E-LEARNING PRACTICE-ORIENTED TRAINING IN PHYSICS: THE COMPETENCE FORMATION

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ABSTRACT

The method of competences level automated management is developed for student's competences formation. An insufficient level of schools graduates in physics is identified as the modern problem of the education. Teacher does not specify which step in a solution a student can not cope with, and the student reiterates his mistake in other tasks solving. It is propose to prepare students to a physics examination by means of tasks solution competences formation. The special software for intellectual support of optimal solution of analytical physical tasks was developed.

KEYWORDS

E-learning, tasks solution, competence level, competences formation.

1. INTRODUCTION

According to Russian government program "Development Program 2020**"**one of the main objectives is the innovative people-centered development of science and technology sectors. For the solution of the posed problem in education the priority is given to technical and natural science disciplines.

The implemented Unified State Exam (the USE) has its goal to select capable school and university graduates. According to the results of the USE 2012 in Physics it has been found out that 26,6% (Ershov A.G. 2012) of all the school graduates got average and high grades and the rest of the school graduates (73,4%) got minimal and low grades (Figure 1).

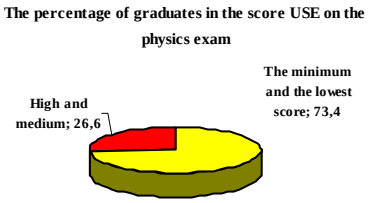
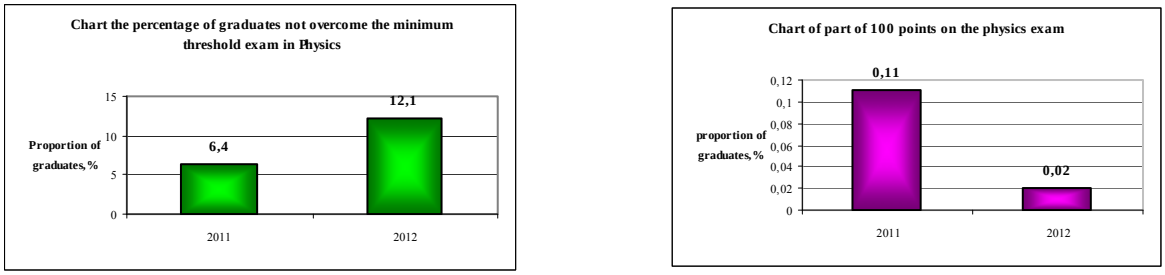


Figure 1. Results of the USE 2012 in Physics

There has been observed a tendency of increasing number of school graduates who have not passed the minimum threshold (Figure 2a). The situation is no better with those who got 100 grades (Figure 2b). As a result the universities specializing in engineering technology missed out on competitive applicants in 2012.

In accordance with the requirements of the Federal State Education Standard all school graduates must be able to apply their knowledge and skills in familiar, changed and new situations. The formation of the ability to apply knowledge and skills in a familiar situation can be achieved by doing similar tasks. Application of knowledge and skills in changed and new situations requires some extra abilities.

Teachers of Physics tend to prepare students for the examination by giving them a great number of challenge tasks. Doing such tasks students acquire knowledge, the very knowledge that they apply at the examination. This preparation method is considered ineffective because one needs much time for fulfilling the tasks and nobody can guarantee that students will be able to cope with the task at the exam. That is the reason why they suggest students being prepared through the formation of task-doing competences.



a) b)

Figure 2. a) Failed results of the USE 2012 in Physics; b) Maximum results of the USE 2012 in Physics

Due to the development of new technologies and new PC hardware in educational institutions the preparatory work should be done through automation of a teaching process.

Researchers (Cecilia Rossignoli, Maria Ferrara and Luisa Varriale, 2013, 2013; Margot McNeill, Maree Gosper and John Hedberg, 2010) propose methods of material assessment, strategies and technologies that enable the learner to embark on a learning process.

