ISSN 1648-3898 Journal of Baltic Science Education, No.2 (4), 2003-10-30; pp. 28-37.

GENERAL PHYSICS AT THE UPPER SECONDARY EDUCATION LEVEL

Andris Broks
Faculty of Physics and Mathematics, University of Latvia

Abstract

As an attempt to fight the crisis in natural sciences education author's concept and the main structure of general physics subject at the upper secondary education level is reported. Systems approach had been adopted and philosophical as well as psychological background was prepared to develop a modern structure and context of the subject when starting the upper secondary (senior high school) education in physics. Diverse macro, micro and mega world bodies and mediums in motion – observations, physical and mathematical modeling of motion for understanding of the scientific method and main achievements in physics research and engineering makes a general guideline of reported design and practical realization of subject.

Key words: physics education, general education, upper secondary education, didactics, research and development of education.

Notes about the modern educational medium and physics today for corresponding development of physics education.

Education is a specially organized way of gaining *life experience for life*, the process and result of getting this experience. Modern human's life needs education and our life in schools (starting from kindergartens up to the universities) must educate for life. The only fundamental question always rises: **what education for what life?** (Broks, 2002).

Educality - person's educational quality as the unity of content and level of his or her *educatedness*. There are three general components of our educatedness as the main characteristics of human's life experience: *knowledge, skills and attitudes*. These components characterize intellectual (knowledge and skills) and moral (attitudes and skills) aspects of our educatedness. At the same time there are also three other fundamental components of our educatedness as main characteristics of human's life processes: *cognition, consideration and behavior*. Humans gain life experience by parts, comparing and connecting them: *cognition* makes background for *consideration*, which is the further basis for purposeful behavior.

The following table 1 demonstrates a general systemic content of our educatedness as a proposed structure for practical realization.

Table 1. The principal structure of human's educatedness.
(Life experience - *knowledge, skills, attitudes* for life – *cognition, consideration, behavior*)

	COGNITION (sensation, coding, description)	**CONSIDERATION** (evaluation, goal defining, decision making)	**BEHAVIOR** (planning, providing resources, execution)
KNOWLEDGE - facts and causality relations	Obtaining knowledge (what is it and why is it so?)	Processing of knowledge (critical thinking)	Use of knowledge in practice
ATTITUDES - value orientation	Cognition of values (study of sample values - what is good?)	Development of attitudes	Practical realization of attitudes
SKILLS - realization of abilities	**S k i l l s** of getting information and its' analysis and synthesis	Evaluation, goal defining and decision making **s k i l l s**	**S k i l l s** of planning, providing resources and execution

There are three main levels of educatedness, which characterize person's creative abilities which are finally achieved during his or her educational activities. The first level – reproductive /primitive creative actions (parrot level), the second /normal level – creative actions based on analogies and the third level – original creative actions.

Educality in action - that is what we really are. Life skills (above all – critical thinking skills and humanistic attitudes' realization skills) at the second level for young people and adults now are coming in the focus of our special educational needs.

Physics is the fundamental part of mankind's life experience about material world's diverse bodies' m *o t i o n.* This is a highly developed branch of our knowledge about material world in space and time aspects, integrating studies of diverse bodies' and mediums' motion on mega, macro and micro levels of this world. *Vision and mission of physics:* scientific research of world's physical phenomena (cognition) for scientific understanding (consideration) and sensible usage of them (behavior). Physics means scientific reflection of physical phenomena in human's consciousness - physics is created by humans for humans. It is fully humanistic field of our life in spite of many situations, when bad people use scientific and technological achievements against other people to satisfy their selfish interests.

Physics today presents itself as fundamental scientific *research* and applied science in *engineering* as well as *education* of physics. Such systemic overview today is very important for all people from science literacy purposes up to research and engineering levels for professionals. Why? Humans continue to develop physics (science) and the main task for all of us today is to take special care of its scientific understanding (education) and humanistic use (engineering). See illustration of these suggestions in table 2.

Table 2. Physics – created by humans for humans.

