Implementing an integrated natural sciences course in Ukrainian high schools: A nationwide experiment from 2018-2022

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Abstract

From 2018 to 2022, Ukraine conducted a significant nationwide experiment to implement an integrated natural sciences course for students in grades 10-11 of general secondary education institutions. This review paper provides a comprehensive overview of the context, design, implementation, and outcomes of this initiative, drawing on the final report and case studies of participating schools. The integrated course sought to develop students' scientific worldview and understanding of cross-cutting relationships between the natural science disciplines of biology, physics, chemistry, astronomy, geography, and ecology. Results indicate the experiment had a positive impact on students' motivation and performance in science. However, ongoing challenges include the need for more teacher training, resources, and alignment with university entrance exams. The Ukrainian experience offers valuable lessons for other countries seeking to reform science education through curriculum integration. This paper discusses the experiment's design, implementation process, outcomes, and implications for future research and practice in integrated science education.

Keywords

integrated science education, curriculum reform, secondary education, Ukraine, educational experiment

1. Introduction

Science education reform has been an ongoing priority in Ukraine, as the country seeks to modernize its educational system and prepare students for the challenges of the 21st century [7]. In recent years, there has been growing interest in integrated approaches to science education, which aim to provide students with a more holistic understanding of scientific concepts and their real-world applications [2].

In this context, the Ministry of Education and Science of Ukraine initiated a nationwide experiment from 2018 to 2022 to develop and implement an integrated natural sciences course for students in grades 10-11 [4]. This ambitious project sought to address several perceived shortcomings in the existing science curriculum, including:

- Fragmentation of knowledge across separate science disciplines

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- Lack of emphasis on interdisciplinary connections and real-world applications
- Insufficient development of students' scientific literacy and critical thinking skills
- Declining student interest in science subjects

The integrated course was designed to combine elements of biology, physics, chemistry, astronomy, geography, and ecology into a coherent curriculum that would foster a more comprehensive scientific worldview among students [9]. This paper provides a detailed review of this experimental initiative, examining its design, implementation process, outcomes, and implications for science education reform both in Ukraine and internationally.

2. Context and rationale

Ukraine's effort to implement an integrated science curriculum can be understood as part of a broader global trend towards more interdisciplinary approaches in science education [3]. This shift is driven by several factors:

1. Recognition that real-world scientific challenges often require knowledge and skills from multiple disciplines
2. The need to develop students' 21st-century skills, including critical thinking, problem-solving, and systems thinking
3. A desire to make science education more engaging and relevant to students' lives
4. The influence of international assessments like PISA, which emphasize scientific literacy across disciplines

In Ukraine specifically, the push for an integrated science curriculum was also motivated by the need to update Soviet-era educational approaches and align more closely with European educational standards as part of the country's broader European integration efforts [1].

3. Design of the integrated natural sciences course

The Ministry of Education and Science of Ukraine approved four curriculum projects for testing in the nationwide experiment [4]. These projects differed in their approach to integration and the balance of content from various science disciplines. Based on analysis by Nechypurenko, Selivanova and Fedorynova [6], the key features of these projects can be summarized as follows:

Table 1
Comparison of the four integrated natural sciences curriculum projects.

Criteria	Project 1	Project 2	Project 3	Project 4
Balance of disciplines	Low	High	Low	Medium
Extent of integration	Medium	High	Low	Low
Skills focus	Medium	High	Low	Medium
Theoretical depth	High	Medium	Medium	High
Practical applications	Medium	High	High	Low

Project 2, developed by Zasiekina et al. [8], was identified as the most balanced and truly integrated approach. This project was structured around cross-cutting themes and real-world applications, with content from different disciplines woven together to explore complex scientific phenomena.

However, a common feature across all projects was a reduction in the total instructional time compared to the previous system of separate courses. This reduction was particularly significant for geography, chemistry, and biology [6]. The rationale behind this reduction was to create space for more in-depth exploration of key concepts and the development of scientific thinking skills, rather than covering a broad range of factual content.

A key feature of the curriculum design was the flexibility given to teachers in terms of sequencing topics and selecting specific activities. This was intended to allow for adaptation to local contexts and student needs, as well as to encourage teacher innovation.

4. Implementation of the experiment

The experiment was implemented in phases from August 2018 to October 2022, eventually involving over 100 schools across Ukraine Ministry of Education and Science of Ukraine [5]. The implementation process can be visualized as follows:

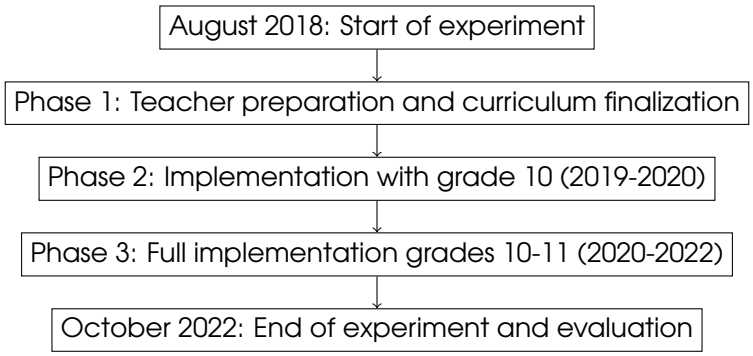

Figure 1: Phases of the integrated natural sciences course experiment

A case study by Nechypurenko, Selivanova and Fedorynova [6] examining the experience of the Kryvyi Rih Comprehensive School No 122 provides insights into the implementation process at the school level. Key findings from this case study include:

- Initial enthusiasm from students and parents about the new integrated approach
- Challenges for teachers in adapting to the reduced hours for individual disciplines and the need to integrate content
- Positive growth in students' interdisciplinary thinking skills
- Some gaps in students' discipline-specific content knowledge compared to the previous curriculum
- Difficulties in conducting practical work due to lack of equipment and materials

These findings highlight both the potential benefits and challenges of implementing an integrated science curriculum, particularly in a context where teachers and schools may have limited resources and experience with interdisciplinary approaches.

