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Interdisciplinarity as a Catalyst for Educational Attainment: A Critical Analysis of PISA-2018 in the Belarusian Context

Abstract

This study examines the role of interdisciplinary approaches in educational achievements through the lens of PISA-2018 results, focusing on Belarus, Russian Federation and OECD as case studies. The research employs quantitative comparative analysis of PISA-2018 science assessment data, examining performance patterns across 33 tasks (115 questions) spanning biology, chemistry, physics, and geography, with particular emphasis on comparing student outcomes in single-subject versus cross-disciplinary problem-solving tasks. The research demonstrates that despite different educational systems, both countries show improved student performance in interdisciplinary tasks compared to single-subject assignments. The analysis reveals that integrated learning approaches contribute to better academic outcomes, even in systems traditionally based on isolated subject programs. The study provides insights into the potential of interdisciplinary education and suggests directions for educational reforms in both national contexts. The study is based on the results of the Belarus National PISA-2018 Report.

Keywords: interdisciplinary education, PISA-2018, educational achievement, Belarus, educational reforms, comparative education

The evolving landscape of education necessitates the adoption of pedagogical paradigms that transcend the rigid demarcations of traditional, discipline-specific instruction. Interdisciplinarity, as an epistemological framework, has gained increasing scholarly traction due to its efficacy in cultivating higher-order cognitive abilities, fostering analytical dexterity, and enhancing students' capacity to synthesize and apply knowledge across diverse conceptual domains. Empirical

studies consistently affirm that students exposed to integrative curricular designs demonstrate superior academic performance and adaptive competencies in comparison to those subjected to conventional, siloed instructional methodologies. The analysis of Belarusian student performance in the PISA-2018 assessment offers a compelling lens through which to examine the tangible impact of interdisciplinary approaches on educational outcomes, while simultaneously diagnosing systemic deficiencies and articulating pathways for strategic reform.

This inquiry juxtaposes the efficacy of mono-disciplinary and cross-disciplinary task engagement, with particular attention to the structural rigidity of the Belarusian educational model, historically characterized by compartmentalized subject instruction. Notwithstanding these constraints, PISA-2018 data substantiate the assertion that even within an entrenched framework of disciplinary isolation, cognitive engagement with multi-faceted problems correlates with enhanced performance metrics. These findings underscore the necessity of reconfiguring pedagogical strategies and advocate for a paradigm shift that extends beyond superficial curricular adjustments to encompass comprehensive systemic, sociopolitical, and institutional transformations conducive to fostering a robust interdisciplinary educational ecosystem.

The implications of these findings extend beyond individual student performance metrics and into the broader educational policy landscape. An effective shift toward interdisciplinarity requires not only methodological recalibration at the classroom level but also structural realignments at the administrative and policy-making levels. Schools and educational institutions must develop frameworks that encourage interdisciplinary collaboration among educators, enabling them to design curricula that seamlessly integrate concepts across disciplines. This integration must be supported by teacher training programs that equip educators with the pedagogical tools necessary to facilitate cross-subject learning experiences that are both meaningful and engaging.

Furthermore, fostering an environment where interdisciplinary learning thrives demands a reevaluation of assessment mechanisms. Traditional evaluation models that prioritize subject-specific mastery must be supplemented with assessment frameworks that measure students' ability to engage with complex, multi-dimensional problems. The development of competency-based assessments, which gauge students' capacity for critical analysis, synthesis, and application of knowledge across diverse contexts, will be instrumental in ensuring that interdisciplinary education translates into tangible academic and professional benefits.

Additionally, the sociopolitical landscape in which education systems operate plays a crucial role in determining the feasibility of interdisciplinary reform. In the case of Belarus, where the education system has long been characterized by rigid hierarchical structures and centralized curricular mandates, meaning-

ful reform necessitates a departure from entrenched bureaucratic mechanisms. Policy initiatives must be directed toward fostering institutional autonomy, allowing schools the flexibility to experiment with interdisciplinary pedagogies and tailor curricula to local and national priorities. This shift requires a concerted effort from stakeholders across multiple sectors, including educators, policymakers, researchers, and industry leaders, to create an educational ecosystem that is dynamic, responsive, and aligned with the evolving demands of the global knowledge economy.

Ultimately, the transition toward a more interdisciplinary approach in education is not merely an academic exercise but a strategic imperative. As demonstrated by the PISA-2018 findings, students who are equipped with the skills to integrate knowledge from multiple disciplines exhibit higher levels of adaptability, problem-solving acumen, and cognitive flexibility—traits that are indispensable in an increasingly complex and interconnected world. The successful implementation of interdisciplinary education hinges on a multi-tiered strategy that encompasses pedagogical innovation, policy reform, and cultural transformation, ensuring that education systems are equipped to nurture the next generation of thinkers, innovators, and global citizens.

Introduction and Research Motivation

The accelerating complexities of the 21st-century global landscape—marked by technological advancements, environmental challenges, and socio-economic interdependencies—underscore the imperative for educational systems to cultivate not merely knowledge acquisition but also its dynamic application in interdisciplinary contexts. Leading international educational assessments, including PISA, TIMSS, and PIRLS, emphasize not only content mastery but also the capacity for transdisciplinary problem-solving and real-world applicability of learned concepts.

