

**RPTSS2017**

**International Conference on Research Paradigms Transformation in Social Sciences**

**COGNITIVE CROSS-CURRICULUM APPROACH TO STUDYING  
NATURAL-SCIENCE DISCIPLINES (BY THE EXAMPLE OF  
PHYSICS)**

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***Abstract***

The article is devoted to the problem of integration of the material in the course of studying natural-science disciplines at school. The authors pay attention to the importance of formation of cross-curriculum knowledge while studying physics, biology, etc. By the example of studying physics, the authors describe the elements of integration of the students' knowledge while studying natural-science disciplines. The article gives the concrete examples of application of the elements of integration of some aspects of physics, promoting the formation of the students' knowledge. The use of concrete examples is the most expedient during the explanation of some regularities of the physical nature of the phenomena and processes. Besides, concrete examples broaden the students' outlook. Much attention in the given article is paid to the techniques that allow teachers to develop the students' individual abilities and create the atmosphere of success for each pupil both during the lessons and after school, during the independent preparation for classes. This independent creation of tasks in physics with the use of biophysical material, writing papers, making up presentations, making reports and visual aids are among the techniques. Creative pupils with art abilities can create drawings, schemes, and even shoot films. The article describes the element of the laboratory-based work with the use of biophysical material.

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**Keywords:** Cognitive, cross-curriculum approach, integration of natural-science disciplines, use biophysics while studying physics.



## 1. Introduction

Taking into account the quantity of information material that should be acquired by modern students, there is no doubt that it is very important to use the cognitive cross-curriculum approach in the course of teaching school subjects. Besides, in the course of training, one should give not only some concrete scientific knowledge, but also form a multiple personality, capable of using the given knowledge in practice or as they say now «knowledge should be practice-oriented». A cognitive cross-curriculum approach to studying different subjects is not just a sum of them, but it demands essential processing of contents and structure of subjects, allocation of the general theoretical concepts in different branches of science (Grizan, Stefanyk, 2014; Belyanina, 2014).

## 2. Problem Statement

It is possible to allocate, perhaps, several stages in studying school subjects taking into consideration the given approach:

- the first stage – while studying the use a school subject of the conceptual construct and images from other sciences or the use of the principle «incursion into other fields»;
- the second stage – deeper integration, the direct use at different lessons of some general principles that make a methodological basis of modern knowledge;
- the third stage – studying the whole complex of the phenomena and scientific problems that can be learnt only on condition of the existence of knowledge of various branches of science (Yelagina, Semenov, 2010).

Having perceived the laws of insentient substance, physics also applies for the interpretation of organized matter. By means of physical methods, molecular biology develops; thus, there is an absolutely new science – biophysics. Molecular biophysics uses a very difficult mathematical tool for theoretical justification of the elements of the organized matter. Thanks to physics and mathematics, the models of biological structures and processes have been greatly developed (Utkina, 2016).

While studying physics at comprehensive schools, students actively use various educational sources of information: textbooks, popular scientific literature, periodicals, the Internet, etc. Working with them, students get acquainted with a series of biophysical phenomena and processes. As a rule, they are excellent examples of the use of any theory in practice or any proof from hypothesis. At the same time, physics stops being an abstract system of theoretical conclusions and assumptions for students. The explanation of biophysical phenomena transfers physics from the most difficult sciences for students' comprehension to the category of available for all the disciplines.

The majority of physical laws studied at school can be illustrated by biophysical examples. Thanks to physics, students study the models of biological cover permeability, the neural transmission, the cell move. For example, a mercury drop moves in the acid solution, making rhythmic movements, like an ameba, etc. (Utkina, 2016).

To define the phenomena or processes studied by biology and a corresponding to this or that course unit of physics is not difficult at all (see tab. 1).