	Science	**Technique**	**Education**
Theory	Explanation *(Theoretical physics)*	Designing	Understanding of physical phenomena
Practice	Experiments *(Experimental physics)*	Production, service	Observation and usage of physical phenomena
	Fundamental physics	***Applied physics***	***Educational physics***

Physics education today as unity of educational theory and practice needs integration of didactic and ontodidactic approach. *Didactics of physics* – traditional theory of physics teaching and learning, following the main principle: from simple to complex. *Ontodidactics of physics* - theory of qualitative changes (not reforms, but transformations) in physics education, following the main principle: step from complex to simple, reaching higher level of subject studies.

There are two main reasons for ontodidactic approach in physics education today as a whole and in general secondary education particularly:

1) remarkable step in the progress of natural sciences and technologies, followed by serious global and local changes in our economical and political life;
2) step from lower secondary level to upper secondary level in general education.

The first reason as the impact of modern science and technologies progress on our life and education is very widely discussed and serves as serious modern context analysis for physics education further development (Black, 1996; Sjøberg, 2002; Broks, 2002). It means cognition of

the situation, which must follow by corresponding consideration and behavior to solve the problems concerned with developmental crisis in physics education.

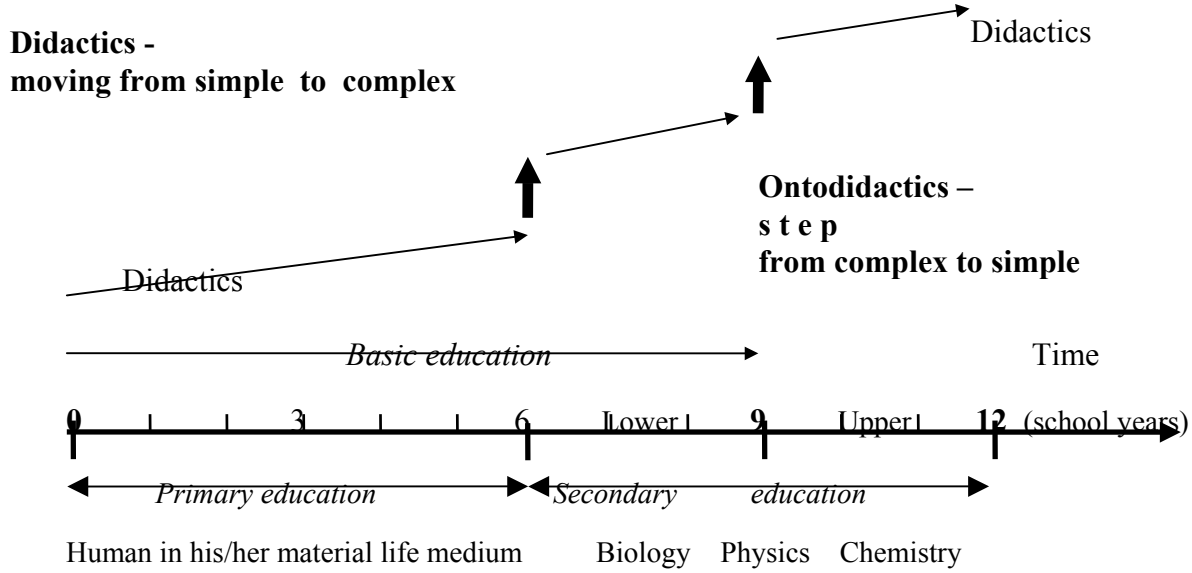

Figure 1. Didactics and ontodidactics in general education.

The second reason presents the actual need to improve the two-part structure of secondary school general physics today. Physical phenomena are all around us already from childhood, but there is no need to introduce a special subject at primary (elementary) school level. Childhood is a period in our life for obtaining wide sensual experience. At secondary school level we start active theoretical description of this experience. Lower stage of secondary schooling means an introduction to this new approach and the start of special subjects (physics, chemistry and biology in natural science sector) – many new words are introduced for better description of observed phenomena. **Education for understanding, further development of scientific way of thinking, making a step from factology to causality – all this characterizes the upper secondary education.** The step from lower to upper level in secondary education – that is what we need to understand as pedagogues and to realize in school practice.

