INNOVATIVE SYSTEMS APPROACH IN GENERAL PHYSICS EDUCATION

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Abstract

As an attempt to meet the crisis in modern natural science and technologies education an innovative systems approach in general physics education is reported. Basic set of physics concepts and ontodidactic two level structure of the physical content has been developed. Motion is used as a most fundamental concept of physics education, which is behind almost all physical phenomena.

This development of general physics education is intended for all and is not bounded to any system of formal education or people's age group.

Modern Information and Communication Technologies (ICT) must be used for practical implementation of the innovative system developed for general physics education.. WebCT 4.1 Learning Management System (LMS) has been used for this purpose and the corresponding mainframe structure has been developed. The development of detailed substructures of the corresponding e-physics content and educational technologies is in progress.

Key words: general physics education, systems approach, ontodidactics, ICT in physics education.

Introduction

Complexity of worldwide phenomena – growing diversity and speed-up of our life processes, political and economical globalization and overall social polarization – has become the *main characteristic* of our modern life. What education for what life – such is the question today. To reach a new quality of education we need **transformational changes –** it means a new *content* and new *methods* of education, as well as a new kind of *educators.* Today it's not enough to have only the quantitative changes or reforms of former educational experience.

There has been done much research in modern education, but practical implementation not always follow. In contrast with traditional research, this work is incorporating basic concepts of systemology and modern didactics, and by itself is a practical ongoing implementation of these ideas in a real educational process using ICT.

Methodology

Qualitative changes in education today start with the reconstruction of the educational content. Transformations always are systemic changes, and so the *systemology* (systems theory or systems approach) as the general theory of order-disorder phenomena with special respect to the arrangement of things and processes has to become the backbone for the sensible development of our modern life and education (Broks, 2001; O'Коннор, Мак-Дермотт, 2006).

Ontodidactics as an applied systems theory for transformational changes in our education has been used (Соколовский, 1973; Broks, 2003). Traditional didactics, following principle of advance from simple to complex, today must be supplemented with ontodidactics, following the principle of transition from complex to simple. It means the step to higher level of generalization when starting new stage of education or developing qualitatively new structure of educational content.

Systemology and ontodidactics are the fundamental background of the methodology of this development.

Principal basis of the reported project contains a concept of world as a conscious part of universe, interconnected concepts of human's life and education as well as concept of universal structure of human's purposeful actions (Broks, 2003, 2005). From Philosophical and Psychological point of view Physics is just a scientific reflection or theory of material world's bodies and mediums motion in human's consciousness. As mediums we understand sets of material bodies, for example substance is a medium which is made from atoms and molecules.

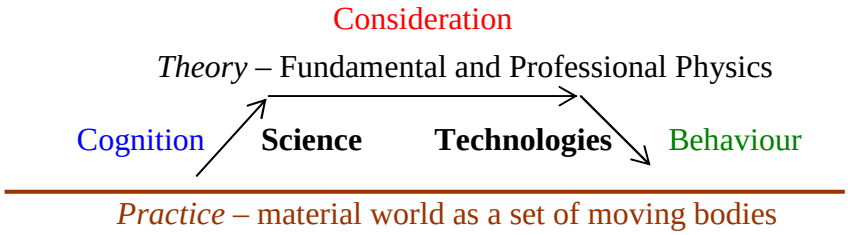

Figure 1: Principal interconnections "Practice-Theory" and "Science-Technology" – unity of cognition, consideration and behavior

Definition of Physics has been introduced and used: p h y s i c s is a fundamental scientific theory (which is a specific human's life experience) that contains factology and causality of material world's bodies and mediums m o t i o n.

Results

Set of basic concepts (Figure 2) includes **motion, bodies, mediums.** Four types of motion have been defined.

1. Motion of bodies within outer medium. For example, fish swimming in the water. Fish is the body and water is the outer medium.
2. Motion of bodies' inner medium (excitations). For example, thermal motion of atoms and molecules in bodies.
3. Motion of bodies' inner or/and outer medium through bodies' surface. For example, evaporation and absorption phenomena.
4. Motion of bodies' inner or/and outer medium excitations through bodies' surface. For example, transfer of heat and sound.