Despite growing recognition of interdisciplinary education's benefits, there remains a significant research gap in understanding how students perform on interdisciplinary versus single-subject tasks within traditionally compartmentalized educational systems, particularly in post-Soviet contexts. While previous studies have demonstrated the general advantages of integrated learning approaches, limited empirical evidence exists regarding their specific impact on student performance in rigidly structured educational frameworks like that of Belarus, where disciplinary boundaries have historically been strictly maintained.

Therefore, this study aims to examine the role of interdisciplinary approaches in educational achievements through comparative analysis of PISA-2018 results, focusing on Belarus and Russia as case studies. Specifically, the research seeks to:

1) analyze performance differences between single-subject and cross-disciplinary tasks among Belarusian students; 2) compare these patterns with Russian Federation and OECD data; and 3) provide empirical evidence for the effectiveness of interdisciplinary learning even within traditionally isolated subject programs, thereby informing educational reform strategies in similar educational contexts.

Interdisciplinary education, by integrating methodologies, conceptual frameworks, and epistemic foundations from multiple subject domains, fosters a pedagogical environment that prioritizes critical inquiry, innovation, and analytical dexterity. Comparative analyses across educational systems confirm that students who engage in interdisciplinary learning models consistently outperform their peers in both academic assessment and cognitive resilience¹.

For instance, in Albania, empirical investigations have demonstrated that interdisciplinary pedagogical approaches exert a statistically significant positive impact on academic achievement among higher education students². Similarly, research in Thailand has shown that cross-subject instructional designs enhance language acquisition and communicative proficiency in English-language learners³. Within the domains of science and mathematics, contextually embedded problem-solving—such as leveraging epidemiological data to elucidate statistical principles—has been shown to facilitate deeper conceptual comprehension and knowledge retention⁴.

PISA-2018 and the Belarusian Context

The PISA-2018 assessment, with its focal emphasis on scientific literacy, provided an unprecedented opportunity to examine the cognitive competencies of Belarusian students within an international comparative framework.

The assessment encompassed three principal disciplinary domains: „Living Systems” (~44%), „Physical Systems” (~33%), and „Earth and Space Systems” (~23%).

¹ A. Basha, N. Lena, *The impact of interdisciplinary integration competence on students' academic performance: A case study of the psycholinguistics subject*, „Multidisciplinary Science Journal” 2024, <https://www.semanticscholar.org/paper/3970e229620147bd41a01125f69bbbd7866a2f08> (23 V 2025); W. Puengpipattrakul, *Modeling the determinants of English writing performance: Directions to interdisciplinary writing instruction*, „Electronic Journal of Foreign Language Teaching” 2021, <https://www.semanticscholar.org/paper/03d13dbdb421d09e95e93cce8d6a2cb9eff980e8> (23 V 2025); K.A. Islamirta, R.I. Putri, H. Hapizah, I. Mawarni, *Development of PISA-Like Math Tasks for Uncertainty and Data Using the Context of COVID-19*, „Jurnal Pendidikan Matematika” 2022, <https://www.semanticscholar.org/paper/af01913c66261926e92548e2b38c8578416df214> (23 V 2025).

² A. Basha, N. Lena, *op.cit.*

³ W. Puengpipattrakul, *op.cit.*

⁴ K.A. Islamirta, R.I. Putri, H. Hapizah, I. Mawarni, *op.cit.*

These thematic clusters were operationalized through 33 tasks comprising 115 distinct questions of varying cognitive complexity, spanning the disciplines of biology, chemistry, physics, and geography.

For this study, data selection and analysis followed a systematic methodological approach based on the Belarus National PISA-2018 Report. Tasks were categorized into two distinct groups: single-subject tasks (requiring knowledge from one scientific discipline) and cross-disciplinary tasks (requiring integration of knowledge from multiple scientific domains).

This classification was determined through content analysis of each task's cognitive demands and knowledge requirements. Single-subject tasks were identified as those explicitly confined to biology, chemistry, physics, or geography without requiring cross-referencing between disciplines. Cross-disciplinary tasks were defined as those necessitating synthesis of concepts from two or more scientific domains to reach a solution.

The analytical framework employed comparative performance analysis between Belarusian students and their Russian Federation counterparts, using percentage scores and success rates as primary metrics. Data from the OECD average served as an international benchmark for contextualizing regional performance patterns.

The Belarusian educational system operates under the Education Code of the Republic of Belarus (2011), establishing unified education standards with mandatory state ideology integration⁵. The system comprises primary education (grades 1-4), basic secondary (5-10), and upper secondary (10-12) with 17 mandatory subjects delivered through rigid disciplinary boundaries⁶. Since 2020, educational institutions have experienced intensified ideological control and militarization, with the Ministry of Education directly managing 266 educational institutions under increasingly centralized governance structures⁷.

Methodology and Data Selection Criteria

The selection of PISA-2018 data for this analysis was based on several key criteria. First, only science assessment tasks were included, as PISA-2018 focused primarily on scientific literacy, providing the most comprehensive dataset for interdisciplinary analysis.

⁵ *Code of the Republic of Belarus about education*, CIS Legislation, <https://cis-legislation.com/document.fwx?rgn=32756> (23 V 2025).

⁶ *K-12 Education System in Belarus*, Belarus Education Information Center 2024, <https://www.belaruseducation.info/k12/belarus-k-12-education-system.html> (23 V 2025).

⁷ *Education serves the regime. The ideologisation and militarisation of Belarusian schools*, „OSW Commentary” 2023, <https://www.osw.waw.pl/en/publikacje/osw-commentary/2023-05-17/education-serves-regime-ideologisation-and-militarisation> (23 V 2025).