Due to serious changes in modern life and physics itself author prefers following main fields of our educational activities in the secondary school physics today:

1) elimination of professional details in general physics education by means of generalizing our former experience;
2) widening contacts between physics and other fundamental branches of our life experience;
3) qualitative innovation and structural optimization of the educational content and corresponding terminology with concentration on principal understanding of physical phenomena and methods of their investigation.

The final introduction note is concerned with notification of highly effective use of systems theory or systemology (general theory and practice of world's arrangement as the result of overall interconnections of phenomena) in education (Broks, 2000; 2001a). Systems approach in education is very important just for ontodidactic projects, where different hierarchical structures must be developed.

Principal guidelines for development of general physics subject

In order to give a short overview of used principal guidelines (figure 2) with some comments follows.

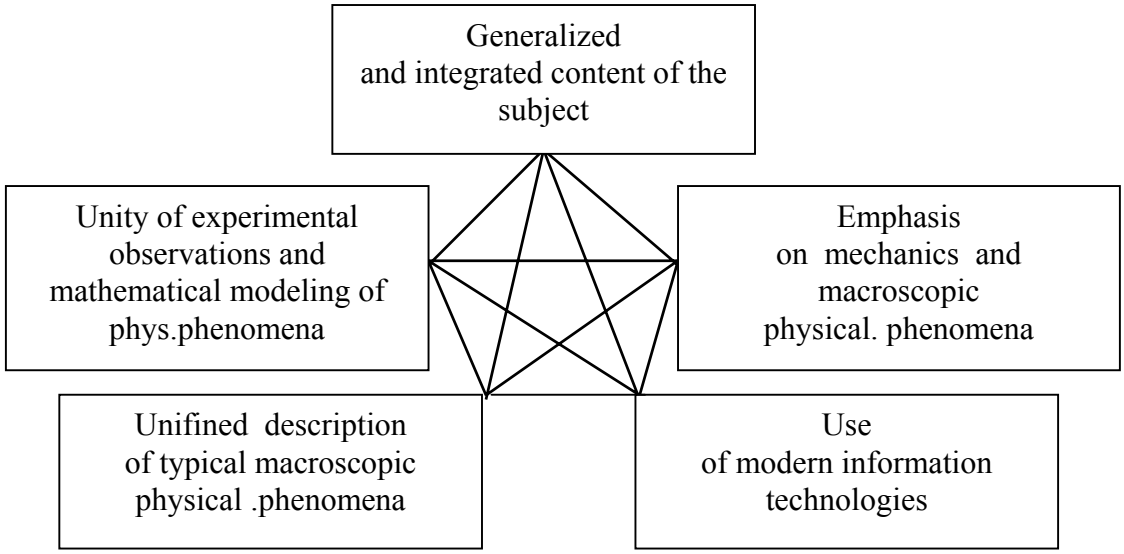

Figure 2. The system of main principles for physics subject development.

There are five subject development principles what were proposed for general guidance during the process of subject construction and implementation.

1. Generalized and integrated content development with an emphasis on common features of diverse physical phenomena when reflecting them in human's consciousness.
2. Closely interconnected realization of physical phenomena observation (experiments, measurements) and mathematical modeling.
3. Mechanics' centered construction of subject and the priority of macroscopic physical phenomena.
4. Systemic description of determinate and stochastic physical processes (using appropriate for secondary school level differential/integral and statistical distribution methods' ideology).
5. Usage of modern information technologies for corresponding data processing, experimental measurements and simulation of physical phenomena.

Content of general physics subject

By no means being scientific subject, general physics at the upper secondary school is not professionally oriented for pupils to become physicists. Our main task for general (not professional) secondary schooling is to develop scientific thinking and introduce pupils to physics methodology for principal understanding of main physical phenomena (Broks, 2001b).

