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ROLE OF COMPUTER ORIENTED LABORATORY TRAINING COURSE IN PHYSICS FOR DEVELOPMENT OF KEY COMPETENCES OF FUTURE ENGINEERS

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Abstract. *In the article the features of the core competencies, which are formed in the course study of Physics at the Technical University are described. Some features and examples of the use of computer-oriented laboratory work for the formation of technological competencies engineering students are highlighted. Definitely possible elements of interactive content notebook integrated with software analysis of the experimental data.*

Keywords: competence approach; flash book; laboratory practice; technological competence.

1. Introduction

At the heart of the transition to a new generation of industry standards is the concept of competence approach, which reflects the trend technologizing and informatization of all areas of human activity and society in general, contributes to the development of human potential, is directed to a new (innovative) development of society and is based on the unity of thought and human activity [5].

The global technology revolution has led to the fact that human activities (especially future engineer) highlights the technological thinking as a way of mental activity, which is holistically perceived, interpreted, understood by the purposeful process of gathering, analyzing and transforming data for optimal solution of practical problems [9].

The development of mathematical and experimental skills in future engineers in the process of studying of physics always forms the total number of common (key) and subject competences which gives future engineer the thinking of flexibility, enable to bring him to the creation of complex systems models, even outside the sphere of physics as a science.

Some of them include technological competence of the basic integrative sign of individual that is a combination of cognitive, operational activity, design, reflective and analytical skills which guarantee the planned result [11].

Indeed, physics (compared to other academic disciplines) provides an extremely broad package of skills that can be transformed, and computer-oriented laboratory training course in particular has opportunities to develop a range of competences to solve practical problems, based on a real "natural" experiment.

A systematic approach is also used to explore the subject "physics" that provides the appropriate type of thinking and is based on comprehensiveness, interdependence, integrity of the examined phenomenon elements.

Creating and using modern educational environment for the study of physics, which is based on the sustainable use of a wide range of software technologies and expanding students' knowledge in the fundamental (physics and mathematics) and applied professionally meaningful science, shape not only the cognitive and operational and technological components that are within the structure of the future professional competence, but also motivational and value-oriented components.

2. Analysis of recent research

Since the first studies of David C. McClelland (1973) [12], the category of variable "competences" that can predict the progress of future professional activities of the individual has undergone significant development, refinement and expansion.

Nowadays there are some definitions of the term "competence". Thus, in the synthesis report on the workshop program of the Council of Europe (Bern, 27-30 March 1996), which focused on identifying key competences, as a result of paradigm of modern education Mr Walo Hutmacher noted that most researchers include the category of "competence" to the conceptual field of "know how" and not "know that" [6]. It was also accepted the definitions of five key competences, which "should have young Europeans".

Most researchers now interpret "competence" as estranged from the subject, given beforehand social norm (request) ... necessary for high-quality productive activity in a particular area [7].

More generally, “competence” is any measured characteristic of man that allows him effectively to carry out a specific activity.

A set of required competences creates professional competence.

According to the division of educational content on general (for all subjects), interdisciplinary (for a cycle of disciplines or educational areas) and subject (for each academic discipline) parts there are three levels in the hierarchy of typology of competences: subject, general subject and key (general) competences, the latter of which specifies in the first two levels [7].

From the standpoint of personal approach key competences can be described with the KSAO standards, which include [1]:

— Knowledge (the actual information that is required to work in this professional position);

— Skills (all employee skills, physical or mental nature);

— Abilities (human tendency to perform certain actions in the future; skills that are often used in practice, gradually becoming skills);

— Other characteristics (all the features of a person that cannot be attributed to any of the above items, but at the same time, these characteristics play an equally important role in the work of employee).

The recommendations of the European Parliament and of the Council of 18 December 2006 on key competences for lifelong learning [8] state that the key competences for lifelong learning are a combination of knowledge, skills and attitudes .... They are particularly necessary for self-fulfillment and development, social inclusion, active citizenship and employment ... contribute to the motivation and satisfaction of employees and quality of work.

The authors also distinguish eight key competences: communication in the native language, communication in foreign languages, mathematical competence and basic competences in science and technology, digital competence, the ability to learn independently, social and civic competences, sense of initiative and entrepreneurship, cultural awareness and ways of its expression.

There is also an interdependence of mentioned above competences; each of them has the ability to critical thinking, initiative, creativity, and willingness to make decisions and constructive problem solving, risk assessment.