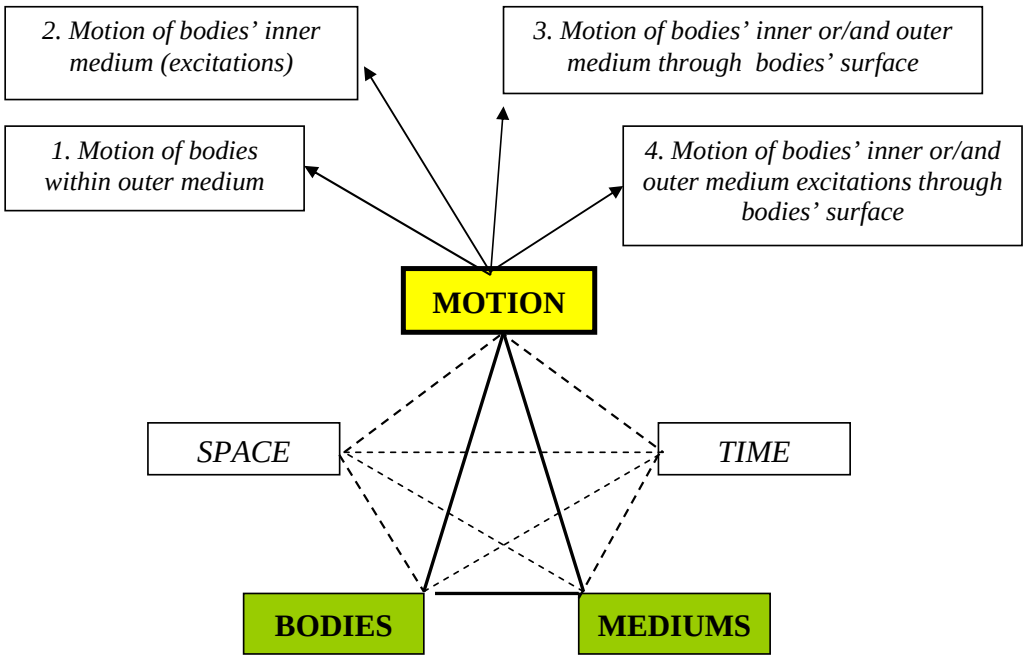

Figure 2: System of basic concepts and fundamental types of motion.

Two level General Physics mainframe structure for lifelong education has been developed. It is General Physics education for all, and content as well as form of studies is not attached to any specific system of formal education or specific people's age group.

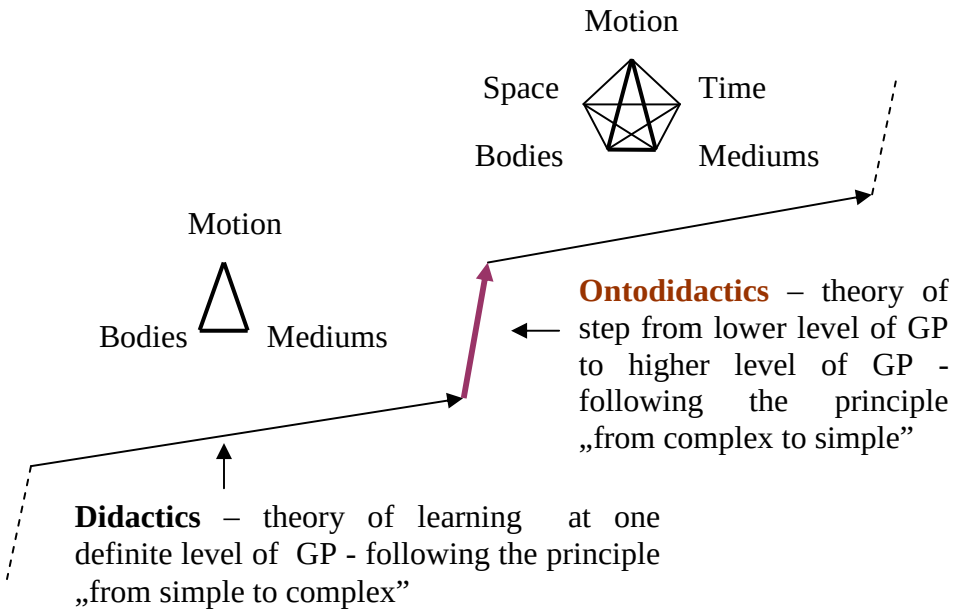

Figure 3: Multilevel or hierarchical structure of General Physics (GP) – unity of Didactics and Ontodidactics