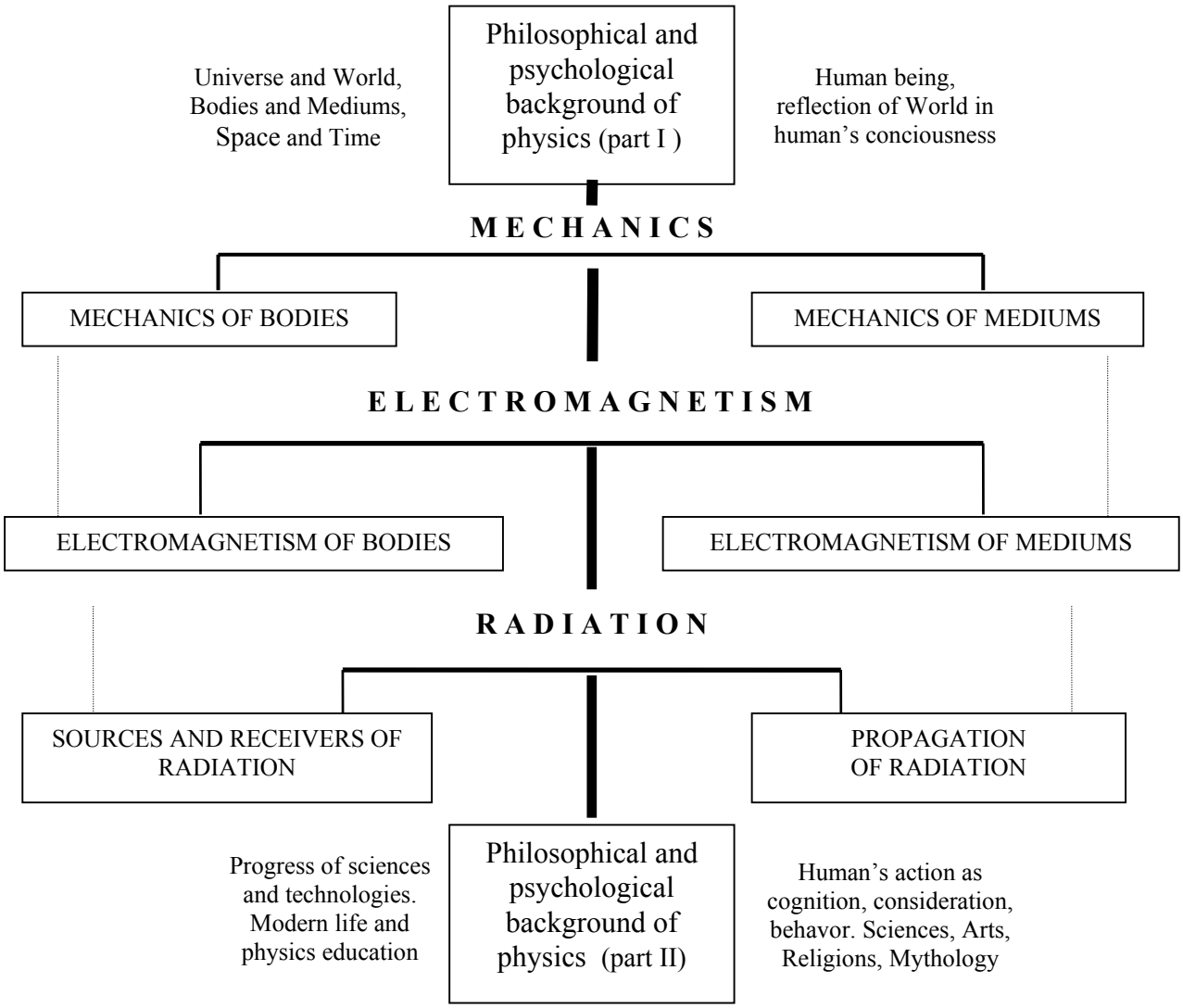

Figure 3. The main structure of general physics subject content.

Philosophical and psychological background of physics (part I)

Set of basic notions World, Human and Physics. *World* as the set of diverse changing bodies - known part of Universe, where *human being* is one of them. Human being – spiritualized material body, human's life as unity of material and spiritual activities. Reflection of the world in human's consciousness. Factology and causality. *Physics* as a fundamental knowledge about the material world – set of fundamental notions: *bodies and mediums, space and time, motion on mega, macro and micro levels of the world.*