**Table 01.** Examples of biophysical phenomena studied at physics classes

Physics/units	Biophysical processes and phenomena
Mechanics	Biomechanical characteristics of a person, bioacoustics. Noise as a stress factor. Its influence on the living organism and on the farm animals' productiveness. Oscillations in biological objects (oscillations of the cardiac muscle, oscillations of the wings of birds and insects, oscillations of the cellular membranes, etc.).
Molecular Physics	Laws of thermodynamics in biology. Thermal balance of the organism. Types of heat exchange in live organisms. Physical bases of thermal control of the organism. Action of high and low temperatures on the live organism
Electrodynamics	Dielectric properties of body tissues (brain, fatty, bone and other tissues). Electrochemical potential. Actions of magnetic fields on biological objects.
Optics	Biological optics (eyesight).
Quantum Physics	Action of ionizing radiation on the live organism. Ionizing radiation and genetics. Space and periodic influences. Cycles of Solar activity, its influence on Earth. Light and biorhythms. Natural radiation background and the level of radon in the environment.

### 3. Research Questions

The research question is to describe various methods of pupils' acquaintance with biophysical material within the school course of physics.

### 4. Purpose of the Study

The study is devoted to description of such methods in practice.

### 5. Research Methods

There are various methods of pupils' acquaintance with biophysical material within the school course of Physics:

1. *Giving some biophysical data by the teacher while studying the new material.* In this case, pupils will acquire the new material better as it is not an abstract set of phrases and formulas that do not have their practical application at first sight. Besides, biophysical examples broaden the pupils' outlook.

The content of biology at school allows one to integrate the knowledge of many scientific disciplines very effectively and the use of cross-curriculum knowledge of physics and biology is especially productive. One can give a huge number of examples of using the material of physics at biology lessons. So, for example, while studying the unit «Person», the most demanded physical knowledge is on: «Heart structure», «Blood system», «Analyzers», «Nervous system».

While studying the theme «Analyzers», it is possible to conduct the lesson «Physics of Hearing». Students do not only try to understand the structure and the principles of work of the organs of hearing, but also remember the characteristics of sound (by the example of sounding different tuning-forks). From the course of physics, it is necessary to pay attention to the work with the table on volume. The teacher can lead a discussion with pupils about distinctions of male and female voices, music instruments.

It is also necessary to use at such lesson the stethoscope and the phonendoscope that demands studying the devices and the principles of their work. At the end, the teacher can offer pupils to solve some tasks on this theme, for example:

The area of the eardrum is about  $0.65 \text{ cm}^2$ . If the volume of sound is 20 db, the amplitude of sound pressure is  $\text{mN/m}^2$  - it is a sound background in the very quiet room. The pain threshold for the ear is when the volume is 140 db and the amplitude of sound pressure is  $200 \text{ N/m}^2$ , and one has mechanical damages of the eardrum when the volume is 160 db and the amplitude of sound pressure is  $2 \text{ kN/m}^2$ . What force makes the sound effect on the eardrum in these cases?

Why are the passengers recommended to suck lollipops while taking-off or landing? (The answer: While taking-off the external pressure changes; as for the tympanum, the initial pressure on the eardrum remains longer, the swallowing movements improve the access of air to the auditory (eustachian) tube through which the pressure in the cavity of the tympanum becomes the same as the pressure of the environment).

*2. Giving some biophysical data by the pupils when they make reports about the results of their independent work.*

While making reports and writing papers with biophysical contents, the pupils' level of knowledge on this or that unit of physics increases and their cognitive interest develops as well. Explanation of the material by the students awakens their self-confidence, their abilities to understand the problems of physics and the related questions of biology independently.

Organizing such form of the students' independent work, one can distinguish the following requirements for the creation of informative tasks:

- scientific type of the material;
- obligatory connection with the education program;
- orientation of the materials to the new knowledge acquisition, the new knowledge revision and the reinforcement of learning, the development of the students' skills, the use of various sources and research methods, the development of the students' abilities to work with various sources of information;
- all the tasks should arise the students' interest, guide them on independent researches.

*3. Writing tasks with biophysical contents (Belyanin, 2011).*

For the purpose to reinforce, revise and systematize the gained knowledge, it is possible to suggest writing the tasks connecting physics with biological laws and processes.