Second, the study utilized the complete national dataset from the Belarus National PISA-2018 Report, encompassing responses from all participating Belarusian students.

The decision to compare Belarus with the Russian Federation was methodologically justified by shared educational heritage, similar post-Soviet institutional structures, and comparable socio-economic contexts, allowing for meaningful comparative analysis while controlling for historical and cultural variables. OECD averages served as the international benchmark to contextualize performance within global standards.

Task classification into single-subject versus cross-disciplinary categories was conducted through systematic content analysis by examining each task's cognitive requirements, knowledge domains involved, and problem-solving demands. Inter-rater reliability was ensured through independent classification by educational assessment experts. Only tasks with clear disciplinary boundaries or explicit interdisciplinary requirements were included in the final analysis, excluding ambiguous cases to maintain analytical precision.

PISA-2018 data yielded critical insights into the efficacy of the Belarusian educational system in cultivating interdisciplinary problem-solving capabilities. Despite the rigid disciplinary compartmentalization characteristic of Belarusian curricula, empirical findings indicate that students demonstrated a relatively stronger performance on integrated, cross-disciplinary tasks compared to isolated, monodisciplinary questions.

This trend aligns with global findings, suggesting that interdisciplinary pedagogical approaches not only enhance student motivation but also align more closely with real-world cognitive demands, thereby fostering a more engaged and intellectually agile student body.

Empirical Validation in Global Research

Empirical investigations across diverse educational contexts substantiate the multifaceted benefits of interdisciplinary methodologies. The increasing complexity of global educational frameworks necessitates a deeper understanding of cross-disciplinary interactions and their impacts on academic success, cognitive development, and problem-solving capabilities:

- 1) Academic Efficacy: Empirical findings indicate that integrative pedagogical strategies yield measurable enhancements in student performance. Studies in Albania⁸ demonstrate that interdisciplinary learning fosters deeper engage-

⁸ A. Basha, N. Lena, *op.cit.*

- ment, leading to improved comprehension and retention. Beyond mere academic metrics, these approaches cultivate intellectual curiosity and adaptive thinking, preparing students for dynamic problem-solving environments.
- 2) Cognitive and Analytical Development: Engagement in cross-disciplinary problem-solving tasks, akin to those employed in PISA assessments, fosters advanced competencies in communication, structured argumentation, and strategic reasoning⁹. Interdisciplinary tasks encourage students to synthesize knowledge from multiple domains, reinforcing higher-order cognitive functions such as abstraction, analysis, and inference. These skills are crucial in both academic and professional settings, where multifaceted problem-solving is increasingly in demand.
 - 3) Disciplinary Convergence.
 - 4) Mathematical and Scientific Cognition: The application of mathematical principles to real-world datasets—exemplified by the analysis of covid-19 epidemiological trends—has been shown to reinforce quantitative literacy and applied mathematical reasoning¹⁰. When students contextualize numerical data within biological, economic, or sociological frameworks, their ability to interpret and manipulate mathematical models improves significantly.
 - 5) Linguistic Proficiency and Composition: Interdisciplinary frameworks in language acquisition, as demonstrated in Thailand¹¹, facilitate significant improvements in written expression through immersive, contextually relevant exercises. Exposure to varied linguistic registers, professional jargon, and technical language enhances students' adaptability in real-world communication, fostering proficiency beyond standardized academic environments.
 - 6) Cultural and Translational Competence: Within translation studies, a robust interdisciplinary paradigm that integrates cultural contextualization enhances the fidelity and adaptability of translated materials¹². Understanding the socio-historical and psychological underpinnings of language improves translational accuracy and depth, addressing not only linguistic nuances but also ideological and contextual meanings.
 - 7) Global Academic Performance Optimization: In Kazakhstan, the integration of interdisciplinary research paradigms within pedagogical practice has been

⁹ K.A. Islamirta, R.I. Putri, H. Hapizah, I. Mawarni, *op.cit.*; M. Tóthová, M. Rusek, *Developing Students' Problem-solving Skills Using Learning Tasks: An Action Research Project in Secondary School*, „Acta Chimica Slovenica” 2021, vol. 68, no. 4, pp. 1016-1026.

¹⁰ K.A. Islamirta, R.I. Putri, H. Hapizah, I. Mawarni, *op.cit.*

¹¹ W. Puengpipattrakul, *Modeling the determinants...*

¹² M. Madkour, *The Impact of Culture and Intercultural Competence on the Performance of Students in Translation*, „Political Economy – Development: Public Service Delivery eJournal” 2018, <https://www.semanticscholar.org/paper/78e7ce1c06597bdcb254d0c37c56b6ecce76535> (23 V 2025).

instrumental in mitigating disparities in PISA outcomes¹³. The deliberate fusion of multiple knowledge domains within analytical tasks has augmented students' evaluative and critical thinking capacities. This suggests that interdisciplinary approaches serve as a corrective mechanism, bridging educational gaps and promoting equitable learning opportunities.