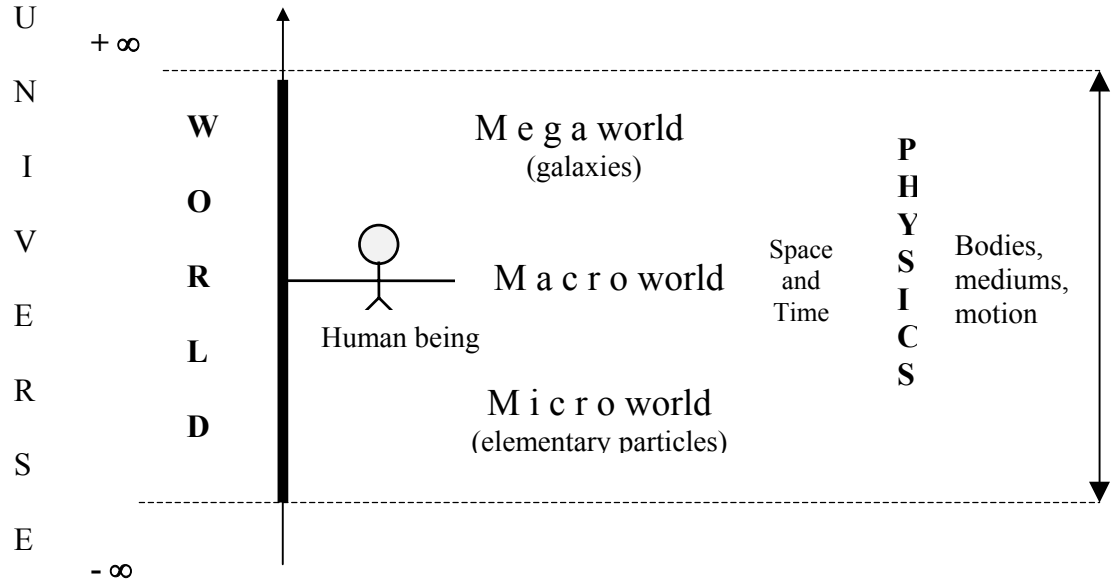

Figure 4. System of top level notions for general physics.

Mechanics

Mechanics as the central part of physics, fundamental kinds of motion, factology (statics, kinetics) and causality (dynamics, energetics) in mechanics.

Mechanics of bodies (translations, rotations, collisions, deformations, gravity of bodies): mechanics of point-like bodies [motion in one dimension - static, kinetics, dynamics, work, energetics (notions of force and energy fields, model of two bodies' interaction), summation of motions (analysis and synthesis); motion in two and three dimensions]; mechanics of definite shape and dimension bodies. Basic phenomena in cosmic and relativistic mechanics.

Mechanics of mediums*:* mechanics of bodies' inner mediums (substantial mediums – structures of solids, liquids, gases and microscopic physics of heat - inner motion of substantial media, its dynamics and energetics, different technical mediums); mechanics of medium transport and mechanics of medium excitations (vibrations and waves, impulse excitations - *sound* emission and absorption, sound propagation, *heat* emission and absorption, heat propagation).

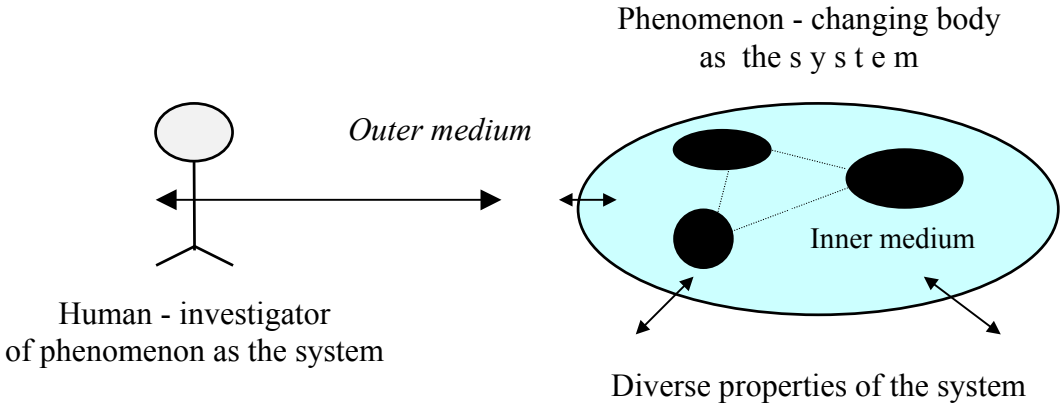

Figure 5. The systemic organization of world's investigation for understanding and sensible behavior in science, engineering and education.

