Theoretical and Psychologic Issues of Engineers’ Modular Training in Physics

Tatyana N. Gnitetskaya, Elena B. Ivanova, Natalya N. Kovalchuk, Andrey B. Martinenko, Valeriy I. Belokon and Valentina I. Tsetslnko

The School of Natural Sciences, Far Eastern Federal University, 8 Sukhanova St., Vladivostok, 690950, Russia

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Abstract. In this paper the issues of modern engineer’s training in physics, based on information technologies and new point of view to modular training in physics, were discussed. The definitions of training module were analyzed. The relation between training process and pedagogical system was shown. The modern pedagogical system was described in this paper. The psychology basis of steps in module was performed. The new definition of concept of training module as a unit of pedagogical system was proposed. This study helps to optimize the future engineers’ learning process of the module teaching, which based on the information technologies.

Introduction

Recently, the number of electronic scientific courses, including physics, designed for remote mobile and on-line learning, as well as an electronic alternative to traditional training courses, has highly increased. Almost all of them have a structure very similar to the structure of modular teaching materials. Despite a rich experience of applying the modular system in education, it is necessary to revise its methodological position relative to the compliance with new information technology in education.

It is impossible to do carefully until previous analysis of the training module’ definition. We propose to formulize the training module definition what is adequate connecting to model of training process

Definition of Concept of Training Module

Today’s pedagogical literature contains more than 20 definitions of a training module in a variety of interpretations. Several authors understand a module as a system of interconnected components, which along with the content of educational material also contain elements of technology education. Such are J.D. Russell, PA Yutsyavichene, G. Owens [2] B. Goldschmidt, M. Goldschmidt [1], A. Huezynski [7]. For example, P.A. Yutsyavichene define module as a finished information block, which includes a logically complete unit of learning material, a target-oriented program of action and a guidance ensuring the achievement of teaching goals [3]. G. Owens [2] understood module as closed teaching complex, which consists of a teacher, learners, educational material and tools to help students and teachers to implement an individualized approach and ensure their cooperation.

Also shows the other important group of studies, the authors of which understand a module as a unit of educational information and put in the forefront a substantial component. For example, S.I. Samygin interprets a module as a logically complete part of educational material [5], A.N. Aleksyuk, S.A. Kashin consider it as a self-contained portion of educational material [4]. This group may also include interpretations of V.N. Lebedev [8], Y.A. Ustynyuk [6] and others.

Therefore, noted definitions of the module could be divided into two types. Definitions of the first type can be treated as a system that contains information, purposes for its receiving and methods of transmission (teaching technology), and definitions of the second type explain a module only as a unit of information. Note that the first type of definitions, based on systemcharacter of
module, give to us an idea about its first type based with the educational process, which has a system nature, what was suggested by the authors and described in this article.

**Relation between Educational Process and Pedagogical System**

At first, we need to find a relation between the process and the system. The definition of the educational process and its structure were described in the 70-ies of the last century by the famous Russian educationalist V.V. Krajevski: "The teaching process is what we call a task-oriented consecutive change of learning tasks and all elements that occurs according to the objective laws and oriented on the formation of learners’ characteristics as a result of their work on mastering the content of social experience" V.V. Krajevski highlights "... the following elements of the learning process as a system: its purpose in the form of educational content, teaching activities, motivation of teaching subjects, learning activities, organizational form, the mechanism of the learning process, teaching outcomes characterized by the degree of assimilation of the content".

![Figure 1. The model of a modern educational system [10].](image)

10 years later, V.P. Bespalko defined the model of the traditional pedagogical system and added to its structure invariant elements, which are: students, goals of training and teaching, educational content, teachers, teaching processes, organizational forms of learning. Where the first three belong to didactic tasks, and the rest compose the educational technology. This model was supplemented with contemporary interaction of components called the model of modern educational system and described by T.N. Gnitetskaya in 2004 (see Figure) [10]. In today's educational system, students directly interact with almost all of its elements (see Fig. 3). Along with the state and society, the identity ("a student") is a customer of educational services. Ordering it students are involved in the process of establishing both global (defining personally-oriented model of a graduating student of...
any educational level) and landmark and operational goals. "The content of education" depending on the set goals forms in together with students.

For example, in addition to the established by the social and state order disciplines, a student orders such ones that are necessary for the formation of a body of knowledge, skills and abilities that meet student’s personally-oriented model. "Educational Technology" in contemporary model is built according to the "goals" and "educational content". However, in contrast to the traditional model, in the modern educational system a student choose by himself in some way the necessary educational technology. On the one hand, it is realized through the purpose and educational content, and on the other hand, through the interaction with a teacher. Described interaction of structural elements of the educational system contributes to the formation of a personally-oriented technology that meets the following requirements of the modern learning process: fundamentalization and general professionalization of education, its individualization, humanization of engineering and science education. Comparing teaching activity, learning activities, student’s motivation and the mechanism for the implementation of the learning process with elements of the pedagogical system, such as: teachers, students, and didactic processes, we can see the identity of elements of V.V. Krajevski’s educational process and V.P. Bespalko’s educational system.

In the same years, J.K. Babanski exploring the educational process in order to identify its composition and structure introduces a unit of educational process or its "step", which should reflect the entire educational process. This "Step" or a unit of the educational process is considered as a teaching process in miniature. It is a bit similar to holography. The whole teaching process is a holographic picture, in which any separated part (unit) looks like the whole picture.