Cross-Disciplinary Methodologies Across Domains

The efficacy of interdisciplinary approaches is manifest in a broad array of academic and professional disciplines. As global education systems evolve, interdisciplinary approaches serve as catalysts for innovation, fostering the integration of diverse epistemological frameworks and practical applications across multiple fields:

- 1) Engineering and Physics: The synthesis of design-thinking methodologies with fundamental principles of physics—exemplified by reverse engineering practices—cultivates a deeper applied comprehension of theoretical constructs¹⁴. When students engage in interdisciplinary engineering projects, they refine their ability to deconstruct complex systems, apply scientific principles pragmatically, and develop innovative solutions to real-world challenges.
- 2) Natural Sciences and Computational Pedagogy: The incorporation of computational thinking within biological sciences, facilitated by digital technological tools, nurtures an expansive skill set encompassing algorithmic reasoning, data interpretation, and scientific inquiry¹⁵. Advanced digital tools, such as artificial intelligence-driven simulations and big data analytics, allow students to explore complex biological interactions, improving their ability to conceptualize large-scale scientific processes.
- 3) Mathematical Integration: The interdisciplinary fusion of mathematics with computational science, biological modeling, geographic information systems, and physics optimizes cognitive processing capabilities and enhances pragmatic problem-solving aptitude¹⁶. This integrative approach extends mathematical literacy beyond abstract computation, fostering tangible applications

¹³ B. Alzhanova, *Developing Students' Skills to Justify Their Decisions Through the Implementation of Research Tasks*, „Eurasian Science Review An International peer-reviewed multidisciplinary journal” 2023, <https://www.semanticscholar.org/paper/54644b419ece2767bf4c6f3e1db9bd5ae2901665> (23 V 2025).

¹⁴ A. Basha, N. Lena, *op.cit.*

¹⁵ D.R. Costa, C.W. Chen, *Exploring the relationship between process data and contextual variables among Scandinavian students on PISA 2012 mathematics tasks*, „Large-scale Assessments in Education” 2023, vol. 11, pp. 1-28.

¹⁶ W. Puengpipattrakul, *op.cit.*

in predictive modeling, environmental analysis, and technological development. Students trained in these methodologies are better equipped to contribute to interdisciplinary research initiatives and technological innovation.

- 4) Linguistics and Cognitive Science: The convergence of psycholinguistics with broader cognitive disciplines fosters superior academic outcomes by elucidating the intersection of language acquisition, cognitive processing, and neurological function¹⁷. By integrating principles of neuroscience and psychology, language education shifts from traditional rote memorization to dynamic cognitive engagement, resulting in improved language retention, critical thinking, and meta-linguistic awareness.

By integrating interdisciplinary methodologies across multiple domains, educators and researchers enhance students' ability to navigate complex knowledge landscapes, fostering intellectual versatility and adaptive expertise. These approaches not only refine domain-specific competencies but also encourage a holistic understanding of knowledge application, preparing learners for the challenges of an increasingly interconnected and technologically driven world.

Belarusian Data: Methodological Framework and Task Distribution

An analysis of the PISA-2018 dataset from Belarus provides a comprehensive insight into the distribution of assessment tasks and their underlying structural composition (Table 1). The data highlights the varying prevalence of different scientific disciplines in the assessment and the corresponding number of questions associated with each domain.

Table 1. Prevalence of different scientific disciplines in the PISA2018 science assessment

Subject	Number of Tasks	% of Tasks	Number of Questions	% of Questions
Biology	15	45%	57	50%
Physics	14	42%	44	38%
Geography	9	27%	39	34%
Chemistry	7	21%	22	19%
Total	33	-	115	-

Source: Own study based on Belarus National PISA-2018 Report.

¹⁷ A. Basha, N. Lena, *op.cit.*; K.A. Islamirta, R.I. Putri, H. Hapizah, I. Mawarni, *op.cit.*

A salient feature of the PISA-2018 assessment is its non-compartmentalized structure, requiring students to apply an interdisciplinary approach to problem-solving rather than relying solely on isolated knowledge within a single discipline. The integration of biology, chemistry, physics, and geography in task design necessitates cognitive flexibility and the ability to synthesize information across subjects. This design paradigm diverges markedly from the traditional Belarusian educational framework, which predominantly maintains rigid disciplinary boundaries and lacks formally structured interdisciplinary curricula. Nevertheless, empirical evidence derived from PISA-2018 suggests that students who encountered similar scientific phenomena across multiple subjects demonstrated a marked improvement in comprehension and problem-solving capabilities.

The absence of systemic interdisciplinary instruction in Belarusian schools poses a challenge to students, particularly in international assessments that prioritize real-world applicability over rote memorization. However, the data also underscores a promising trend: when students are exposed to a problem from multiple disciplinary perspectives, their performance significantly improves. This suggests an innate ability to construct conceptual linkages and transfer knowledge across domains, despite the lack of explicit curricular support for such cognitive integration.

Comparative Performance in Single-Subject vs. Cross-Subject Tasks

A comparative analysis of Belarusian students' performance in single-discipline versus cross-disciplinary tasks reveals a striking divergence in results. In assessments that were confined to a singular subject, Belarusian students underperformed relative to both the OECD average and their Russian Federation (RF) counterparts. This discrepancy was particularly pronounced in the domains of chemistry and physics, where students exhibited significant challenges in problem-solving and application-based reasoning.

Table 2. Comparative breakdown of performance in single-subject versus multi-subject tasks

Subject/Type	BY (%)	RF (%)	OECD (%)
Chemistry (single)	38.4%	48.8%	51.7%
Physics (single)	40.8%	45.0%	49.9%
Chemistry/Geography (multi)	56.9%	56.4%	58.4%
Biology/Chemistry (multi)	56.9%	54.8%	56.2%

Source: Own study based on Belarus National PISA-2018 Report.

