Mobile learning in the sphere of physical problems solving using the semantic structures method

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Abstract— The article proposes an original way to train skills of solving problems in physics using the method of semantic structures developed by T.N. Gnitetskaya withing the framework of the informational model of intra-subject connections. The analysis of a physical task is performed in the course of building the structure, which semantic elements are physical concepts, values, laws located on subordinate levels and logically related to each other by internal connections. Using this method allows three levels of correction and self-monitoring of students' work in mobile learning, the only one of which is full-time. The proposed approach to mobile learning in the sphere of solving physical problems promotes improvement of analytical skills and students' intellectual level.

Index Terms— Mobile learning, semantic structures method, information model of intra-subject connections, distant learning, solution of problems in physics, analytical thinking, mobile technologies.

1 Introduction

TODAY'S information technologies have become an integral part of learning process. Recently appeared wireless technologies have reflected in education as mobile technologies that are typically implemented in alternative courses. Of course, it is easy for students to use wireless devices such as Ipads and Iphones, so it started active discussions on their use for educational purposes.

At first glance, the possibilities of mobile and distant learning are not so different. Indeed, both cases suppose that students' independent activity is possible at any convenient place and time involving on-line educational resources and background information. However, it is important that mobile learning gives a possibility to correct students' independent activity. It involves text-messages - correspondence in the "question-answer" mode, and organization of students' free access to self-testing. Certainly, the advantages of mobile devices are quality and quick playback of graphic, audio and video files.

Despite the positive aspects of mobile learning, there are several disadvantages, the main of which are: 1) perception difficulties of the content of lengthy texts and volume formulas using mobile devices with small screens ; 2) mobile devices fragility that becomes a serious obstacle when combining self-learning and everyday activities; 3) mobile devices dependence on power supply devices is significantly perceived when playing graphic files, many of which, such as video files, have megabit sizes.

If the second two shortcomings identified above can be removed with the assistance of the relevant technical equipment, the first drawback can be leveled only by involving another method of educational material representation.

As it is shown by comparative study conducted in Russia, the U.S. and Japan, the most accessible form of educational material representation for students from the countries listed above is the content of the educational material structured by portions, each of which is represented as a diagram [1]. We should admit that the scheme is fully reproduced on the screen of a mobile device, what is an additional argument in favor of this method.

2. The study – the problems in the form of structures

In previous studies we have developed the semantic structures method based on informational models of an intra-and inter-subject connnections [2]. This method is applied to the process of independent activity while solving physical problems.

Solving physical problems is known to cause difficulties for students that study physics. It has logic, because not every student has analytical skills that are used when solving physical problems, and no study of problem solving techniques can help here. Physical problems solving, in fact, is a creative process of hooking up disparate facts stated in an experimental or theoretical problem. There is an idle opinion that distance or wireless technologies oriented to students' individual work are easy to be applied in liberal arts, because they require less explanation than natural sciences that may not be comprehended by self-studying. This is not quite true. It is known fact that the content of the training material in natural sciences, such as physics, is built step by step according to the principle of causality. Fundamental physical laws reflect a cause-and-effect relation, where the cause expressed by a physical value multiplied by the coefficient of proportionality is placed to the right side of an equation and the physical quantity associated with a conclusion - to the left. Therefore, the content of physics, as a rule, is built by both deductive (from general to particular) and inductive (from particular to general) methods. It is important that the content has intra-subject connections. From this point of view, stating a portion of the physical content in a physical problem with the help of semantic structure of intra-subject connections doesn't contradict to the principle of the unity of theoretical and experimental skills and abilities to solve physical problems. The performability of this principle can be measured by two criteria [2]:

1) criterion of skills well-formedness and ability to solve physical problems by experiment. This criterion represents an evaluation of knowledge level of measurement technology and instruments, measurement techniques, and skills of using

measurement technology and instruments and ability to choose a physically grounded method of measuring and conduct physical experiments;

2) criterion of skills well-formedness and ability to solve physical problems in theory. This criterion represents an evaluation of skills and ability to analyze in theory physical phenomena, select the basic physical laws, to use mathematical methods of solving physical problems.

In the context of the second criterion there is an example of solving a theoretical physical problem, where the analysis of the condition is performed in the process of building a deductive structure, and the problem is solved by building an inductive structure. We chose a rather simple problem from I.E. Irodov's collection № 3.202 "Problems in General Physics" from "Electrodynamics" section. These problems are given to second-year students claiming for the physics major degree [3]. Condition of the problem: there is a metal plate placed in a parallel way between a plate capacitor's plates, the thickness of the plate is η=0,60 of the distance between the capacitor's plates. The capacitor's capacity in the absence of the plate is C=20 nF. The capacitor is connected to a dc source U=100V. The plate was slowly removed from the capacitor. Find: a) capacitor's energy gain; b) mechanical work expended in extracting the plate. As usual, problem solution is carried out in two stages: Stage 1 - analysis of the problem's condition; Stage 2 - direct solution of the physical problem.

The first step is the analysis of the problem's conditions, when a deductive structure of the conditions is being built. All the concepts involved in the problem's condition are written out and numbered, the complex concepts are divided into their simple components. Then, the written out concepts are sequentially drawn up in the form of a semantic structure (Figure 1). While the concepts involved in the problem's condition are drawn up on the first (the highest) level of the structure conditions, the second (the lower) level is filled up with the concepts of the second order, which belong to the content of the concepts of the first row. And so on, until the content of every concept involved in the problem's condition is divided into elements.

