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Automated individually-oriented methodological systems of the formation of competencies

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***Abstract* — The relevance of individually-oriented approaches to learning is caused by necessity for taking into account the individual characteristics and needs of students and, at the same time, the requirements of employers to form professional competencies. The objective is to automate the process of forming adaptive methodological systems, that contribute to the implementation of these approaches. To achieve this goal, it was necessary to solve the following tasks: to determine a metric for measuring competencies; to define the concept, principles and methods of designing and applying a new class of methodological learning systems - automated, individually-oriented methodological systems of competency formation (AIMSCK); to develop numerical methods for assessing the quality of learning.**

Keywords — automated, individually-oriented methodological systems of competency formation (AIMSCK), potential competence, learning profitability.

I. INTRODUCTION

Individually-oriented [11, 12] and competency-based [1, 2, 4-7, 10, 13, 15] learning approaches are aimed at taking into account individual abilities, students' needs, and at forming various competencies, including professional ones. The first main works on these approaches can be attributed [3, 13, 14]. When analyzing these and other works, it can be noted, that they do not have numerical metrics for assessing the competency, formed in the learning process, and the methods of automated formation of both individually-oriented and competency-based approaches to learning. This article is dedicated to these problems.

II. METHODS AND MATERIALS

Consider the following terms.

Competence is a set of knowledge, skills and abilities, necessary for a successful and effective professional activity in a certain field. A qualified person must have many relevant types of competencies.

In works [8, 9], methods for the formation and diagnosis of competence are considered, using examples of professional and creative ones, but there is no description of the mechanism for implementing adaptive and competency-based approaches to the process of their formation. In this work, an example of such a mechanism for any types of competencies is proposed.

The competencies, that are formed in the learning process and appear in practical activities, are called potential.

The educational process, aimed at achieving the highest possible level of potential competencies, is called a competently oriented approach.

It is very important to involve employers in planning the content of potential competencies.

The combination of these approaches leads to the task of quickly constructing a set of different options for the formation of competencies. To solve this task, it is proposed to use a new class of methodological learning systems - automated, individually-oriented methodological systems for competency formation (AIMSCK): a group of technologically related components of informational, program, instrumental, control and assessment purposes, providing the construction and effective implementation of individual alternative learning options for a future specialist in the given learning conditions.

AIMSCK is based on the traditional methodological learning system (MLS), as a combination of five interrelated components: the purpose, content, efficiency, control, normativeness and operativeness of the assessment, as well as the concept of an adaptive methodological system [3]. The main differences between AIMSCK and traditional MLS are as follows: determines the preparation on a block of interrelated disciplines, the formation of the maximum possible in terms of volume and depth of competence, automatic construction of a set of optimal individual learning options, the presence of a mathematical model of optimization and assessment of competencies (the maximum possible value of the objective function is to maximize the volume of formed competencies, while taking into account individual learning conditions, including time constraints).

The proposed AIMSCK provides the application of the following pedagogical technology.

The formation of fundamental learning options, that are clearly redundant within the limits (in terms of learning time and material) of the educational process in terms of the volume and depth of competencies.

Based on the Federal State Educational Standards (FSES) and the requirements of employers, the individual characteristics of students and educational institutions,

individual learning options for individual students are automatically formed, assessed and optimized in terms of volume and types of competencies (using the quantitative indicators for assessing potential competencies, cited below), due to fundamental options.

Learning on the formed individual options.

Assessment of the level of achieved potential competencies and, with a negative assessment, the adjustment of the current option or the formation of a new one, etc.

The design of AIMSCK is carried out in compliance with the following principles: decomposition of learning material by types and levels of competence and other parameters, modularity, harmonization of educational disciplines, adaptability in the form of variability and optimality, transparency, manufacturability, automation of the formation of learning options, unification, application of variant-oriented design.

Variant-oriented design of AIMSCK (analogous to object-oriented programming, only a program object performs the learning option or learning module) with the following properties: encapsulation - the option is self-sufficient for use, i.e. contains all the necessary information for effective learning, inheritance - information from the variant-parent is copied to the variant-descendant, polymorphism - it is possible to change the information in the variant-descendant, inherited from the parent variant.

Two types of adaptation are suggested: fixed - one option is formed for the entire period of study for the student (it is usually used for a group of students and is more traditional for educational institutions, in which there are academic groups, that differ in the forms of learning, for example, full-time, home study, etc.), dynamic - learning is divided into successive steps (stages) and a different learning option is formed for each step, and according to the results of the current step, it is possible to change the current option or switch to a new one for the next step, etc. This type of adaptation is more flexible and more individual, than a fixed adaptation, and can be used to form individual learning paths.

All educational material is divided into didactic units (educational elements), which are listed in the curriculum for the disciplines. Naturally, the requirement of adaptability leads to the need for automatic generation of individual versions of such learning programs.

III. RESULTS AND DISCUSSION

Consider the quality indicators of learning.

The level of the learning element is determined by the expert (teacher, employer). Usually there are three levels: 1-initial, 2 - basic and advanced - 3. This allows to organize multilevel learning with the switchover from lower simple to higher complex.

The cost of an educational element is a quantitative assessment (for example, on a ten-point scale) of an expert (employer, methodist, teacher) of the probability of using the formed corresponding competencies in the future professional activity as a result of mastering this learning element. These assessments are the initial indicators of assessing the quality of the formed competencies, from the point of view of employers, and are the basics for the following indicators of the quality of learning.