However, a markedly different trend emerges when students engaged with interdisciplinary tasks. In such cases, the performance gap between Belarusian students and their RF counterparts was significantly reduced, and in some instances, Belarusian students demonstrated superior results. This is indicative of the fact that cross-subject contextualization enhances comprehension and facilitates a more nuanced understanding of complex scientific concepts.

These findings reveal a paradox requiring theoretical explanation. Following Scott's hidden transcript theory¹⁸, Belarusian students appear to maintain dual cognitive systems: public compliance with rigid subject boundaries alongside private cultivation of cross-disciplinary connections. This „latent cognitive resilience” manifests through three mechanisms:

First, cultural transmission resilience – historical intellectual traditions persist through family and community networks despite official suppression¹⁹. Second, cognitive compartmentalization – students separate performative compliance from genuine intellectual exploration²⁰. Third, cognitive dissonance navigation – constant exposure to contradictions between official ideology and observable reality may enhance students' capacity for complex reasoning, as documented in other post-Soviet educational contexts²¹.

This aligns with research showing cognitive flexibility can emerge as a reactive response to authoritarian educational environments²². Similar patterns appear in Hong Kong's National Security Education resistance, where educators use „metaphors, jokes and prayers” to maintain critical thinking²³. The persistence of interdisciplinary thinking in Belarusian students thus reflects deeper patterns of intellectual resilience documented in post-Soviet contexts²⁴.

Furthermore, the data highlights a broader implication for pedagogical strategies in Belarusian education. The observed improvements in student performance on multi-subject tasks point to the potential benefits of incorporating interdisciplinary teaching methods, particularly in science education. Given that

¹⁸ J.C. Scott, *Domination and the Arts of Resistance: Hidden Transcripts*, New Haven 1990, pp. 45-47.

¹⁹ N. Bekus, „Hybrid” *Linguistic Identity of Post-Soviet Belarus*, „Journal on Ethnopolitics and Minority Issues in Europe” 2014, vol. 13, no. 4, pp. 26-51.

²⁰ N. Massoumi, M. Morgan, *Hidden Transcripts of the Powerful: Researching the Arts of Resistance*, „Sociology” 2024, vol. 58, no. 6.

²¹ S. Vasilevich, *Higher Education in Belarus after 2020: The Erosion of Academic Freedom and Institutional Autonomy*, „Belarus-Analysen” 2024, no. 4, pp. 2-8.

²² A. Portelli, *The Battle of Valle Giulia: Oral History and the Art of Dialogue*, Madison 1997, pp. 46-49.

²³ L. Lui, *Winning quietly: Hong Kong educators' resistance to National Security Education*, „Sociology of Education” 2023, vol. 72, iss. 2, pp. 451-470.

²⁴ D. Halavach, *Samizdat and the Ambiguities of Resistance in the Post-Stalin USSR*, Budapest 2014.

PISA assessments are designed to evaluate the application of knowledge in novel contexts rather than mere recall of information, it becomes evident that a shift towards interdisciplinary instruction would better align Belarusian students with the cognitive demands of international assessments.

From a policy perspective, these insights necessitate a reevaluation of current curricular structures. Implementing a more integrated approach to science education, wherein students are encouraged to draw connections between various scientific disciplines, could yield substantial improvements in both national and international academic performance metrics. Given that cross-disciplinary reasoning skills are highly valued in contemporary scientific and professional landscapes, fostering such cognitive abilities in students would enhance their adaptability and preparedness for the evolving demands of higher education and the workforce.

Ultimately, the evidence from PISA-2018 strongly suggests that interdisciplinary cognition fosters deeper comprehension and more effective problem-solving abilities among students. This calls for a concerted effort to refine Belarusian educational methodologies to cultivate a more holistic and integrative approach to science instruction, thereby ensuring that students are better equipped for the complexities of the modern knowledge economy.

Visualization and Trend Explanation

A meticulous analysis of the national report's graphical data (Fig. 1 & 2) reveals notable trends regarding Belarusian (BY) student performance in comparison with both regional and international benchmarks. Specifically, Belarus exhibits superior proficiency in cross-disciplinary tasks compared to Russia, at times even approaching the OECD benchmark. However, in single-discipline tasks, Belarus consistently ranks lower, indicating a divergence in cognitive strengths depending on the nature of the assessment.

This disparity can be attributed to the cognitive and structural demands of cross-subject tasks, which frequently present real-world scenarios requiring the synthesis of diverse knowledge domains. Unlike traditional assessments focused on subject-specific memorization, cross-disciplinary tasks emphasize conceptual comprehension, problem-solving strategies, and adaptive reasoning. Students engaging with such tasks tend to exhibit higher cognitive flexibility, demonstrating the ability to apply interdisciplinary knowledge rather than relying solely on isolated factual recall. This phenomenon aligns with educational theories that emphasize the role of meaningful learning in fostering long-term retention and analytical capacity.