Describing the structure of a unit of the educational process J.K. Babanski closely follows the structure of V.P. Bespalko’s pedagogical system [9]. But the concept of the educational system does not coincide with the concept of the learning process. Semantic identity of the elements of V.V. Krajevski’s educational process and the structure elements of educational systems is quite natural if we take the rule that the learning process is a process of transition of educational system from one state to another. For example, at the beginning of a lecture pedagogical elements of the system are in one condition and when the lecture is over—they are in the other one. The same rule remains in the case of a semester, academic year and so on. This rule establishes a relation between the learning process and teaching system and allows to introduce the definition of a training module.

Psychological Grounds for the Modular Teaching Approach

The module’s topic study stages are arranged so as to connect them with stages of multidimensional psychological changes evoked due to the human performing new actions, building new images and ideas which is appropriate to the development reflecting the study objectives attaining. The stages mentioned were investigated in details by P. Ya. Galperin [14] who promoted L. S. Vygotsky’s opinion regarding the issue of interrelation of study and development. The theory of stepwise intellectual action formation (SIAFT) drafted based on his ideas considers the psychic processes as a special type of investigatory activity and the knowledge as derivates of the actions and acquisition thereof. The unit of analyzing any human activity, according to P. Ya. Galperin’s opinion, is the action which can be divided into three components: the approximate component, the execution component and the controlling component. The above-mentioned components comprise the activity’s structure including the learning activity. Therefore, taking into account the three elements mentioned and the aggregate of stable links between them, the sequence of the module’s topic study stages can be determined and appropriate form and method choice for the module study technology be made.

Based on the above-mentioned reflection, we suggest arranging the module topic’s stage sequence in accordance with the intellectual actions’ formation stages [8]. Let us arrange them at the example of studying the topic of a physics module for university engineer’ students where the study is organized with the means of the following study forms: students’ self-guided work, colloquium, lab, solving tasks, computer modeling, seminar, lecture.
The first (1st) stage suggests building the approximate action’s foundation: the students are suggested to get to know the module’s academic complex containing the objectives, question plans for the module’s topics and a complex individual work [3]. At this stage, the students’ motivation is fortified. At the second stage, the students make individual notes according to the question plan using references to the study literature recommended for each issue (up to 10 titles). This activity, according to N. F. Talyzina, is entitled formation of a material action. At first sight, the study sequence proposed can seem questionable at the first stages where the students for the first come across the new terms and proportions individually and not with the teacher’s explanations. But at those stages, the students overcome the barriers of the unknown forming their own ideas (probably not full ones) of the phenomena studied and accumulating a list of questions the answers to which will be obtained at the following stages.

Thereby, the learning motivation is built. The third stage provides for discussion of the knowledge accumulated on the topic during the colloquium and review of typical and individual problems. At this stage, all actions can be represented as a dialogue with the teacher and with the students group which is interpreted by the SIAFT as the stage of forming a social-speech action. At this stage, the first level of the students’ individual works control and correction is performed. The SIAFT emphasizes that the social-speech action can be well-formed not only as oral speech (speaking out loud) but as written speech, as well. Therefore, the second part of the third stage can be a lecture reviewing the issues on the module’s topic too complex for individual study which were formed during the individual work. At the next stage (4), the students are suggested to write a lab and to accomplish an individual task or to model the phenomena studied with the means of computer. This stage corresponds to forming the social speech to oneself. Here, according to P. Ya. Galperin’s opinion [14], “the action taking the intellectual form begins to shrink and automatize rapidly acquiring the form of an action according to a formula’. At the fifth stage (stage of inner speech), the students review their individual problems and labs. The module study is finished with a summarizing seminar at the sixth stage. The most complicated and incomprehensible issues emerging during the module’s topic study are discussed at the seminar.

Determining the didactic route to studying each structural element of the subject’s contents (class, topic, module) suggests including the corpus of knowledge, abilities and skills into goal-oriented learning activity represented as a system of interrelated issues and problems developed in accordance with the module approach’s logic and based on the intra- and intersubject connections. Thus, it provides the cyclicity and steadiness of learning process. A teacher chooses appropriate forms of teaching that are used in certain topics. The stages of learning the topics of the module are constructed in accordance with the proposed educational technology [3].

Proper organization of students’ independent work ensures successful implementation of the educational technology. Students’ independent activity provided by a variety of forms and methods in the modular technology education approach promotes the accumulation of experience of mental activity and, thus, the formation of sustainable skills that can be invariant with respect to different objects of knowledge required in everyday engineers’ activity.

**Conclusion - Training Module as a unit of the Pedagogical System**

Considering the educational system as an open dynamic system, which operates in social environment and consists of a set of interacting invariant elements let’s define a training module as a unit of the pedagogical system that contains all the invariant elements of the system. These invariant elements of the educational system are: students, teaching and training goals, educational content, teachers, teaching processes, organizational forms of learning. The first three belong to didactic tasks, and the rest go with teaching technology. Such understanding of a training module common to all of the definitions of a module of the first type allows to match to the training module a "step" or a unit of the educational process, determines the structure of the module that coincides with the structure of the educational system. Furthermore, the modular training in physics is in psychologic connection with goal-oriented learning activity represented as a system of interrelated issues and problems based on the intra- and intersubject connections in physics course.
Thus, the construction of the module in physics under this definition will optimize the process of teaching physics in engineering education, a limiting case of which are technology of Open Engineering Education.

In papers [10, 11, 12, 13] examples of forming of training module on physics for engineers to be are described. The modular training, what organized according the model described above, allow to establish a standard of methods in modular training in physics. Also that could make a positive influence to the modern engineering education.

References


