INTERDISCIPLINARY APPROACH TO THE STUDY OF PHYSICS AND MATHEMATICAL ANALYSIS

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• High-quality physics and technology education is impossible without good mathematical training, and the problem of interdisciplinary connections is always in the focus of higher education pedagogy.

• Often students do not see any connection between individual academic subjects and put in question the necessity to study certain general education disciplines as they do not realize where and how they can be applied in future professional activity.
• some of the students have difficulties in perceiving educational material due to insufficient training in physics and / or mathematics.

• approximately 70% of students studying physics and mathematical analysis traditionally consider these subjects to be quite complicated (according to student survey data).

Assessment of complexity level in mastering disciplinary content (response rate in %)
1. Increasing of motivation, as one of the key components of the learning process

Authors see their task in building a learning process that arouses a keen interest in the subject and forming students’ academic motivation by implementing a personal-activity approach, which implies a shift in the goals of education from knowledge accumulation to the development of the ability and motivation for active learning.
2. Agreement on academic programs for physics and mathematical analysis

The purpose of agreement on academic programs of the disciplines was to establish the conceptual and temporal correspondence of the topics studied. Coordination and adjustments to the thematic and calendar plans of lectures and practical classes in mathematical analysis and physics were carried out, the use of cross-references between disciplines was proposed.
2. Agreement on academic programs for physics and mathematical analysis (example)

The course "Mechanics and Molecular Physics", taught in the first semester, requires knowledge of the fundamentals of differential calculus, proficiency in differentiation methods, understanding of the physical meaning of the derivative and differential, and knowledge of the basic simplest methods to find an antiderivative, scalar product and vector product. The course “Mathematical Analysis” traditionally begins with the theory of limits, which is essential in a competent delivery of mathematical analysis contents. In order to prepare students for the perception of the contents of the course “Mechanics and Molecular Physics”, we, firstly, practice intensive lectures on mathematical analysis at the beginning of the semester, and, secondly, the “cyclical” nature of the material presentation, which first gives the necessary conceptual basis on the topics of “derivatives and differentials”, “integrals”, and then returning to these topics, we study the properties of the derivative, differential, antiderivative, definite integral in greater depth. In the second semester, the vector analysis apparatus is used to describe the electromagnetic field, and already at the first lecture it becomes necessary to familiarize students with the basic concepts of vector analysis: vector flow, differential operations in scalar and vector fields (gradient, directional derivative, divergence, rotor). In the course "Mathematical Analysis" this topic is studied later, as required by the logic of the material presentation. Therefore, when studying electromagnetism, the “cyclical” nature of the material presentation is also used. Namely, when summarizing the material studied in the topic “Maxwell's theory and equations for the electromagnetic field”, it is proposed to return to the description of the field properties at a higher mathematical level.
3. The use of modern educational technology in the disciplines

In the process of teaching, along with traditional educational technologies, various learner-centered, interactive, and information and communication technologies are used. According to the authors, the most important among them are score-rating technology for assessing learning outcomes, modular technology of training, technology of individualized learning, technology of project-based learning, as well as various interactive forms of training within an interdisciplinary approach.
Interdisciplinarity requires the synthesis of the results obtained in various scientific disciplines. Interdisciplinary project activity is of particular importance in the educational process in engineering areas of training.

While implementing educational (research) projects, as part of interdisciplinary project activities, students develop the ability to apply knowledge to solve educational (research) problems from other subject areas.

Due to the application of project-based learning in the framework of an interdisciplinary approach, the principle of activity is implemented, which is aimed at cognitive skill formation necessary for research.

Students who most successfully completed their creative projects made presentations at the scientific conference of students and young scientists, which is annually held at Petrozavodsk State University (https://petrsu.ru/page/science/nirs/studentcheskienautchnyekonferentsii).
4. Student’s involvement in interdisciplinary research projects

The projects were in different areas and of different complexity. We distinguished a mathematical and a physical part, the latter one, in turn, consisted of a theoretical and an experimental parts.

**Example of the topic:** The study of various types of oscillations requires knowledge of linear second order differential equations.

- The theoretical physical part: the study of specific oscillatory systems, namely, a mathematical pendulum, a spring pendulum, and an electric oscillatory circuit.
- The practical part: students experimentally determine the period of free oscillations of harmonic oscillators, study electrical damped oscillations and resonance phenomenon.
4. Student’s involvement in interdisciplinary research projects

Some of the project topics:

► Gaussian distribution of a random variable. Experimental verification of the law.

► Transport phenomena.

► Damped electrical oscillations: mathematical description and experimental study.

► Physical pendulum. Rigid body moment of inertia determination by the period of oscillations of the physical pendulum.
CONCLUSIONS

An interdisciplinary approach to the study of physics and mathematics has shown that such activities are extremely necessary:

• to create conditions for increasing academic motivation,
• developing students' personal abilities, independent thinking, expanding their horizons,
• for popularization of such disciplines as physics and mathematical analysis.

Involvement of first- and second-year students into research activities:

• makes them an active part of the learning process;
• creates the atmosphere for the development of scientific and creative potential.
• allows to acquire the necessary skills in the design of a physics experiment applying the knowledge of conceptual and theoretical foundations of physics and mathematics in future professional activity.
Thank you for your time!