic character of scientific knowledge. The psychological foundations include the associative-systemic theory of thinking, the regularities of concept generalisation and the phenomenon of learning transfer. The didactic foundations are represented by the principles of systematicity, scientific rigour and the connection of learning with

[14] Ishmuhamedov R., Yuldashev M. Ta'lim va tarbiyada innovatsion pedagogik texnologiyalar. – Toshkent: Nihol, 2013.

[15] Bybee R.W. The Case for STEM Education: Challenges and Opportunities. – Arlington, VA: NSTA Press, 2013.

life, as well as by the competence-based approach. Finally, the methodological foundations comprise leading ideas, key concepts and universal learning actions that are common to several subjects and can therefore serve as "bridges" between them.

Relying on these foundations, we propose a four-stage model for enhancing the pedagogical potential of interdisciplinary integration. Its distinctive feature is that integration is treated not as an occasional event but as a cyclical, managed process embedded in the school's methodological work (Table 2).

Table 2. Stages of the model for enhancing the pedagogical potential of interdisciplinary integration

Stage	Content of activity	Expected result
1. Diagnostic and analytical	Analysis of curricula of related subjects; identification of overlapping concepts and of mismatches in the timing of topics; study of pupils' interests and learning needs	A map of interdisciplinary links for each grade
2. Design	Formulation of integrated learning outcomes; choice of a leading idea or problem; joint planning by teachers of different subjects	Integrated units, binary lessons and project assignments
3. Implementation	Integrated lessons, case studies, STEAM projects, problem-based and project-based learning supported by digital resources	Holistic knowledge, transfer of skills, higher learning motivation
4. Reflective and evaluative	Criteria-based assessment of interdisciplinary competences, portfolios, pupils' self-assessment and teachers' reflection	Feedback used to adjust the next cycle

The effectiveness of the model depends on a number of pedagogical conditions. First, sustainable collaboration among subject teachers is required: interdisciplinary methodological groups and dedicated time for joint planning help transform integration from an individual initiative into a collective practice. Second, the sequencing of topics in the curricula of related subjects should be coordinated so that a concept introduced in one subject is reinforced, rather than contradicted or anticipated, in another. Third, teachers need targeted professional development aimed at forming their own interdisciplinary competence. Fourth, the assessment system should capture interdisciplinary outcomes, for example through contextual tasks similar to those used in international studies of functional literacy. Fifth, a digital educational environment can substantially widen the range of shared resources, simulations and collaborative tools available to teachers and pupils.

These provisions can be illustrated by an integrated unit for the seventh grade built around the question "How can our school consume less electricity?". In physics lessons pupils study electric power and the operation of household appliances; in mathematics they process measurement data,

calculate percentages and construct diagrams; in informatics they create a spreadsheet model of the school's energy consumption; in native language lessons they prepare a persuasive appeal to classmates; and in technology lessons they design a simple energy-saving device. The unit concludes with a presentation to the school community. In this way, school subjects become instruments for solving a personally significant problem, and pupils experience the practical value of the knowledge they acquire.

At the same time, integration should not be pursued at the expense of systematic disciplinary knowledge. Excessive or mechanical integration may lead to superficial learning, to a loss of the internal logic of individual subjects and to an overload of both teachers and pupils. For this reason, in line with the position of H.H. Jacobs, integration in general secondary school should complement, rather than replace, subject-based instruction, and its forms should be selected according to the age of the pupils, the nature of the content and the intended learning outcomes.

Conclusion

The study shows that interdisciplinary integration in general secondary schools rests on a coherent set of philosophical, psychological, didactic and methodological foundations, and that it should be distinguished from simple interdisciplinary connections as a higher, synthesising level of organising educational content. Its pedagogical potential is revealed most fully when integration is planned as a managed cycle that includes diagnosis, design, implementation and reflective evaluation, and when it is supported by teacher collaboration, coordinated curricula, professional development, appropriate assessment tools and a digital learning environment.

The proposed model can be used by school methodological associations when designing integrated units and binary lessons, as well as by in-service teacher training institutions when developing courses on interdisciplinary teaching. Further research should focus on the experimental verification of the model, on the development of diagnostic instruments for measuring pupils' interdisciplinary competences, and on the adaptation of integration practices to the specific features of primary, lower secondary and upper secondary levels of schooling.

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