Integration of knowledge of nature studies as a means of forming cognitive interests while teaching Physics in secondary schools

EDVCATIO PHYSICORVM
QVO NON ASCENDAM?

Stepan Velychko[1], Victoria Buzko[2], Viktor Matsyuk[3]
[1]Faculty of Physics and Mathematics, Kirovohrad Teacher Training University, Shevchenko Street 1,25006, Kirovohrad, Ukraine.
[2]Specialized Secondary School №6,Kirovohrad Municipal Council, Kirovohrad Region,Timiriazev Street,6, 25006, Kirovohrad, Ukraine.
[3]Faculty of Physics and Mathematics of Ternopil V. Gnatiuk National Pedagogical University, M. Kryvonis Street, CP 46027, Ternopil, Ukraine.

E-mail: Velychko@mail.ru

(Received 25 December 2012, accepted 12 May 2013)

Abstract

The article deals with formation of pupils' cognitive interest in the process of teaching Physics in Ukrainian schools by means of integration of Nature Studies. Specific examples of forming pupils' cognitive interest for Physics while studying the themes "Nucleus. Nuclear Energy" are analyzed.

Keywords: cognitive interest, teaching Physics, integration of Nature Studies, doing sums.

Resumen

El artículo trata sobre la formación de interés cognoscitivo de los estudiantes en el proceso del aprendizaje de la Física en las escuelas de Ucrania por medio de la integración del conocimiento natural. Analizado ejemplos específicos de la formación de interés cognitivo de los estudiantes por la Física durante del aprendizaje del tema "Núcleo atómico. Energía nuclear".

Palabras claves: interés cognitivo, enseñanza de la Física, la integración de los estudios de la naturaleza, hacer sumas.

PACS: 01.40.E-, 01.40.Ha. **ISSN 1870-9095**

I. INTRODUCTION

The problem of forming pupils' cognitive interest while teaching Physics at comprehensive school is actual for the system of education in general and teaching Physics in particular. The problem of interest in the context of various cognitive-searching activities of students is being increasingly researched nowadays. It allows to bring to light theoretical foundations of this phenomenon, form and develop pupils' interests, enrich each pupil's individuality, bring up his active attitude towards learning process and life activity.

Interest, as a complex and meaningful formation for a human being, has various interpretations in psychological pedagogical aspects of its definition. It is considered as:

- selective focus of people's attention (N. F. Dobrynin [1], T. Ribo [2]);
- manifestation of his mental and emotional activity (S. L. Rubinshtein [3]);
- active emotional and cognitive attitude to the world (N. G. Morozova [4, 5]);
- specific attitude of an individual to the object caused by the realization of its vital significance and emotional appeal (A. G. Kovaliov [6]);
- a form of manifestation of cognitive needs, that provides the focus on individual's understanding of activity goals and thus contributes to orientation, familiarization with new facts, reflection of reality in a fuller and deeper way (according to Petrovsky [7]).

One of the drawbacks of organizing the educational process in modern secondary schools in Ukraine while teaching Physics, is the contradiction of the principle of continuity of Nature Studies in Grades 5-6 and 7-9. One of the reasons of this phenomenon is that the knowledge obtained by pupils during previous years of studying occurs in an isolated form and is not linked by general laws. The task of an educational process is to combine such knowledge in pupils' consciousness and constantly provide an individual with new knowledge while forming a personal outlook. One of means of such directions of pedagogical activity is the integration of the knowledge of

Nature Studies while teaching Physics in a comprehensive school.

II. PROBLEM EXAMINATION AT A PRESENT - DAY LEVEL

The problem of forming cognitive interest and the organization of this problem is depicted in the works of L. A. Aristova, H. A. Davydova, V. K. Demydenko, A. M. Matiushkina, N. H. Morozova, M. N. Skatkina, H. I. Shchukina. The works of A. A. Babenko, S. I. Zhmursky, M. T. Martyniuk, N. O. Posternak, I. S. Voytovych, S. V. Horchynsky, T. V. Dubova are devoted to the study of pupils' interest for some school subjects.

A whole range of research by psychologists and pedagogues aims at the study of aspects of a cognitive interest. The psychological nature of interest is studied in some research works (M. F. Bieliayev, L. A. Gordon), the cognitive interest is viewed as a means of teaching (H. I. Shchukina, V. B. Bondarevsky), or as a motivation (A. N. Leontiev, S .L. Rubinshtein) in other works.