Fig.1. Comparative performance of Belarusian students in single-subject vs. cross-disciplinary tasks

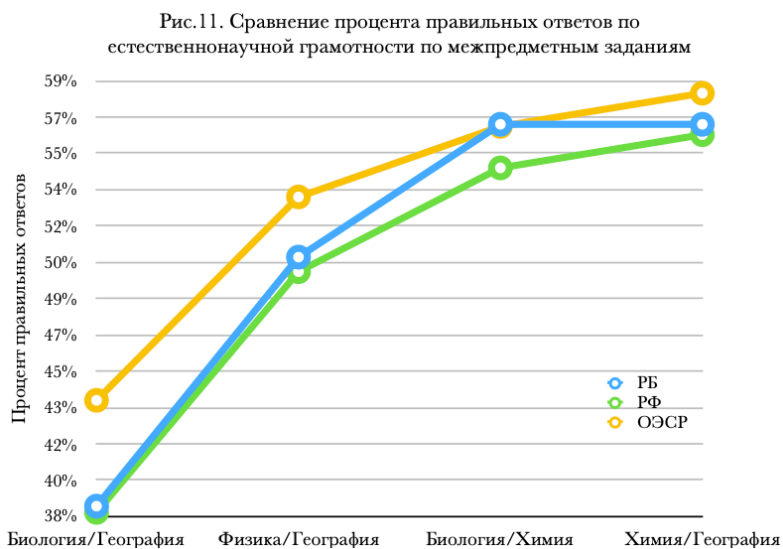
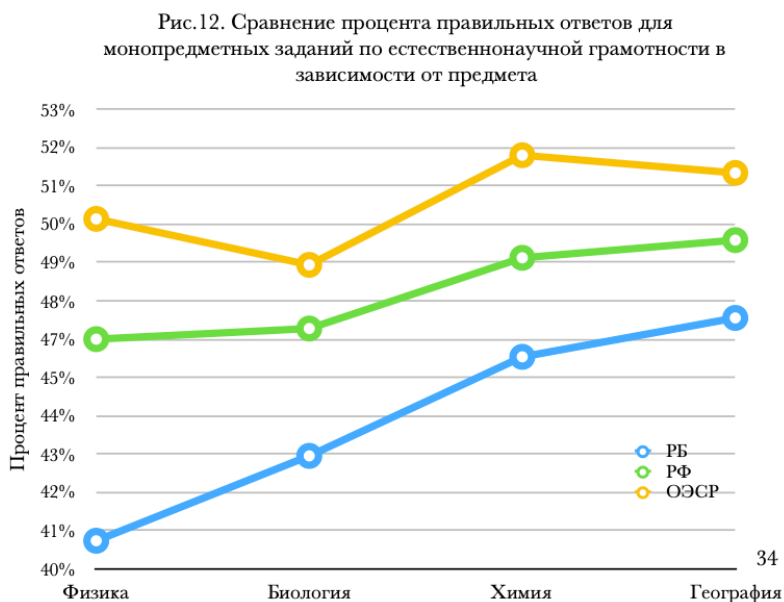


Fig.2. Performance trends across different scientific domains in PISA-2018 assessment



Source: own study based on Belarus National PISA-2018 Report.

Comparison with International Trends

Belarusian performance patterns align with broader global trends, underscoring the effectiveness of integrated pedagogical frameworks in enhancing learning outcomes. Empirical studies from Albania, Thailand, Kazakhstan, and various other nations corroborate the benefits of interdisciplinary instruction, demonstrating its capacity to cultivate critical thinking skills, bolster student motivation, and improve long-term retention of complex concepts²⁵. These findings underscore the universality of interdisciplinary approaches, suggesting that their effectiveness is not confined to specific cultural or geopolitical contexts. Rather, they represent a fundamental shift in pedagogical strategies that transcend traditional subject boundaries, encouraging students to transition from passive knowledge acquisition to dynamic cognitive engagement.

Further evidence indicates that educational systems that prioritize cross-disciplinary curricula tend to produce students with superior problem-solving abilities and adaptive reasoning skills. By fostering connections between disciplines, these methodologies create learning environments that more accurately reflect real-world cognitive demands, equipping students with competencies necessary for the modern knowledge economy. The international education community continues to advocate for such approaches, recognizing that mechanical memorization alone does not adequately prepare students for the complexities of contemporary professional and academic landscapes.

For Belarus, these international comparisons reveal critical lessons for educational transformation. Despite systemic constraints, Belarusian students demonstrate inherent interdisciplinary thinking capabilities that, if properly cultivated through educational reform, could significantly enhance national academic performance and align the country with global educational best practices. The evidence suggests that Belarus possesses untapped potential for educational excellence, requiring strategic policy interventions to unlock students' natural capacity for cross-disciplinary reasoning and problem-solving.

Pedagogical Consequences and Improvement Strategies

A comprehensive evaluation of PISA-2018 outcomes suggests several strategic recommendations aimed at enhancing the Belarusian education system and aligning it with international best practices:

²⁵ A. Basha, N. Lena, *op.cit.*; W. Puengpipattrakul, *op.cit.*; B. Alzhanova, *op.cit.*