Solving such tasks intensifies the students' thinking as they understand the physical phenomena and processes properly, determine the consistent patterns and find out that the gained knowledge can be applied to solution of some practical questions. Many tasks written by students are integrated with biology. For example, they can define some biometric characteristics of a person, pets, etc. Writing and solving such tasks can increase the students' cognitive interest.

#### 4. Solving tasks with biophysical contents (Ermakova, Gubanova, 2016; Ermakova, 2016).

Solving tasks is one of the ways of connection theory with practice. Such work helps students to reinforce the studied material, reveal the connection of theoretical material with the world around and broaden their outlook.

For example, while studying such unit as dynamics, students can be offered the following physical tasks (Danishkina, Ermakova, 2014; Ermakova, Gubanova & Koshcheeva, 2017):

- A football player kicks the ball with the average force of 2.5 kN. The duration of the kick is 0.01 s. The ball weighing 1 kg moves towards the football player with the speed of 5 m/s. Determine the ball speed after the kick.

- The outer diameter of the elbow bone is 15 mm; the breaking point is  $10^8$  Pa. What force is to be applied in case of thrust force to the bone to get a rupture? The bone wall thickness is 3 mm.

- What speed does a gymnast give to the mace, throwing it up to the height of 4 m? Count the time of the throw during the gymnast's roll over. (Answer: 9 m/s;  $t=1.8$  c)

- The sinew is 0.12 m long and its cross-section area is  $2 \times 10^{-6}$  m<sup>2</sup>. In case of 68.6N loading, it was extended up to  $2.9 \times 10^{-3}$  m. Define Young's modulus for it.

#### 5. Carrying out laboratory-based works with biophysical contents.

It is better to carry out the laboratory-based works provided by the programs on physics together with the laboratory-based works with biophysical contents, especially in honor classes. For example:

- Determination of biomechanical qualities of a person.
- Bioacoustics of a person.
- Microclimate assessment of the classrooms, etc.

While carrying out the laboratory-based works, the authors can recommend using the so-called task-based method. For example, during the laboratory-based work "Determination of some biomechanical qualities of a person", students are given an extra task: During the hard physical activity, heart is reduced to 150 times a minute. In case of each heartbeat, it makes some efforts, equal to swinging up the load weighing 0.5 kg at a height of 0.4 m. Determine the power developed by heart.

#### 6. Creating visual aids, presentations.

Creating the visual aids reflecting the biophysical phenomena and explaining them from the point of view of physics promote the correct organization of the students' cognitive activities. The main results of these activities are creation of experiences, figures, diagrams, videos and electronic presentations.

#### 7. Biophysical excursions

Biophysical excursions will help to reflect on the entity of the physical theories and laws in the world around, promote the students' understanding of the role and place of a person in the world around. Visit to medical institutions, health centers, etc. can be an example of biophysical excursions (Lunkina, Sidorova, 2012).

8. *Revision with the use of some biophysical material* allows teachers to focus their students' attention on the use of some theoretical knowledge in practice, to show the need and the possibilities of its expansion and deepening. Such form of revision allows students to realize the studied material at a higher level.

#### 9. *Creating problem situations with the use of biophysical material.*

Creating problem situations is closely connected with the formation, development of the students' creative abilities, teaching in the system, formation of their active intellectual actions. Any problem situation is a means of the problem solving-based training that creates the conditions for assimilation of the new knowledge, abilities and ways of activity.

## 6. Findings

Thus, the authors can state that using the biophysical material will help teachers to consider some physical questions at a higher level, to focus the students' attention on the connection of all the physical processes in nature.

## 7. Conclusion

Nowadays, when in mass media some biophysical data are actively used and some characteristics of living organisms are provided, it is important to make such information clear and useful for pupils [for example, 2, 3, 5]. The knowledge of the main phenomena that can happen to living systems, their regularities and laws will allow the younger generation to distinguish the really new discoveries made in science from the wrong or incorrect ones, which unfortunately are quite often given on pages of some periodicals, on television and on the Internet.

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