E-learning platforms are now widely used by educators to enhance the learners' interest in learning, shorten the learning portfolio, and improve the overall learning outcome (Silvia Knittl & Hans Pongratz, 2010; Said Hadjerrouit, 2013). Individual learning paths may be used and suggested to user in dependence on a given answer of an exercise (Julia Schrock et al, 2010; Stefanie Sieber & Andreas Henric, 2010; Najat Smeda, Eva Dakich and Nalin Sharda, 2010; Vangel V. Ajanovski, 2013).

However, the question of the organization the e-learning practice-oriented training remains unresolved. Accordingly, the development of the automated management method of students' competences formation is viewed to be a vital target.

2. COMPETENCES FORMATION

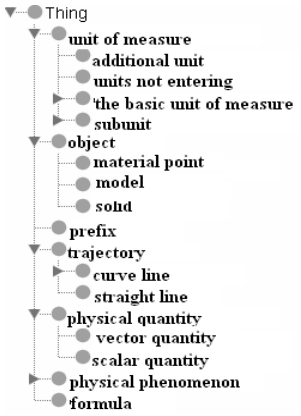
2.1 Ontology of a Physical Task

Design of a physical object model is guided by object-oriented paradigm with its emphasis on decomposition. Each object is viewed as an instance of a particular class. Concepts of physical task: object, physical phenomena, physical value, formula of the law or the physical quantity determination. These terms are defined as classes. Classes (concepts) and relationships between classes form the conceptual framework of a physical task, or ontology. Ontology of the physical task is formally described by tuple type <C, I, L, P, A, F, G>, where C — concepts (classes), I – copies, L– dictionary: LC ∪ LP∪ LI,∪LA, P: V×V – relations, where V=C ∪ I={v| v ∈ C or v ∈ I}, p∈P, p(v_i,v_j): v_i –domain, v_j –range, A: V×LA – attributes, F: LC→C, G:LP→P. In Figure 3 the part of classes' hierarchy and descriptive logic rules are shown.

The Semantic Web of key concepts of the physical task is represented as a graph. In Figure 4 the part of physical task ontology with relations is presented. Concepts "object of study" and "physical phenomenon" in the task are fundamental. The object of study is involved in a physical phenomenon. For example, the material point moves, i.e. is involved in the mechanical motion.

The theoretical material required by solving the function is included into the ontology of a physical task (Kravets A.G. & Titova O.V., 2011). The obtained functions are now task-doing competences, which are to be formed in students.

Aiming at the automation of competence level control process there have been set the tasks to control the system of practically oriented teaching in the field of natural science, within the framework of which there has been offered an idea of mathematical controlling the level of students' competences (Titova O.V. and Kravets A.G., 2013). As a result of solving the problem of the competence level control there has been obtained an optimal teaching mode. It is characterised by gradual increase in the competence level during the study process (Kravets A.G. & Titova O.V., 2012).



1. **x: ClassOfObject ⇒ object**
2. **y: ClassOfphysical_phenomenon⇒ physical phenomenon**
3. **∃object ∧∃physical phenomenon∧ ∃ *involved_in*(object, physical phenomenon) ∧ ∃*described* (physical phenomenon, formula)⇒ formula ∃ object ∧ ∃physical phenomenon ∧∃ *involved_in*(object, physical phenomenon) ∧ ∃*characterized* (physical phenomenon, physical quantity)⇒ physical quantity**
4. **∃ formula ∧ ∃*Contains_a_value*(formula, physical quantity)⇒ physical quantity**
5. **∃ physical quantity ∧ ∃*Contained_in_formula*(physical quantity, formula)⇒ formula**

Figure 3. Hierarchy of classes and descriptive logic rules.

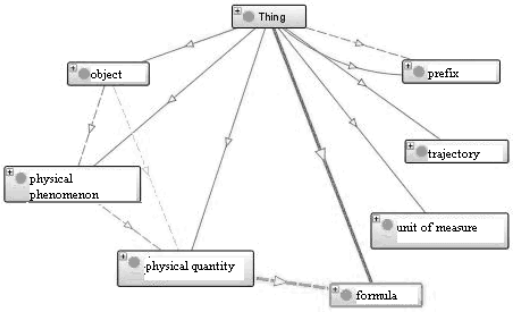


Figure 4. Part of physical task ontology.