The questions of pupils' integration of knowledge and one of the most developed of its levels in particular - interdisciplinary links - were profoundly highlighted in the works of well-known methodologists: O. I. Buhayova, S. U. Honcharenko, I. D. Zvereiev, V. R. Ilchenko, I. M. Kozlovska, O. I. Liashenko, V. M. Maksymova, P. I. Samoylenko, O. V. Sergeyev, A. V. Usova, V. M. Fedorova and many others.

Methodological and theoretical problems of knowledge integration were examined in the works of S. U. Honcharenko, I. M. Kozlovska, P. I. Samoilenko, O. V. Sergeyev and others;

- organization of the educational process on the basis of integration became the research subject in the scientific works of I. M. Kozlovska, Y. M. Sobko, V. T. Fomenko, T. D. Yakymovych and others;
- the integration of the knowledge in Nature Studies was analyzed in the scientific works of Y. I. Dick, V. R. Ilchenko, M. T. Martyniuk, V. G. Razumovsky and others;
- the principles of interdisciplinary connections and professional orientation training were examined in the works by V. M. Maksimova, V. I. Palamarchuk, V. M. Fedorova and others.

The essence of the integration of training is to combine ideas, scientific theories, concepts, teaching technologies by coordinating the activity of teachers of different Nature Studies disciplines and cognitive and learning activities of students. The idea of integrating content and form of teaching has always interested scientists and educators who worked practically. For instance, S. U. Honcharenko and I. M. Kozlovska offer to implement the integration into the educational process using several ways:

- related elements, concepts or actions are selected among two subjects and an integrated course is developed;
- the knowledge of different subjects is grouped around a particular object (this option can be called modular or profiled);
- being based on really existing objectivity of knowledge, one subject can comprise the elements of knowledge and skills in other subjects that are necessary in general and particular cases (basic academic subject is placed in the center and concentric circles of approximation of different order accrue around it).

The studies of S. P. Velychko [8] prove convincingly that it is important to form and develop scientific and research thinking and make it possible to effectively use it to solve different didactic purposes in physics in secondary school in order to prepare a highly qualified teacher who will be able to implement basic tasks of individually oriented technologies while teaching physics. It is important to integrate mandatory professional psychological and pedagogical disciplines studied at Pedagogical University and to complement them with additional special courses that are of an integrated nature both in content and in their procedural component for a positive solution of this global didactic problem.

Under the circumstances, an integrated approach to special disciplines being created should be combined with: 1) the opportunity to get acquainted with the latest scientific advances in physics, pedagogy and psychology and issues of methods of teaching physics and to solve complex scientific and methodological problems of differentiated instruction at school simultaneously; 2) the intensification of the role of an active individual activity of each student in developing specific guidelines and in the aspect of his personal development as a future specialist; 3) dealing with contemporary problems of physics methods not only at the lectures where the teacher's competence is in no doubt, but mainly during laboratory practical sessions and while carrying out individual tasks, which are based on independent and active cognitive searching activity of students and which simultaneously develop cognitive interest towards the subject under the study and make the teacher an active and effective practitioner; 4) each student's possessing the completed materials and works (like: synopses of the lessons, educational activities, instructions, etc.) that have previously been discussed and evaluated and are allowed to be used during teaching practice and independent activity) [8, p. 289]. The following samples of such specialized disciplines that were introduced in our pedagogical university and are implemented to prepare future teachers of physics for different educational qualifications the following courses can be considered: for the "bachelor" level — "Modern innovative technologies of teaching physics in high school", for the level of "specialist" — "Using a training laser in teaching the school course of Physics", for the level of "Master" —"Computer facilities in the educational process while teaching Physics."

The essence of integration is to obtain a new cognitive outcome that has an advantage because of its heuristic significance of the cognitive value of all integrated components. The following features of integration should be pointed out: 1) the integration is formed as the interaction of isolated elements, that were previously scattered (new conditions that vary in quantity can arouse only due to different elements); 2) the integration is connected with qualitative and quantitative transformations of related items, as a gradual change of separate elements takes place. The elements are included into an increasing quantity of links, the accumulation of these changes leads to changes in the structure, the appearance of new functions of elements, i.e. the nascence of a new integrity; 3) the process of integration has its logical and profound basis (the construction of integration means, first of all, the determination of a common framework for combining scattered elements of knowledge, the search and reasoning of the criteria of unity of different sets) [9].