5. Outcomes and impact

The final report on the experiment [5] indicated several positive outcomes:

1. Student engagement improved, with many schools noting an increased interest in science subjects among participants of the integrated course.

2. Students developed interdisciplinary skills, showing growth in their ability to connect scientific disciplines and apply concepts to real-world situations.
3. Scientific literacy increased, with 98% of students demonstrating medium to high achievement on national assessments after two years of the integrated course.
4. Schools reported higher enrollment in elective science courses, with several noting an increase in the number of students choosing additional science electives.

To visualize the impact on student achievement, we can represent the data from the national assessments as follows:

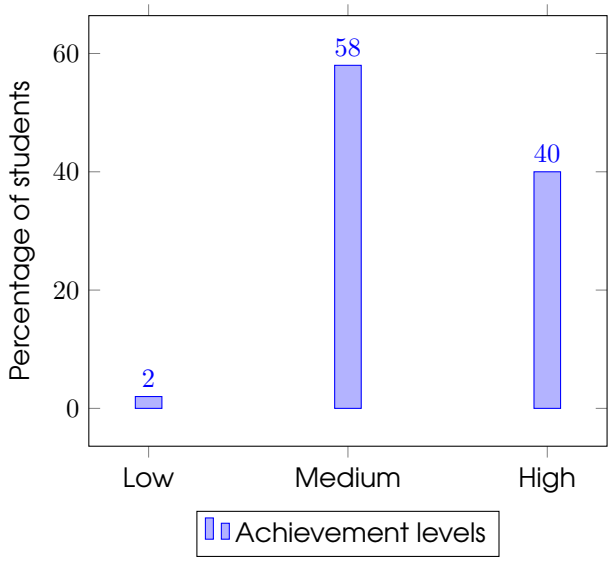

Figure 2: Student achievement levels in scientific literacy after two years of the integrated course.

However, the report also identified several challenges and areas for improvement:

1. Teacher preparation was an issue, with many teachers expressing a need for more training and support to effectively integrate content from multiple disciplines.
2. Resource constraints, including insufficient textbooks, laboratory equipment, and digital resources, hindered the full implementation of the curriculum in some schools.
3. Concerns were raised about assessment alignment, particularly regarding how well the integrated course prepared students for discipline-specific university entrance exams.
4. Some teachers and students felt that the integrated approach resulted in a loss of depth in certain subject areas, especially in physics and chemistry.

These findings highlight the complex nature of curriculum reform and the need for comprehensive support systems to ensure successful implementation.

6. Discussion and implications

Ukraine's experience with implementing an integrated natural sciences course offers several important lessons for science education reform efforts:

1. Curriculum integration can increase student engagement and foster interdisciplinary thinking skills, but requires careful design to avoid gaps in essential content knowledge.

2. Teacher preparation is crucial for the success of integrated approaches. Significant investment in professional development is needed to help teachers adapt to new pedagogical approaches and content integration.
3. Flexibility in curriculum design can help address local needs and constraints, but may lead to inconsistencies in implementation across different schools.
4. Alignment with assessment systems, particularly university entrance requirements, is critical for the long-term sustainability and acceptance of integrated curricula.
5. Resource constraints, including lack of appropriate textbooks and laboratory equipment, can significantly impact the implementation of new curricula, particularly in less well-resourced schools.

These findings align with international research on integrated science education, which has similarly highlighted the potential benefits of integration while emphasizing the challenges of implementation [2].

The Ukrainian experiment also raises important questions for future research and practice in integrated science education:

- How can integrated curricula be designed to balance breadth and depth of content coverage effectively?
- What are the most effective models for teacher professional development to support integrated science teaching?
- How can integrated science courses be aligned with discipline-specific higher education requirements?
- What are the long-term impacts of integrated science education on students' academic and career trajectories?

Addressing these questions will be crucial for refining and improving integrated science education approaches, both in Ukraine and internationally.

7. Conclusion

Ukraine's nationwide experiment with an integrated natural sciences course for grades 10-11 from 2018-2022 represents a significant effort to reform science education and align it with contemporary educational thinking. The initiative demonstrates both the potential and challenges of integrated approaches to science education.

While the experiment showed promising results in terms of increased student engagement and the development of interdisciplinary thinking skills, it also highlighted significant challenges in implementation, particularly in terms of teacher preparation, resource availability, and alignment with existing assessment systems.

As Ukraine continues to refine its approach to science education, the lessons learned from this experiment will be invaluable. Moreover, the Ukrainian experience offers important insights for the international science education community, contributing to the ongoing global dialogue on how best to prepare students for the scientific and technological challenges of the 21st century.

Future research should explore the long-term effects of integrated science education, find effective ways to support teachers' professional growth, and develop models for expanding these approaches in various educational settings. By continuing to innovate and learn from projects like this, educators and policymakers can work together to build science education systems that nurture scientific literacy, critical thinking, and a genuine passion for discovery in all students.

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