Ontology a physical task it is created in the Protege 4.1 software supporting format RDF/OWL. In ontology the classes (concepts) hierarchy of the physical task solution on a theme "Uniform movement of a material point" is presented. The set of the RDF-statements received as a result of a relations establishment, forms oriented graph in which tops are classes and copies, and edges are marked by attitudes.

2.2 Formation of the Competence

For automated control of the competence level it is suggested that they perform a model of a student as a set of many competences: $M_s = \{ C_1, C_2, \ldots, C_n \}$,

where C_i – i-th the tasks solution competence.

With the help of the worked out method of presenting a range of competences there have been defined certain connections between the competences. It are represented the tasks solution competence in the form of sets: $C_1=\{k_1, k_2\}$; $C_2=\{k_2, k_7, k_8, k_{13}, k_{14}\}$; $C_3=\{k_1, k_5\}$; $C_4=\{k_2, k_3\}$; $C_5=\{k_3, k_{10}\}$; $C_6=\{k_5\}$; $C_7=\{k_4\}$; $C_8=\{k_6\}$; $C_9=\{k_8, k_9\}$; $C_{10}=\{k_{11}\}$; $C_{11}=\{k_{12}\}$; $C_{12}=\{k_7, k_{14}\}$,

where C_i – competences, k_i.– elements of a theoretical material (packages of knowledge).

For controlling the level of the competences there has been worked out a method of the competence level evaluating and developing an individual teaching strategy (Titova O.V. and Kravets A.G., 2013).

The level of student competences is evaluated with the help of software developed in ASP.NET MVC 3 RTM. It allows to evaluate the competences level and to build up an individual strategy of the educational process (Figure 5).

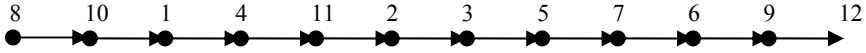


Figure 5. Individual teaching strategy.

Criterion of involving order of competence to the learning path: max ε_i , i=1,2,…,n

$$\varepsilon_i = \frac{rc_i}{n} - \frac{1}{n} \cdot \frac{\sum_{j=1}^{m} w_{ij} \cdot lk_j}{\sum_{j=1}^{m} w_{ij}}$$, where n-number of competencies, lk_j – grade for j-th package of knowledge; w_{ij} – reentrance of j-th package of knowledge in i-th competence.

If the deviation of the competence level from the target is non-zero, then the path includes the competence. For each knowledge package the tasks set is defined.

To train the competence the special software for intellectual support of optimal solution of analytical physical tasks was developed (Figure 6). The code is written in Java using Eclipse Classic 3.7.2 Indigo IDE. The program features a graphical user interface as close as possible to the form of the solution in the student notebook. To handle the ontology Protege-OWL libraries are used.