The *objective* of this article is to reveal the potential for integration of knowledge in Nature Studies to form cognitive interest while teaching Physics at school, the main objectives include the possibility to integrate theknowledge in Nature Studies to create and enhance cognitive interest of students by studying the theme "Nucleus. Nuclear energy "(Grade 9).

III. IMPLEMENTATION OF INTEGRATION OF THE KNOWLEDGE OF NATURE STUDIES AS A MEANS OF FORMING COGNITIVE INTEREST WHILE TEACHING PHYSICS IN SECONDARY SCHOOL

The term "integration" is derived from Latin integratio — recovery, replenishment, from integer — whole, which means the process and result of interaction between elements (with properties given), that are accompanied by the restoration, establishment, complication and strengthening of significant ties between them on the basis of sufficient cause, resulting in emerging integrated object (system) with qualitatively new properties, which are stored in the structure properties of individual source elements [10, p. 337]. Methodical basis of an integrated approach to learning is development of the knowledge about the surrounding world, establishment of interdisciplinary and intersubject connections while teaching Physics. Thus, we consider it advisable to call any lesson having its own structure an integrated one, if the knowledge, skills and results of the material analysis that is studied by methods of other Nature Studies disciplines are applied for its conduction. Because of it integrated lessons are also called interdisciplinary. Such basic didactic requirements towards an integrated lesson can be pointed out:

- the lesson should have a specific educational and cognitive aims that are distinctly formulated;
- the lesson should arouse pupils' interest for establishing links between adjacent fields of science;
- a high activity of students to apply knowledge from other disciplines (fields of sciences should be provided in the classroom);
- the lesson should deepen and expand the students' outlook;
- the lesson should encourage the development of skills while studying popular scientific literature, stimulate the students' desire to acquire new knowledge independently.

It is hard to imagine the modern approach to teaching Physics without making interdisciplinary connections with other subjects connected with natural sciences. Using interdisciplinary connections intensifies the educational process, stimulates students' learning interest, promotes the outlook expanding. In particular, the links between physics, biology and chemistry that are successfully revealed and shown, reinforce the practical orientation of both a school subject and the educational process in general. Thus, integration aims at laying the foundation for students' holistic understanding of nature and society and forming their personal attitude towards the laws of their development [11, p. 26].

Here are specific examples of the integration of natural knowledge to create and enhance students' cognitiveinterest for Physics while studying the theme "Nucleus. Nuclear energy "(Grade 9).

Table I. The list of interdisciplinary connections that are used in teaching Physics:

Form, Chapter	*School Subject*	*Contents*
Form 9 Nucleus. Nuclear Energy	Biology	Form 10. Cytoplasm and its components Form 11. Hypotheses of life arousing on earth
	Chemistry	Form 8. The Nucleus Structure: nucleus and electronic shell. The composition of atomic nuclei (protons and neutrons). Proton number. Nucleon number. Isotopes (stable and radioactive)
	Geography	Form 8. Major climatic factors: solar radiation, atmospheric circulation.
	Physics	Form 7. Substance Structure.
	Primary school	Form 3. Bodies, substances, particles.
	Nature Studies	Form 5. Bodies and substances surrounding a man.

It is appropriate to use historical information about the scientists who made a significant contribution to the development of an appropriate direction while teaching this topic: E. Rutherford, J. Thomson, Maria Sklodowska-Curie, Pierre Curie, N. Bohr and others. It is worth considering the issues of biological effects on the theme "Ionizing radiation effects". Biochemical changes can occur both in a few seconds, and in several decades after the exposure and become an immediate cause of cell death or the changes in it, which can lead to a serious and complicated disease. The radioactive radiation influences the heredity intensively and affects the genes in the chromosomes in particular. In most cases, the effect is adverse.

The exposure of living organisms can have some benefit as well. For example, the cells that multiply rapidly in malignant tumors are more sensitive to radiation than normal ones. The inhibition of cancer by γ-rays of radioactive drugs that are more effective for this purpose than X-rays is based on it.