At first level typical groups of physical phenomena have formed (macroscopic bodies' and mediums' motion, sound and heat, electricity and magnetism, electromagnetic radiation, main cosmic and microscopic world phenomena). It's supposed not to use heavy mathematical approach, and fundamental concepts of space

and time are not especially discussed (Voitkans, 2006). At second level study of mathematical modeling and generalized structure of physical phenomena (mechanics, electromagnetism and radiation) is proposed and concepts of space and time are discussed (Broks, 2003).

ICT technologies can and must be used in different ways to support the implementation of innovative educational content (Voitkans, 2006). In this work, the main focus is on the use of internet technologies (particularly learning management systems – LMS). The implementation using LMS (development of e-course) allow to achieve most benefits ICT can offer. Besides well known e-learning advantages, development and use of general e-physics education can help to:

- Provide opportunity to get understanding about physics for a wider audience – not only schools, but also non-physics students in universities and lifelong learners.
- Improve effectiveness of physics studies.
- Quickly and thoughtfully renew basic knowledge about physical phenomena.
- Offer innovative general physics structure, which is based on certain system of terms, taking into account ontodidactics. This will help learners to set right their own conceptions about daily life phenomena.
- Build multilevel physics, where it is possible to navigate easily between levels.
- Create human networks between physicists, teachers and students (Esquembre, 2001).

The main development guidelines are strategic decisions which we use in the implementation process of general e-physics using ICT (particularly WebCT LMS). Implementation guidelines should agree with the aims and specifics of development.

Following main implementation guidelines were specified, on which general e-physics development was based on:

- E-physics has to be multilevel. This way it is possible to adjust the e-course to different target audiences with different learner characteristics.
- To successfully complete the first level of general e-physics, no special entrance requirements are necessary.
- Every next level requires knowledge and skills of previous level. Currently we are planning two level general e-physics implementation.
- Every two levels in education are separated by ontodidactic step – transition from complex to simple, rising to a more general (higher) level of educational process. (Broks, 2006)
- Main structure of e-physics is similar in both levels – Introduction, Physics, Conclusion.
- In the first level, the main physical concepts are introduced, which are extensively used in the next levels. In the first level there is less mathematics and other formal structures, but more explanations and examples from daily life.
- In the second level, physics is viewed from a new point of view: concepts and physical phenomena which are introduced in the first level are generalized and systematized.
- It should be possible to switch easily between different levels of e-physics, and differences should be observed easily.
- E-physics should have a thought-out and consistent terminology.

Technical implementation of general e-physics is based on a use of DocBook[1] and LaTeX[2] technologies, which are very flexible and powerful, and can support complex course structure. In this implementation DocBook is used as an XML DTD schema, and it is customized to be suited for the needs of general e-physics implementation. Two kinds of materials are generated from DocBook sources – HTML[3] and PDF[4]. PDF generation is implemented using LaTeX as an intermediate format.

Navigation of general e-physics course is implemented according to previously stated guidelines using WebCT 4.1 environment. In the course visual navigation methods are used. We believe that visual navigation can not only facilitate navigation through educational material, but can also help to get an understanding about the physics structure.

The first screen is simple. Students can choose one of the course levels. Information about course and two level structure is also available (*Figure 4*). Course language is our state language – Latvian.