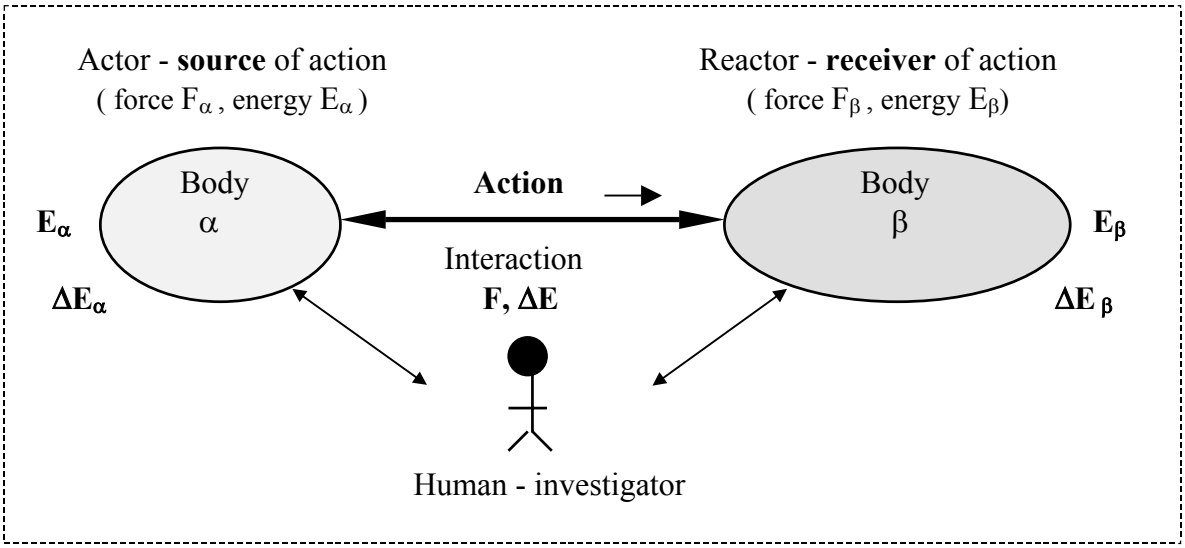

Figure 6. Pair interaction – simple causality investigation.

Electromagnetism

Electric properties of bodies – electrostatics: electrization of bodies, interaction of electrically charged bodies, notion of the electric field; electric polarization of bodies and notion of electric dipole (dielectric, piezoelectric and spontaneous electric polarization). ***Inner electric medium of bodies*** - transport of electric charge, notion of the electric current, electric conductors, semiconductors and insulators; sources and devices of direct current, direct current electric circuits and their main elements. ***Magnetic properties of bodies*** – magnetostatics: magnetic bodies and their interaction, notion of the magnetic force, magnetic dipole and its magnetic field; induced and spontaneous magnetization of bodies. ***Inner magnetic medium of bodies -*** diamagnetic, paramagnetic and ferromagnetic materials. Causality relationship between direct electric current and magnetism.

Unity of changing electric and magnetic field - electromagnetic induction: notions of electromagnetic field and alternating current. Industrial and high frequencies alternating harmonic currents - generation, propagation and absorption, electromagnetic impulses. Simple alternating current circuits and their main elements. Alternating currents as electromagnetic excitations of substantial mediums. Microscopic view on electromagnetic phenomena - motion of electrically charged particles.

Table 3. The principal structure of chapter "Electromagnetism".

Electromagnetism	S t a t i c s		C h a n g i n g electric and magnetic fields
	Electrostatics (electrical properties)	Magnetostatics (magnetic properties)	
Bodies	*	*	*
Mediums	*	*	*

Radiation

Radiation as the flow of microworld particles, the main classifications of radiation phenomena. General macroscopic and microscopic characteristics of radiation (continuous and discrete character of radiation - waves and particles, energy and content spectrum, flow, density and intensity of radiation, sources (emission) and receivers (absorption) of radiation, propagation of radiation (reflection, refraction, scattering, interference, diffraction). Formation of images.