Students consider it to be interesting that scientists themselves have only recently realized that radon is the most significant of all the natural sources of radiation. It is an invisible, tasteless and odorless heavy gas, which is 7.5 times heavier than the air. According to the United Nations estimates radon and its products of radioactive decay generate approximately 3/4 doses of radiation received by the population from terrestrial sources of radiation. A person receives the bulk of the radiation dose from radon while being in the rooms that are not ventilated. Then it is advisable to analyze the diagram concerning the influence of a room ventilation on the contents of radon in it (Fig. 1).

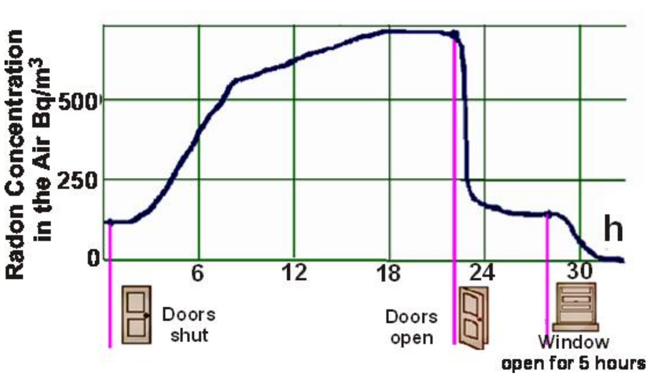

FIGURE 1. The influence of airing the room on the contents of radon in the air of a bedsitter in a single-family house.

It is useful to show the diagram at the Physics lesson, which is conducted as a conference. It should be noted that the pupils were previously offered to do an individual or group research or mini-projects. The results of pupils' independent research can be integrally presented as diagrams, that are illustrated in Figure 2 and 3.

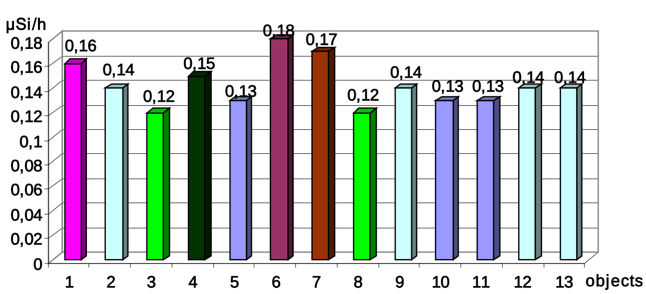

FIGURE 2. Measuring the equivalent doses of γ-radiation on the school premises (1 - 8 — classrooms, 9 — Physical Laboratory, 10 — the Principal's Office, 11 — Methodical study, 12 — Teachers' Room, 13 — Assembly Hall.

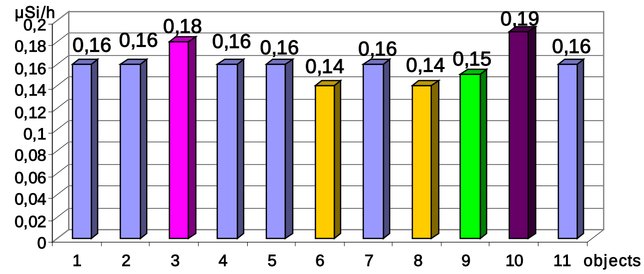

FIGURE 3. Dosimetric measurements of radioactivity in the centre of the town (1 — school yard, 2 — Velyka Perspektyvna Street (Part I), 3 — Velyka Perspektyvna Street (near the surface), 4 — Kirov Square, 5 — Kirov Square (near the surface), 6 — Shevchenko Street, 7 — Bohdan Khmelnytsky Square, 8 — over the Ingul River, 9 — on the banking (Part I), 10 —on the banking (Part II), 11 — Velyke Perspektyvna Street (Part II).

Doing home laboratory assignments in Physics as a means of developing pupils' cognitive interest, forms the flexible and critical thinking, observation, increases the interest for Physics as a science and a school subject.