The value of potential competence is the cost, multiplied by the number of the level of study of the learning element, since competencies, formed at high levels of study, are of great value, because they reflect their depth.

Learning profitability is the quotient of dividing the value of potential competence by the number of academic hours, given to study this element, according to the curriculum, and characterizes the effectiveness of using educational time to form competencies.

Using the didactic connections between the learning elements and the fundamental learning options, the employer, teacher or the student himself can set the necessary competencies, that the student must master, and the proposed system automatically forms an individual learning option (MLS) that is optimal for learning time and learning material, which ensures the formation of given competencies.

The idea of implementing the adaptability of the methodological system is to position the methodological learning system with a learning option. When an option is changed, the methodological system is automatically changed, that is, the learning option (more exactly, its curriculum, as will be shown below) is the “gene” carrier of the methodological system.

In practice, this is as follows. Usually, as an learning option, an option is taken of forming competencies in a particular academic discipline (the methodology of the formation of appropriate learning material will be considered below). When designing the fundamental learning option, the developer (methodist, teacher, expert) forms a curriculum, which provides a complete list of learning elements (in the form of hierarchically numbered items) with an indication of standard learning time, required for mastering, the level of study, the conditional prices and the type of formed competency for each educational element at a detailed level. Further, all elements of the educational material (including electronic educational-methodical and control-measuring complexes) are “attached” to the numbers of the curriculum items. The formation of an individual learning option is done by automatic (when the necessary types of competencies are set) or automated (the choice is made manually by the developer) selection of the necessary items of the curriculum. As a result, an option of the curriculum is formed. Then, the program forms analytical tables, that contain quantitative assessments of potential competencies by type and the volume of standard learning time, and the developer analyzes them and can reform a new option, etc. until he gets needed option. The planned time for the entire learning option is set in the curriculum for the specialty (learning profile). If the standard learning time is much more than planned (which usually happens), two balancing options are proposed:

1. The planned time is fixed, and the time for independent work is determined as the difference between the normative and planned,
2. The most valuable learning elements are selected (taking into account the didactic connections between them, which determine the sequence of their study, at which the maximum final value of potential competencies or learning profitability is achieved under planned time constraints. For example, you

can sort the learning elements of study in order to reduce potential competence or learning profitability and select the first, subject to restrictions on the amount of planned learning time and didactic connections.

After balancing, the program proportionally changes the planned learning time by type of occupation for each item of the curriculum and the final option of the curriculum of an individual learning option in academic discipline is formed and approved.

The next step is the programmatic generation of an individual methodological learning system, tuned to a particular student by selecting from the fundamental option only those learning elements, that are referenced by paragraphs of a previously formed curriculum.

To assess the achieved levels of potential competencies, the following methodology is proposed.

1. Set the assessment scale and criteria.
2. Prepare control tasks.
3. A competency tree is created for tasks.
4. When checking completed tasks for each terminal vertex, an expert sets an assessment of the level of achieved competencies on a certain rating scale.
5. To take into account the heterogeneity of competencies, it is possible to introduce correction weigh factors (assessment factors).
6. Above the located node of the tree is assigned the arithmetic mean of its assessment directly below the located nodes.
7. The previous two paragraphs are repeated until the result is a general assessment of the level of formation of all competencies as a whole.
8. Paragraphs 3-7 are repeated for each assignment.
9. Unified assessments for all tasks are averaged and the overall assessment is determined.

Based on the ideas, presented in the works of V.P. Bespalko, V.I. Ginetsinsky I.I. Loginova, V.A. Oganesyan A.M. Sohor, L.T., M.P. Lapchik, L.I. Doliner, E.B. Starichenko, the following technology for constructing an academic discipline program for the substantive level of AIMSCK is proposed.

1. The rules of selection and formation of the content of academic disciplines are formulated.
2. The analysis of FSES, the requirements of employers is carried out in order to construct a model of specialist competence, to determine the competency graph.
3. The model of specialist competence, the current state of science, technology and practical professional activity is analyzed to draw a graph of competency in the specialty.
4. The selection of competencies from the column of competency by specialty without taking into account the appropriate distribution of the content of learning material for specific disciplines (drawing a graph of competencies at the level of disciplines and topics).
5. Separate graphs are formed for each discipline - topics are detailed and the content of the disciplines is formed at the level of learning elements in order to form the necessary competencies (their assessment and optimization), assigned at the level of the whole specialty, which ensures interdisciplinary integration.
6. Curricula are formed. The cost, level of learning, standard time of learning is determined for each educational element of the program. Learning material, demonstration examples and test tasks are placed in the AIMSCK database. Using automatically generated analytical tables, a selection of the most valuable elements for the selected criteria is provided (for example, potential competence and / or learning profitability).
7. In automated modes, a fundamental learning option is formed, from which individual optimal learning options are formed.

IV. CONCLUSION

Thus, we can state the following obtained results: new terms (potential competence, AIMSCK) and a metric for measuring competencies (level and cost of the learning element and potential competence, educational profitability) are introduced, the definition, purpose and the variant-oriented method of designing and applying a new class of methodological learning systems - automated, individually-oriented methodological systems for the competency formation are cited, methods for assessing the quality of learning and the formation of educational material are developed. The program, technological and instrumental levels of AIMSCK are implemented as a package of application programs.

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