The project TUNING identifies three general types of competence: tools (cognitive, methodological, technological and linguistic ability), interpersonal (social interaction and collaboration), system (combination of understanding, sensitivity and knowledge, which leads to the understanding of how the parts of a whole are correlated with each other and evaluate each component of the system) [16].

Types and characteristics of competences that are formed during the study of general physics were determined during implementation of the international educational project [14]. They are:

— applied skills (an inherent level in the graduates of first cycle): professional activity within the applied technology, which in industrial and household levels is related to physical knowledge, in particular, radio, television and video communication, satellite remote control ... the ability to analyze and simulate based on physical skills and computer literacy;

— familiarity with basic and applied research: understanding of natural phenomena and knowledge of physical research methods and how they can be applied to other areas;

— experimental skills: the ability to conduct experiments on their own, in particular, describe, analyze and critically evaluate experimental data and to get acquainted with the most important experimental methods;

— math skills: the ability to use the most widely used mathematical and numerical methods;

— skills evaluation: the ability to evaluate the magnitude of various physical phenomena, draw an analogy in order to solve new problems on the basis of already known ones, to assess the significance of the obtained results;

— modeling skills: to be able to determine the basis of the process/situation and to create a working model of it, to be able to perform the required approximation, critical thinking to construct physical models, to be able to adapt existing models to new experimental data;

— problem solving: to be able to calculate their own or with a PC, including the ability to use the software for processing numerical data, physics simulation or control experiments;

— culture of physics: to be aware of the most important branches of physics and the approaches they use;

— common types of work (level inherent in the second cycle graduates): to be able to carry out activities such as the initiation and development of science and technology innovation, technology planning, etc.;

— learning ability: to be able to development new areas of knowledge;
— deep knowledge and understanding: to have a good understanding of the main physical theories (logical and mathematical structure, experimental basis, described phenomena), including knowledge of the fundamental principles of modern physics, such as quantum theory, etc.;
— literature search skills: to be able to find and use natural and other technical literature information relating to scientific research and other technical projects.

Good knowledge of technical English required for online search.

Obviously that almost all the competences are related (directly or indirectly) to the possibility to use computer technology in a future professional activity.

Analysis of a variety of literary sources, materials of conferences and developments set out in the Internet, has shown that the above mentioned approach is widely used in the international educational space and is realized through a combination of the classic study of the course of general physics and various types of computer-oriented activities, such as popular software for analysis and visualization of data Microsoft Excel, Mathcad, MATLAB, MicroCAL Origin [15], etc. Making of flash models of general physics course, based on the combined analysis of physical phenomena and processes of programming using modern programming languages (e.g., C + + Builder) and software (e.g., Flash Professional) [2] plays a special role.

Open-source software (Tracker, Data Point, etc.) which is used in laboratory practice (especially the section "Mechanics") and gives the students the opportunities to analyze their own video material is very original, informative, and one that develops research skills [4].

3. The purpose of the article

Based on the competence approach the author analyzed the possibilities of modern laboratory equipment for the use in the educational process of technical university and the concept of laboratory work in physics, which can be later issued in the form of flash notebook to perform computer-based laboratory work.

The urgency of implementing such a product is dictated by, among other things, the need for the formation of future engineers' knowledge about a variety of methods, tools and forms that are used for scientific description of physical phenomena.

4. The results of research

The role and importance of laboratory work in physics, without exaggeration, can be called a determining factor in the formation of engineering thinking.

The availability of relevant material base creates a foundation for development of engineering practice of future specialists.

Classes in the form of studio are currently very popular in the world and allow to realize teaching physics at a high scientific level.

A necessary condition for the formation of technological competence is the isolation of individual thinking procedures which include the identification and analysis of problem situations, conflicts that are associated with it, the definition and development of specific problems, such as problems, search of specific options to solve them in the given conditions, the choice of the best option, construction of the scheme and its realization.

The development of modern educational environment can be defined as the era of digital creation of computer labs [3], which had a long period of complex formation. In any of them there are technological segments that are continuing now to improve: the perception of external information with sensor, its transformation into a digital signal, the further study of information technology tools and convenient representations for a subject of cognitive activity adapted to its previous experience: visual, tabular or graphic.

Procedural tools for the development of research skills of subjects of cognitive activity using digital interactive labs contain interactive fragments, hyperlinks on network resources and implanted samples of measuring operations. They form a new (digital) thinking of a subject of cognitive activity in the implementation of educational and research objectives.