The research of natural radioactivity of food is the example of the task whose didactic objective is to experimentally measure the radioactivity of the mostly wide-spread items of food. Such a research develops pupils' cognitive interest for Physics and forms independence while carrying research work out. Besides theoretical information, we consider it appropriate to reveal the essence of the concept of background radiation, natural radioactivity, measured in Bq/kg, radiation of substances that enter the human body through food. However, it is appropriate to reveal the possible effects of radioactivity, which influence the human body, getting there by food and respiratory tracts. Therefore, the ability to explore food's radioactivity is an important aspect of life.

The equipment and materials used in this home laboratory assignment consist of a dosimeter, buckwheat, instant coffee, milk and other products.

Procedure:

1. Set the dosimeter on the mode of estimation of volume activity of radio nuclides in the samples.
2. To measure background activity, then the total activity with the product under study and to calculate the activity of the product.
3. To write the results into the table (Table II).
4. To draw conclusions.

Special attention should be paid, in our opinion, to solving integrated and interdisciplinary problems. Such training problems in physics with interdisciplinary content are a source, means and a necessary condition for pupils' interest. If a student has solid knowledge and skills in the field of Physics, this ability to solve applied problems significantly activates his cognitive activity. It is possible due to the use of interdisciplinary interaction [13, p. 267].

Table II. The results of the study of natural radiation of products.

№	*Names of product items*	*Background Activity* A_{back}	*Activity Measurement* A_{meas}	*Product Activity* $A=K(A_{meas}-A_{back})$		*Natural specific radioactivity (table meaning)*	
				Bq/kg	*Ki/kg*	*Bq/kg*	*Ki/kg*
				$K_2=20$	$K_1=8\cdot10^{-9}$		
1	Buckwheat					60-70	$(1,6\text{-}1,9)\cdot10^{-9}$
2	Instant Coffee					900	$2,4\cdot10^{-8}$
3	Milk					30-60	$(0,8\text{-}1,6)\cdot10^{-9}$

The revision and generalization of the material learned previously, the solution of non-standard creative tasks that require creative thinking are other examples of the integration of knowledge in the natural sciences. The following sums can serve as the examples of such tasks:

1. To give examples that characterize the quantity and sizes of atoms and molecules:

a) There are $2\cdot10^{22}$ drops of water in the Black Sea. There is an equal number of molecules in one water drop.

b) A pin head contains more than 10^{19} atoms of iron. If these atoms are distributed by one in a row on the way from the Earth to the Sun (150 million km), then there will be half a million atoms on every millimeter of the way [14, p. 151].

2. The average capacity of an exposure dose of radiation in an X-ray room is $6{,}45\cdot10^{-12}\,\frac{Kl}{kg\cdot s}$. A doctor spends 5 hours a day in this office. What is his dose of radiation in six weekdays? [15, p. 147].

3. Isotope phosphorus-32 is widely used in biology and medicine. Thus, using the method of tracer atoms, the processes of assimilation of nutrients from fertilizer by plants and metabolism in the body are learnt, the growth of plants' root system is examined. The therapy of blood diseases is done in medicine. The half-life of phosphorus is 14 days, it is a β-radioactive isotope. The maximum radiation energy equals to 1.71 MeV. Define the chemical element whose nucleus is formed as a result of the following reaction ($^{31}_{15}P\rightarrow^{31}_{16}S+^{0}_{-1}e$) [16, c. 239].

4. Solving crossword-puzzles as a means of raising interest for Physics is presented in Fig. 4.

Horizontally:

3. The tiniest particle of a chemical element that consists of a nucleus and electrons.

7. A chemical element thar was discovered in 1789, it was obtained in a pure form only in 1841 (the metal of a grey-steel colour).

8. The English physicist who offered a nuclear model of an atom.

Vertically:

1. A part of atom that has a positive charge.

2. The name of the woman who is one of the founders of the radioactivity doctrine and who discovered the influence of radiation on a living cell. She was the first to use radiation in medicine.

4. A French Physicist who was one of the founders of the doctrine of radioactivity.

5. A positively charged particle of a nucleus.

6. An uncontrolled conversion of unstable isotopes into other isotopes, which are accompanied by the emission of elementary particles.