- 1) **Curricular Integration:** To effectively address disciplinary fragmentation, curricula should be structured to establish explicit interconnections between subjects. For instance, the integration of geography-biology or physics-mathematics-chemistry can facilitate more holistic learning experiences. Additionally, adopting a longitudinal approach that progressively deepens content integration across educational levels will foster the development of cross-disciplinary competencies, ensuring that students acquire both foundational knowledge and higher-order analytical skills over time.
- 2) **Project-Based Learning:** The incorporation of real-world, problem-based case studies in ecological, social, and technological domains presents a highly effective method for reinforcing interdisciplinary knowledge application. Project-based learning not only cultivates student engagement but also strengthens research proficiency, enhances teamwork capabilities, and refines critical thinking skills²⁶. This approach fosters an authentic learning environment in which students actively construct knowledge rather than passively receive information.
- 3) **Assessment Design:** Traditional assessment methodologies often fail to capture the full spectrum of students' analytical and integrative skills. To better reflect the interdisciplinary nature of contemporary cognitive demands, evaluative mechanisms should be revised to incorporate cross-subject competencies. PISA serves as an exemplary framework, demonstrating how assessment models can be designed to transcend conventional subject-specific evaluations and better assess students' ability to apply knowledge in complex, real-world scenarios.
- 4) **Teacher Professional Development:** A crucial factor in the successful implementation of interdisciplinary approaches is the preparedness of educators. Teachers must not only possess expertise in their respective disciplines but also be proficient in interdisciplinary pedagogies, capable of fostering cross-subject integration, and adept at utilizing digital tools to enhance instruction²⁷. Thus, investments in continuous professional development, the establishment of peer collaboration networks, and the provision of digital resources are imperative to equip teachers with the necessary skills and knowledge to effectively implement interdisciplinary teaching strategies.
- 5) **Technological Integration:** The modern educational landscape increasingly relies on digital learning environments to facilitate interdisciplinary instruction. Advanced technological tools such as simulations, interactive databases, and adaptive learning platforms offer innovative means of reinforcing cross-disciplinary learning while simultaneously accommodating diverse student

²⁶ M. Tóthová, M. Rusek, *op.cit.*

²⁷ D.R. Costa, C.W. Chen, *op.cit.*

needs. By leveraging these digital resources, educators can create more engaging and dynamic learning experiences, ultimately fostering greater cognitive flexibility and real-world problem-solving abilities among students.

In conclusion, the Belarusian educational system stands at a critical juncture where strategic reforms can yield substantial improvements in student outcomes. By embracing interdisciplinary approaches, refining assessment methodologies, investing in teacher professional development, and integrating advanced technological tools, Belarus can align its educational framework with international best practices. These efforts will not only enhance student performance in standardized assessments such as PISA but also prepare them for the evolving demands of higher education and the global workforce.

Theoretical and Practical Significance of the Research

From a theoretical perspective, the findings substantiate the efficacy of constructivist and sociocultural learning paradigms, wherein knowledge is actively constructed within the context of authentic, real-world tasks. This aligns with extensive research in cognitive and educational psychology, which underscores the role of situated learning and scaffolding in knowledge acquisition. By embedding learning within meaningful contexts, students engage more deeply with material, facilitating both retention and the transfer of knowledge to novel situations.

Furthermore, the practical implications of these findings underscore the necessity of a cross-disciplinary instructional approach, which more accurately reflects the complexity of real-life challenges. Unlike traditional subject-bound methodologies that compartmentalize knowledge into discrete domains, interdisciplinary frameworks foster a holistic cognitive architecture, enabling students to synthesize and apply knowledge in a multifaceted and integrated manner. This, in turn, cultivates adaptability, problem-solving skills, and innovative thinking—competencies that are increasingly vital in a rapidly evolving global landscape.

The Hidden Transcript of Interdisciplinary Learning

The superior performance of Belarusian students on interdisciplinary tasks despite systemic constraints suggests operation of what Scott terms the „hidden transcript” – covert resistance to dominant power structures²⁸. In educational

²⁸ J.C. Scott, *op.cit.*

contexts, this manifests as shadow education networks where learning survives totalitarian control through informal knowledge transmission²⁹.

Research consistently shows cognitive rigidity correlates with authoritarian support³⁰. However, our PISA findings present a paradox: students educated within Belarus's rigid authoritarian system demonstrate *greater* cognitive flexibility on interdisciplinary tasks than on single-subject tasks. This suggests that exposure to systemic rigidity may, counterintuitively, foster compensatory cognitive flexibility as students develop adaptive strategies to navigate contradictory demands.

Political and Social Context of Educational Reforms

It is imperative to recognize that the PISA-2018 results for Belarus constitute a singular data point, precluding definitive conclusions regarding long-term trends. While the observed patterns are promising, without rigorous longitudinal comparative analyses, it remains difficult to ascertain the durability and replicability of these findings across different cohorts and educational settings. Nevertheless, the available data offer substantive insights into the interplay between curriculum design and student performance. Specifically, the evidence suggests that students in a rigidly compartmentalized educational system demonstrated superior outcomes when confronted with interdisciplinary tasks, indicating the latent efficacy of integrative pedagogical strategies. This finding is particularly significant as it implies that even within an inflexible curricular framework, opportunities for cross-disciplinary learning can yield measurable benefits.

Despite these encouraging results, the Belarusian educational landscape has long been characterized by centralized control, rigid curricular mandates, and an overarching emphasis on compliance rather than innovation. This top-down approach has historically constrained pedagogical flexibility, stifling the ability of educators to experiment with novel instructional strategies. To effectively institutionalize interdisciplinary methodologies, systemic transformations are required. These transformations necessitate not only the dismantling of entrenched institutional constraints but also a fundamental reconfiguration of the broader political-educational framework. Specifically, granting educators and institutions greater agency in determining pedagogical structures, content delivery models, and assessment mechanisms will be pivotal in fostering a more dynamic and responsive educational ecosystem.

²⁹ *Shadow Education: How Learning Survives in Totalitarian Regimes*, International Human Rights Organization World 2023, <https://ihroworld.odoo.com/shadow-education-how-learning-survives-in-totalitarian-regimes> (23 V 2025).

³⁰ J.T. Jost, J. Glaser, A.W. Kruglanski, F.J. Sulloway, *Political conservatism as motivated social cognition*, „Psychological Bulletin” 2003, vol. 129, no. 3, pp. 339-375.