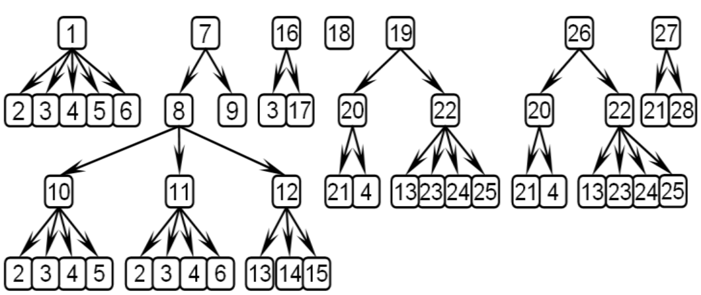

Fig.1. Semantic structure of the condition of the problem № 3.202

Agreed notations: 1 – capacitor's plates; 2 - electric field; 3 – conductor; 4 – charge; 5 - plate 1; 6 - plate 2; 7 - plate capacitor; 8 – capacitor; 9 - flat plates; 10 – capacitor's plate 1; 11 - capacitor's plate 2; 12 – dielectric; 13 - dielectric conductivity; 14 - distance between the plates; 15 - electric field inside the dielectric; 16 - metal plate; 17 – plate; 18 - η = 0,60 of the distance between the plates; 19 - capacitor C_1; 20 - total capacitor's capacity; 21 – voltage; 22 – plate capacitor C capacity; 23 – vacuum's dielectric conductivity; 24 - area of the plate; 25 - distance between the plates; 26 - capacitor C_2; 27 – IP device.

In our example the content of the first concept of capacitor's plates includes the following concepts: plate 1, plate 2, conductor, charge, electric field. A list of the components of the concept of capacitor's plates may be increased, for example, you can expand the concept of the electric field, but in the framework of this task no further specification is required.

Once the condition structure is built and analysis is finished we may proceed to the second stage, namely, to the solution of the problem. The solution of the problem is also performed with the help of the structure (Figure 2) that is built downright. At the top of the structure there is the required in problem physical value whose connection with the other values is determined by the corresponding relation. The correlating physical values take the next row below and so on, until a logical chain between the unknown value and the data in the problem is built. In general, this structure represents a way of problem solution.

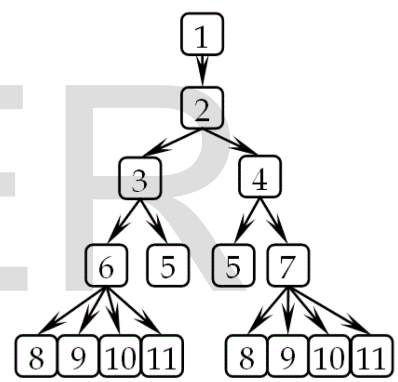

Fig.2. Semantic structure of problem solution № 3.202

Agreed notations: 1 – work; 2 - energy difference; 3 - energy W_1; 4 - energy W_2; 5 – voltage, 6 - capacitor C_1 electrocapacity; 7 – capacitor C_2 electrocapacity; 8 – dielectric conductivity; 9 - vacuum's dielectric conductivity; 10 – area; 11 – distance.

The purpose of this method of solving physics problems is to teach students to determine by themselves internal connections of physical values, concepts and laws that promote formation of critical thinking skills and skills of analyzing physical situations.

The undeniable advantage of the method is the possibility to control and correct student's independent activity in mobile learning, the organization of which is a serious problem when preforming distance tasks.

Assignment for independent work is sent to students after being prepared by a teacher. It contains: 1) the condition of the problem, 2) a list of the concepts included in the content of the problem, 3) an unfilled structure of the condition, 4) an unfilled structure of the solution. The first three are available at the website for independent work and students can download the assignment to their mobile devices at any time. In this case one should analyze the condition of the problem by filling in the structure blanks with physical concepts or values chosen from the list. For the majority of students this stage will be enough to build the structure of the solution by themselves and thus to solve the problem.

Students who didn't manage to solve the problem may compare their condition structure with the correct one on the website - so that is how the first level of students' self-correction is carried out.

If there are any difficulties after this stage, the student may request the structure of the problem solution with blank cells from a teacher. That is the second stage of students' self-correction.

Finally, the third stage of students' control and self-correction is performed during the defence of the problems in the classroom. The defence requires the structure of solving the problem drawn on a paper and the solution itself with the necessary mathematical transformations. If necessary, a teacher may ask for the structure analysis of the problem's conditions, but, as a rule, it is not required.

Hence, the proposed method is implemented in three stages of correction and knowledge control, two of which are carried out distantly without teacher's consultation, and this organization is preferable.

The small size of the image of the structure makes it possible to work with it using the limited screen of a mobile device, and this fact removes one of the main drawbacks of mobile devices usage.

The method allows to focus on the student's individual intelligence level, it excludes algorithmization in performing distance work. In circumstances where mobile learning is limited it promotes development of student's creative approach to problem solving and skill of taking non-standard decisions. What is very important today to organize while preparing students studying natural sciences.

In the age of searching for new types of fuel, new technologies of environment refinement and other strategic problems, we face the need of new specialists with a high knowledge level in natural sciences who will be able to analyze the problem, set goals and develop an optimal strategy for achieving it. So any new directions in natural sciences including mobile technology are possible, but they must match the current needs of the society and be science-based.

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