Attention is attracted by a particular segment of the National Center "Small Academy of Sciences of Ukraine" — "Laboratory ManLab" [10], which implemented a learning environment "Experymentariy", aimed at developing the research skills of subjects of cognitive activity using modern digital laboratories.

The author on the basis of the above mentioned laboratory investigated the possibilities of educational equipment from leading manufacturers of educational technology "Phywe" (Germany), "Fourier" (Israel), "Educational technology" (Ukraine, Rivne) and developed a number of original works, the performance of which may constitute significant cognitive interest for future engineers (in particular, the airline industry).

It should be noted that the research involves the use of appropriate software, for example, Multilab, Tracker, Data Point, Measure, etc. Among them: “The study of jet propulsion based on a dynamic track”, “The study of electromagnetic braking system based on dynamic track”, “Research the laws of gyroscope”, “Defining the speed of sound in air and solids”, “Exploring Earth's magnetic field”, “The study of water electrolysis and fuel cell”, etc.

Let us look in more detail those of them which have the most evident technological component of modern educational environment.

1. Measurement of overload during the jump. Equipment: digital measuring system Cobra 4, recorder of acceleration. Software: Measure. Measured: the dependence on the weight change in body during the jump. Calculated: overload with different body movements (repulsion, flight, landing). Fig. 1 is an example of obtained dependence screenshot.

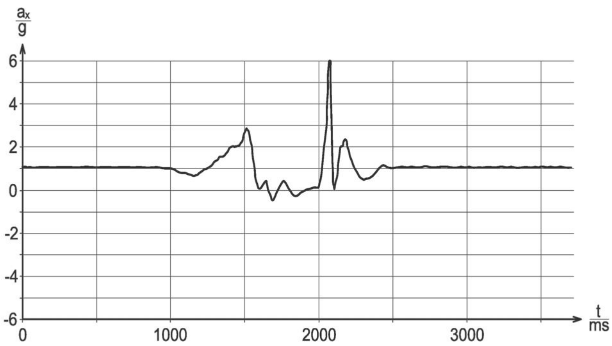

Fig.1. The screen-shot of Measure: the view of experimental dependence

2. Investigation of the distribution of velocities in water whirlpool. Equipment: magnetic mixer, mold, sheet of paper, water, ground coffee, webcam, PC (Fig. 2).

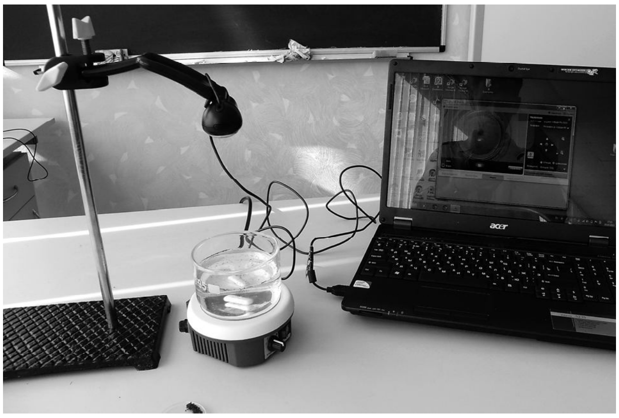

Fig.2. The appearance of the unit for the laboratory work

Software: Tracker. Measured: the radius of the particle's motion, the velocity of the particle. Calculated: the distribution of the particle’s velocities along the radius of the whirlpool (Fig. 3). The instantaneous linear velocity vector are defined for certain segments.

Fig.3. The screen-shot of Tracker during the implementation

3. Study of Benard cells. Equipment: heated magnetic mixer, metal cup, castor oil, paraffin, aluminum powder, thermal imager. Software: software imager. Measured: temperature gradient. Calculated: Benard cell density (Fig. 4).

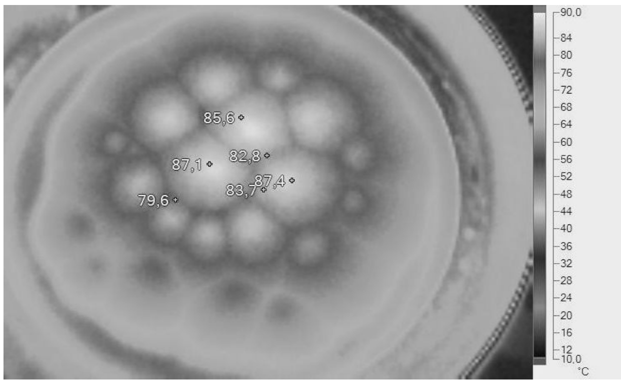

Fig. 4. The screen-shot of the analysis phase of linear sizes of Benar’s cells

Investigation of water electrolysis and fuel cell operation. Equipment: installation for water electrolysis and study of fuel cell, lamp, power supply, current recorder, voltage recorder, NOVA LINK, connecting wires, PC.