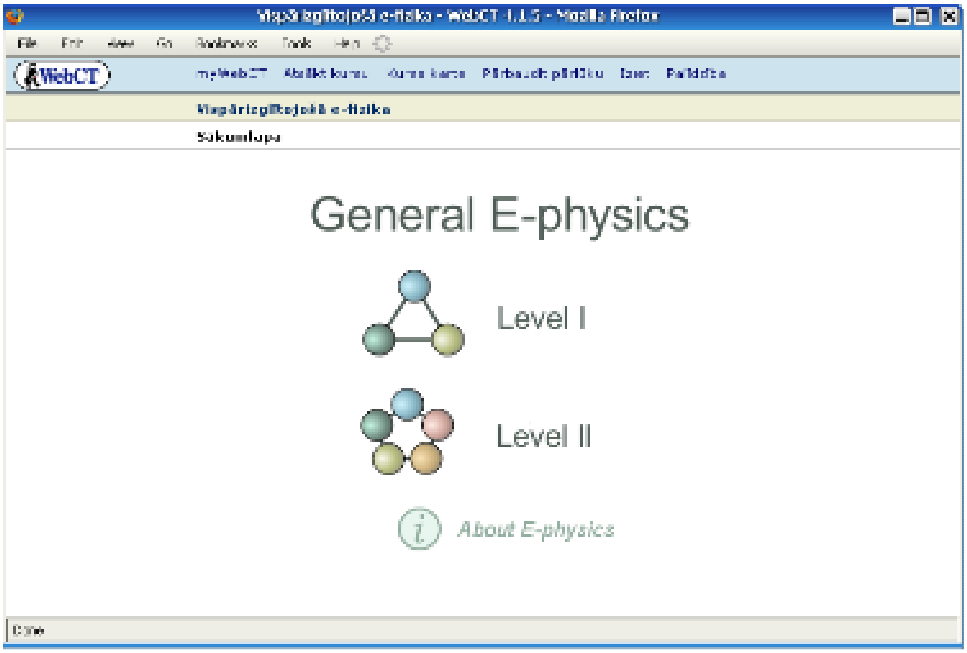

Figure 4: First page of the general e-physics for all (screenshot)

The main structures of physics of both levels are shown in the *Figure 5* and *Figure 6*. In the first level, we speak about physics like phenomena groups – Motion of Bodies, Motion of Mediums, Sound and Heat, Electromagnetism, Electromagnetic Radiation, Cosmic and Microworld physics phenomena. In contrast the second level physics has more general structure – it consists of three main parts – Mechanics, Electromagnetism and Radiation.

1 DocBook is a variety of XML/SGML markup languages, dozens of organizations are using DocBook for millions of pages of documentation, in various print and online formats, worldwide (DocBook.org).

2 TeX is programmable typesetting system which can be used for almost any formatting task. LaTeX is a document markup language and document preparation system for the TeX typesetting program, and LaTeX has made it usable by almost anyone. Nowadays dozens of publishers are accepting LaTeX documents for publication, and hundreds of thousands of users are using LaTeX for millions of documents (Wikipedia, LaTex; Flynn, 2003).