The Science at Risk Report (2024) documents systematic erosion of academic freedom through surveillance integration and ideological mandates³¹. Despite these constraints, evidence suggests knowledge transmission continues through what shadow education theorists identify as underground networks – informal spaces where interdisciplinary thinking persists through family transmission, peer networks, and cultural practices resistant to state control³².

Moreover, meaningful reform cannot be achieved in isolation from broader sociopolitical considerations. The hierarchical structure of the Belarusian educational system reflects deeper patterns of governance that prioritize standardization and control over adaptability and learner-centered approaches. Consequently, any substantive shift toward interdisciplinarity must be accompanied by structural adjustments in education policy, teacher training frameworks, and resource allocation strategies. Without such comprehensive changes, efforts to implement interdisciplinary approaches risk being superficial and unsustainable.

Conclusions and Perspectives

An in-depth examination of Belarusian PISA-2018 performance, contextualized within the broader international research discourse, underscores the efficacy of interdisciplinary learning even within rigidly subject-specific curricular frameworks. The enhanced performance of Belarusian students on integrative tasks indicates a latent cognitive adaptability, affirming the potential benefits of transitioning toward more interdisciplinary, problem-solving-oriented education models. These findings align with global educational trends emphasizing the value of interdisciplinary competencies in preparing students for the complexities of the modern workforce.

Notably, this observation is corroborated by a growing body of international scholarship affirming the pedagogical superiority of cross-disciplinary instructional strategies. Research has consistently demonstrated that these methodologies enhance comprehension, facilitate deeper learning, and cultivate higher-order cognitive skills, including critical thinking, adaptive reasoning, and real-world problem-solving capabilities. Furthermore, interdisciplinary approaches are associated with greater engagement and motivation among students,

³¹ *Academic Freedom in Belarus: State Repression and its Consequences* [IV 2024], Science at Risk Report 2024, https://science-at-risk.org/wp-content/uploads/2025/04/report_belarus_2024_print2-1.pdf (23 V 2025).

³² P. Tereshkovich, *Current trends in the development of the education sector in the Republic of Belarus*, Belarus Research Network on Neighborhood Policy, <https://belarusnetwork.org/wp-content/uploads/2024/08/Analytical-Article-no.-10.pdf> (23 V 2025).

as they mirror the interconnected nature of knowledge and practical applications in professional contexts.

For Belarus to fully capitalize on this potential, sweeping educational reforms are necessary. These reforms must encompass curricular redesign to integrate cross-disciplinary content, assessment restructuring to better evaluate integrative thinking, reformed teacher preparation protocols emphasizing interdisciplinary methodologies, and more dynamic models of educational administration that prioritize innovation and adaptability. In addition, investment in professional development initiatives will be crucial in equipping educators with the necessary skills and resources to effectively implement interdisciplinary strategies.

Achieving these objectives necessitates a fundamental departure from hierarchical, authoritarian educational governance. Instead, the development of an open, flexible, and participatory educational ecosystem is essential. This requires a paradigm shift in the role of educators, moving from passive implementers of prescribed curricula to active agents of pedagogical transformation. Empowering educators with creative and instructional autonomy while concurrently providing students with opportunities for multifaceted intellectual engagement will be instrumental in fostering a more robust and adaptable education system.

Ultimately, PISA-2018 results transcend mere statistical interpretation. They constitute an empirical foundation substantiating the imperative of interdisciplinary education, reinforcing its necessity in cultivating graduates who possess the requisite competencies to navigate and excel in an increasingly complex and interconnected global landscape. As education continues to evolve in response to the demands of a knowledge-driven society, the insights gleaned from interdisciplinary research must be leveraged to shape a more effective, inclusive, and future-ready educational framework.

Abstrakt

Igor Waraxe

Interdyscyplinarność jako katalizator osiągnięć edukacyjnych: Analiza krytyczna osiągnięć PISA-2018 w kontekście białoruskim

Niniejsze badanie analizuje rolę podejść interdyscyplinarnych w osiągnięciach edukacyjnych przez pryzmat wyników PISA-2018, koncentrując się na Białorusi, Federacji Rosyjskiej i OECD jako studiach przypadku. Badanie stosuje ilościową analizę porównawczą danych oceny naukowej PISA-2018, badając wzorce wyników w 33 zadaniach (115 pytań) obejmujących biologię, chemię, fizykę i geografę, ze szczególnym naciskiem na porównanie wyników uczniów w zadaniach

jednoprzedmiotowych i interdyscyplinarnych. Badanie wskazuje, że pomimo różnych systemów edukacyjnych, oba kraje wykazują poprawę wyników uczniów w zadaniach interdyscyplinarnych w porównaniu z zadaniami jednoprzedmiotowymi. Analiza ujawnia, że zintegrowane podejścia do nauki przyczyniają się do lepszych wyników akademickich, nawet w systemach tradycyjnie opartych na izolowanych programach przedmiotowych. Badanie dostarcza wglądu w potencjał edukacji interdyscyplinarnej i sugeruje kierunki reform edukacyjnych w obu kontekstach narodowych. Badanie opiera się na wynikach Narodowego Raportu PISA-2018 na Białorusi.

Słowa kluczowe: edukacja interdyscyplinarna, PISA-2018, osiągnięcia edukacyjne, Białoruś, reformy edukacyjne, edukacja porównawcza

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