Software: Multiplan. Measurement: current with electrolysis, the amount of generated gas, time, current and voltage when operating the fuel cell, the amount of spent gases. Calculated: electrochemical equivalent of hydrogen and oxygen, the electron charge, the efficiency of the fuel cell, the fuel cell power (Fig. 5).

Fig. 5. The appearance of the unit for laboratory work

The mentioned above laboratory work can be successfully used by the subjects of cognitive activity through flash notebooks, all of which can be downloaded to the user's terminal and has interactive features, hyperlinks, implanted examples of the results and implementation details of studying and research work.

The conditions necessary for the formation of technological competence in the performance of mentioned laboratory work as an expression of a number of related core competencies and technological thinking are:

— identify and analyze of problem situation;
— set of options for possible solutions;
— taking into account the dynamic of changes in the environment (the factors of the system), taking into account the consequences of the activity.

At the National aviation university it was started to work on creating this latest educational product, a screenshot of which is shown in Fig. 6.

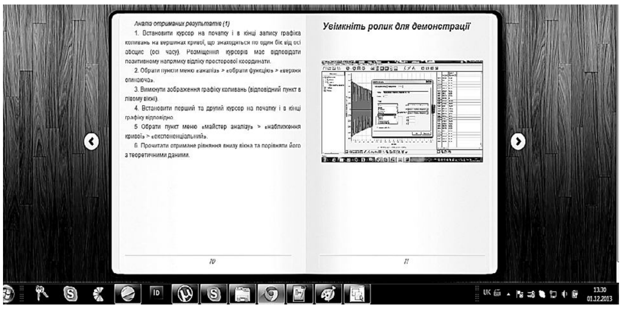

Fig. 6. The screen-shot of the software using flash technology, implemented as a laboratory workbook

This notebook is integrated with the analog-to-digital equipment and such software as Excel and Multilab (Fourier), which is implemented through the appropriate hyperlink.

It was held a video with a demonstration of data analysis too.

The notebook also includes the lack of paper documentation; the files with obtained digital and graphical data can be stored in a convenient way and send to a teacher to check via e-mail or online study.

5. Conclusions

The question of creation both information and component content associated with the analysis and interpretation of the results arises for the developer of interactive books for laboratory training course in physics.

The concept of this software is developed according to several basic components: the key competences of the future specialist identified in educational and vocational programs and educational qualification specifications, content of the subject “general physics”, features of typical software and analog-to-digital software based on modern digital labs.

Modern laboratory equipment offers the students both high quality traditional “natural” laboratory experiment and study outside of its research methods, in which students choose their own research, design and carry out it in mini groups, thereby realizing the actual version of the problem-centered or(and) student-centered learning.

The formation of key competences in modern competitive specialists is based on the basic position of leading methodological approaches in professional training: systematic, competence, active, student-centered, integrative.

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І. А. Сліпухіна. Роль комп'ютерно орієнтованого лабораторного практикуму з фізики у формуванні ключових компетенцій майбутніх інженерів

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Проведено аналіз загально предметних компетенцій, які входять до складу технологічної компетентності майбутнього інженера. Розглянуто можливості компютерно орієнтованого лабораторного практикуму для формування технологічного мислення студентів. Визначено роль і особливості створення контенту інтерактивного зошита, інтегрованого з програмами аналізу отриманих експериментальних даних.

Ключові слова: компетентісний підхід; лабораторний практикум; технологічні компетенції; флеш-зошит.

И. А. Слипухина. Роль компьютерно ориентированного лабораторного практикума по физике в формировании ключевых компетенций будущих инженеров

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Проведен анализ общих предметных компетенций, входящих в состав технологической компетентности будущего инженера. Рассмотрены возможности компьютерно ориентированного лабораторного практикума для формирования технологического мышления студентов. Определены роль и особенности создания контента интерактивной тетради, интегрированной с программами анализа полученных экспериментальных данных.

Ключевые слова: компетентностный подход; лабораторный практикум; технологические компетенции; флэш-тетрадь.

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