3 Hypertext Markup Language, http://www.w3.org/MarkUp/

4 Portable Document Format, http://en.wikipedia.org/wiki/Portable_Document_Format

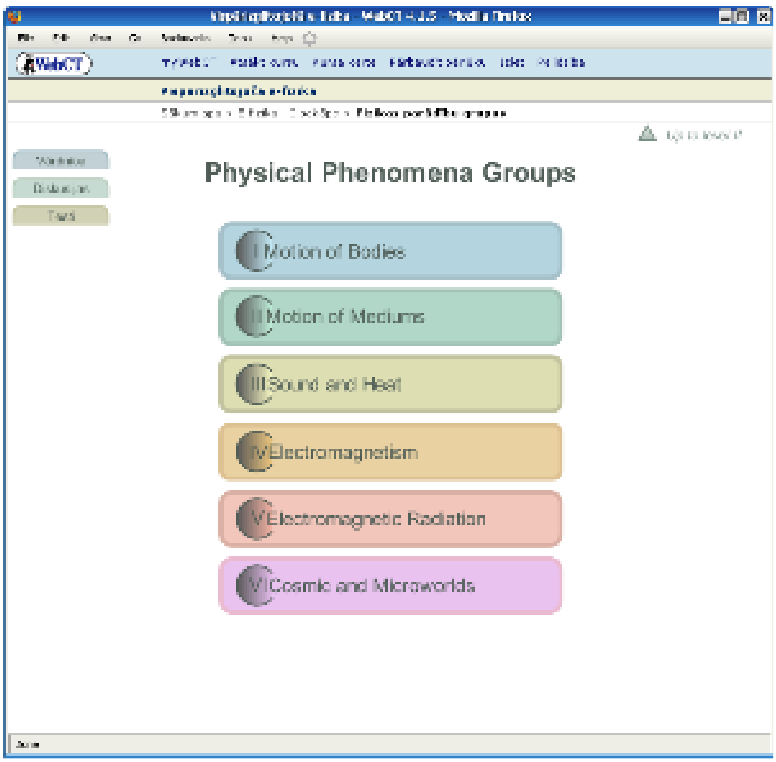

Figure 5: First level. General e-physics for all

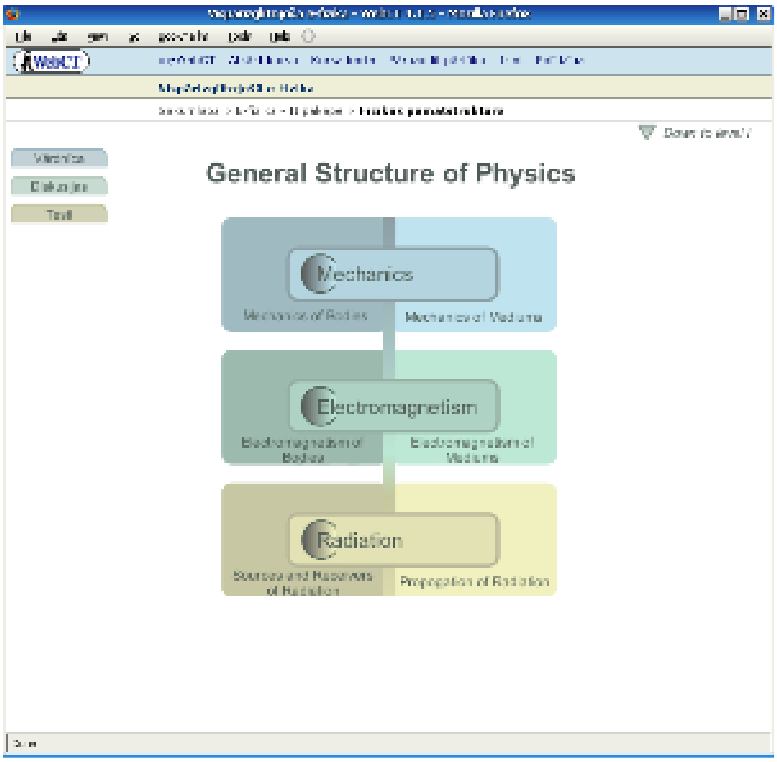

Figure 6: Second level. General e-physics for all

Technically the visual navigation used in the course is implemented using HTML image maps. WebCT breadcrumb also gets updated when users are navigating through the course.

Discussion

The structures created and used in this development differs from the structures, which are widely adopted in traditional physics education. The offered structure meets the actual need for systemic and ontodidactic output of modern science education research and development.

We need to expose physics as fundamentally important basis for our modern life to our youth – our emerging generation of scientists, engineers and science/technology educators. For this purpose, effective use of modern ICT is necessary, but it is not enough to use ICT with at least hundred years old curricula of physics, chemistry and biology. Firstly, it is necessary to rethink and optimize Science subject's curricula, and it has to be done considering modern possibilities ICT is offering.

At the same time, it is also very important to develop a new generation of educators who will be able to accept modern Science education content and technologies.

Conclusions

Firstly, the principal basis for further development of general e-physics have been established. The main structures of e-physics have been realized and implemented in WebCT LMS.

Secondly, huge amount of work is still needed to add a detailed educational content to the developed main structures. It is necessary to involve different people in the further development of the content.

Thirdly, to ensure the innovation of the general physics education, the modern methods and interactive technologies ICT is offering (podcasts, vodcasts, simulations, blogs, etc.) must be adopted in the further development of general e-physics.

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