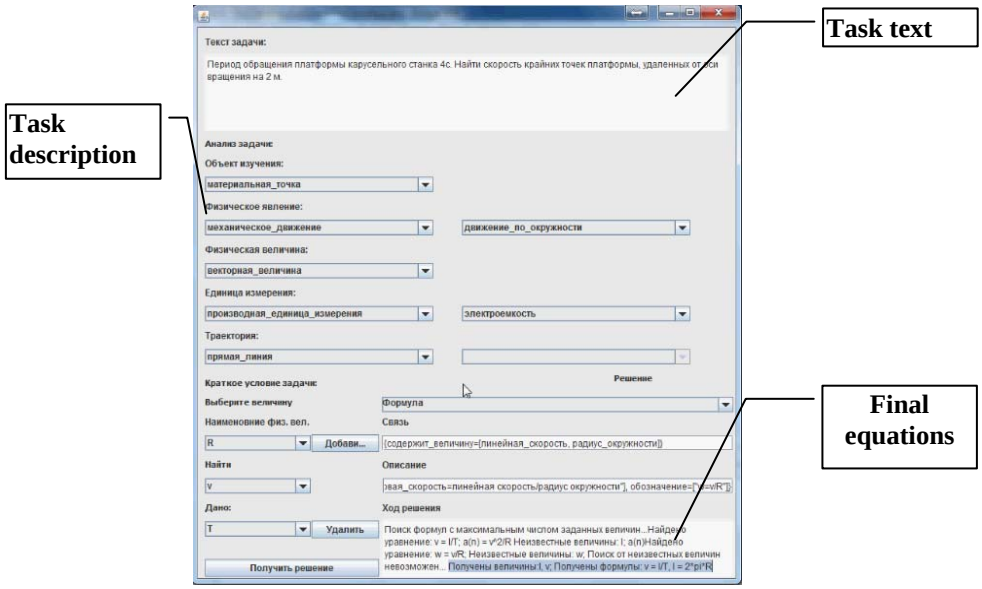


Figure 6. Software for intellectual support of optimal solution of analytical physical tasks.

2.3 E-learning of Physics Tasks Decision Competences Formation

During last 4 years the pupils and students' e-learning of physics tasks decision competences formation were performed. The Internet Consulting Center (ICC) was organized in 2004 and the new method was implemented from 2009.

The ICC education is commerce based. Without changing of the payment amount it was reduced the training time by 15% thanks to the implementation of developed methods and programs, incomes increased by 17,6%. Number of ICC site visitors is increased too (Figure 7). We compared the average level of training at the groups with traditional and experimental (with proposed methods) ways of training (Figure 8).

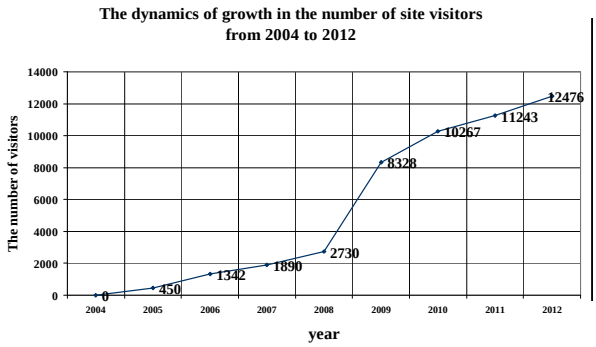


Figure 7. Number of ICC site visitors

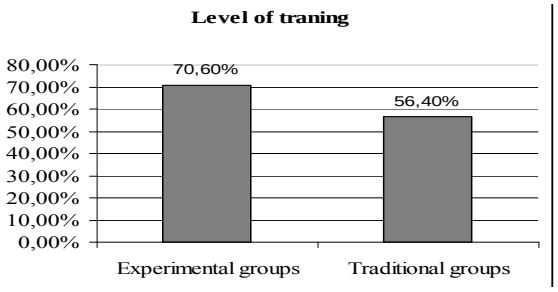


Figure 8. The diagram of training level

The level of training is higher at the experimental groups. The results of new methods implementation for students: training quality increased by 14,2%; training time decreased by 15%.

3. CONCLUSION

The designed method of the automated students' competences formation differs from the known methods in:

- The ontological model of a physical task has been the first to be developed. Ontology of a physical task is a field of knowledge, which includes both basic data of the task and the desired quantity. Solution to any task is included into this field of knowledge.
- There has been proposed a new method of the task-doing process formalization. It differs from the known ones due to the carried out the detailed task-doing process and the defined logical conclusion for completing the task from the basic data using ontology and descriptive logic.
- Software for intellectual support of optimal solution of analytical physical tasks which uses an ontology of physical tasks has been developed. The code is written in Java, development environment Eclipse Classic 3.7.2 Indigo.
- As a result, learning formation of competences of solving physical tasks found that the level of training in the experimental group is higher by 14.2% than in the control group. The implementation of methods and software has reduced training time by 15%. ICC has received economic benefits - increased revenue by 17.6%. The effectiveness of the system of practice-based learning is higher in education system with the solving tasks competences formation.

This research proposes the innovative methodology that includes ontology of physics tasks and builds the competences formation system to assist teachers to create the e-learning practice-oriented courses.

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