Electromagnetic radiation. Electromagnetic waves and photons, the electromagnetic spectrum: low frequency, radio frequency, microwave, infrared, visible light, ultraviolet, X – rays and EM (gamma) rays radiation; Energetics of electromagnetic microworld phenomena (atomic world - basic principles of quantum mechanics).

Electron beams. Nuclei radiation - structure, stability and transformations of atomic nuclei, natural and artificial radioactivity, nuclear reactions, spectrum of nuclei radiation, kinetics of radioactivity. *Cosmic radiation*. High energy particle physics. *Radiation and human* - radiation as information carrier, radiation and material technologies, human as the source and receiver of radiation.

Philosophical and psychological background of physics (part II).

Set of notions Physics, Life and Education. Human's action as cognition, consideration, behavor. Chaos and order of things and processes, systemic organization of human's consciousness. Sciences, Arts, Religions, Mythology. Progress of sciences and technologies and crisis of life and education today. What physics education for what life?

Discussion

First, let us make the note that this paper reports only the main principles of author's ideology as well as only the main structure of general physics subject at upper secondary education level. In details such projects usually are heavily authorized – many details of subject realization are very personal and not very interesting for general discussion. So, excuse me, dear readers, for details which are not described here fully enough. We need direct in-service meetings and special publications for more detailed description of the proposed subject structure and its practical realization.

Secondly, author would like to turn special attention to the fact that we need seriously to think about the **terminology of physics** education as well as science and engineering **for international cooperation when using English words and language structures**. To express author's thoughts in definite logical structures for foreign people, who do not know Latvian language, International English Latvian version is used. Why? Our thoughts in our native languages very often are impossible to express precisely in native English. The logical structures are typical for each native language and we need to work very correctly in our mutual interaction in order not to loose sense of native logical structures, when changing languages. By the way – what does "native English" mean? British or American English? Billions of people today all around the world use and develop International English – so did also the author of this report, expressing his Latvian language based thoughts – logical structures in English for readers with different native languages. International English gives us wide possibilities to enrich our native languages and develop our national *systems* of education and professional terminology without producing formal senseless mixtures of words – widespread loosing of precise thought structures based on native languages.

Finally some words about possible realization of reported concept and proposed content of physics subject. It seems not to be easy and quick to realize this project in practice. Observations show, that experienced educators try to follow their traditional way of working. They say: "yes, it's interesting and may be perspective, but school system (educational standards, text books, teachers, methods) is not ready for such development". It is true, but pupils are ready - they wait, need and demand corresponding changes. Do we – educators like to

become ready? Let me put this question also to you, dear readers. What do you think and what could be your suggestions about the reported approach? What experience do you have in your country and school, in your personal work for better future physics education?

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Резюме

ОБЩЕОБРАЗОВАТЕЛЬНАЯ ФИЗИКА В СОВРЕМЕННОЙ СРЕДНЕЙ ШКОЛЕ

Андрис Брокс

Статья посвящена сообщению результатов разработки основных принципов и структуры содержания предмета физики в общеобразовательной средней школе с учётом наступившего кризиса в образовании физики. Она содержит краткий обзор современной среды образования в условиях существенных изменений жизни современного общества как результата широчайшего внедрения достижений современной науки и техники, а также предложения автора для преодоления кризиса в образовании физики путём онтодидактического подхода в разработке новой структуры и содержания предмета. Обращая особое внимание на общеобразовательный характер предмета физики, предлагается ориентация предмета на обеспечение понимания методологии научного познания и усиленное развитие причинно-следственного мышления учащихся, ведущее к научному пониманию физических явлений и механизма научного отображения мира в сознании человека.

Ключевые слова: общее образование, среднее образование, дидактика, исследование и развитие образования.

Received 05 August 2003; accepted 20 October 2003.

Andris Broks

Associate professor, doctor of Physics

University of Latvia, Faculty of Physics and Mathematics
Zellu 8 - F402, Riga, Latvia, LV – 1002
E-mail: andrisbroks@hotmail.com
Phone: + 371- 6567120 (mobile)

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