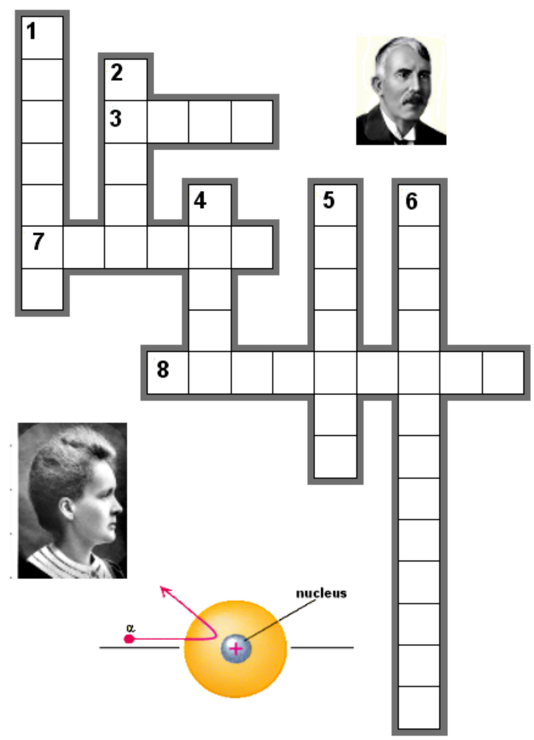

FIGURE 4. Nuclear Physics.

IV. CONCLUSIONS

The integration of fundamental and special knowledge in Nature Studies promotes: forming generalized and systemized knowledge, skills and competences in different school subjects and corresponding fields of sciences; the complex realization of the educational components; forming pupils' general learning skills and competences; the deeper and more long - lasting acquisition of general scientific notions in different school subjects; a coordinated activity of students and teachers, removing the repetition and economizing time, keeping the principle of continuity during the first concentrum of teaching Physics at school.

REFERENCES

[1] Dobrynin, N. F., *Attention and its Upbringing,* (Moscow, 1951), p. 30.
[2] Ribo, T., *The Psychology of Attention,* (Moscow, 1976), p. 208.
[3] Rubinstein, S. L., *The Grounds of General Psychology*, (Peter, St. Petersburg, 2000), p. 712.
[4] Morozova, N. G., *The Upbringing of Children's Cognitive Interests in the Family,* (Moscow, 1961), p. 224.
[5] Morozova, N. G., *About a Cognitive Interest for Teacher,* (Moscow, 1976), p. 46.
[6] Kovaliov, A. G., *Psychic Peculiarities of a Man: Character,* (Leningrad, 1957), p. 263.
[7] Petrovsky, A. V., *Back to Understanding Personality in Psychology*, (Voprosy Psihologiyi,1981), №2, p. 40-46.
[8] Velychko, S., *On the Experience of Forming and Developing Research Thinking of Physics Teachers,* (Conference Proceeding “Democracy and Education”. — June 1-2., Kyiv, Ukraine, 2001). Montclair State University; Kirovograd State Pedagogical University, (Kyiv, 2002), p. 289-294.
[9] Tiunnikov, Y. S., *Methods of Discovery and Description of Integrated Processes in Educational Work, (*Academy of Pedagogical Sciences, Moscow, 1986), p. 47.
[10] Dychkivska, I. M., *Innovative Pedagogical Technologies*, (Academy Publishing, Kyiv, 2004), p. 352.
[11] Buzko, V. L., *Integration of Natural Studies in the Process of Teaching Molecular Physics in Secondary School*, Scientific Notes, Issue 2, (Kirovohrad State Teachers' Training University Publishing, Kirovohrad, 2011), p. 202.
[12] Shylov, V. F., *Laboratory Works at School and at Home: Quantum Physics*, (Prosveshcheniye, Moscow, 2006), p. 96.
[13] Buzko, V. L., *Solving Sums as a Means of Integrating Natural Knowledge while Teaching Physics in Secondary School*, A Digest of Scientific Works Kamianets-Podilsky National University, (Kamianets-Podilsky National University, 2011), p. 330.
[14] Bilimovych, B. F., *Physical Quizzes in Secondary School*, A Manual for Teachers, (Prosveshcheniye, Moscow, 1977), p. 159.
[15] Remizov, A. N., *A Collection of Sums in Medical and Biological Physics,* (Drofa, Moscow, 2001), p. 192.
[16] Semke, A. I., *Non-Conventional Sums in Physics. For the Forms of Natural and Humanitarian Profile*, (Academy of Development, Yaroslavl, 2007), p. 320.
.