Information technology in the educational program design

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Abstract. The system analysis of the educational process of the university considers the possibilities of automation of its certain components while design and functioning. The educational process in Russian universities is implemented on the competence-based approach. Competence is a complex of knowledge required to solve a certain type of tasks within the framework of professional activity. For each type of professional activity tasks one can specify the actions of the specialists required to solve these problems. These actions are the basis for the formation of the required competencies. The task of training within the framework of the competence approach is formulated as follows: the transition from the input competencies A to the output competencies B. To automate the design of the educational program, it is required to use the automated information systems for decision-making support.

1. Introduction
The system analysis of the educational process of the university considers the possibilities of automation of its certain components while design and functioning [1, 2, 3, 4, 5, 6]. The educational process in Russian universities is implemented on the competence-based approach. Competence is a complex of knowledge required to solve a certain type of tasks within the framework of professional activity.

For each type of professional activity tasks one can specify the actions of the specialists required to solve these problems. These actions are the basis for the formation of the required competencies.

The task of training within the framework of the competence approach is formulated as follows:

- there is a set of input competencies prior to the training A;
- there is a set of output competencies at the end of training B.

The transition from the input competencies to the output competencies can be displayed as follows:

\[ A \xrightarrow{R} B, \]

where is \( R \) — a rule of formation \( B \) out of \( A \).
It is required to define the rule $R$ by means of which the learning trajectory is formed connecting the initial competencies with the competencies at the end of the training (figure 1).

This task is solved within the framework of the appropriate educational program (bachelor’s degree, master’s degree, specialist’s degree).

Each action element consists of didactic elements that must be included in the relevant training discipline. The formation of competences occurs by the interaction of didactic elements from various disciplines (figure 2) which make up the graph, for example, in the form of a tree of concepts.

Currently the educational program is formed as follows (figure 3):

- the list of disciplines is compiled;
- the disciplines are included in the curriculum and their parameters are set – the semester, a type of classes (lectures, seminars, laboratory classes), the number of hours for each type of the class, a type of certification (an exam, a credit);
- a work program is created for each discipline;
- in accordance with the work program the training material for each discipline is prepared in the form of a set of knowledge elements.

As a result, the educational process is formed from general to particular — from the curriculum to the specific elements of knowledge in the training materials.

![Figure 1](image1.png)

**Figure 1.** Formation of output competencies at specified input competencies.

![Figure 2](image2.png)

**Figure 2.** Formation of output competencies through the didactic elements.

![Figure 3](image3.png)

**Figure 3.** A relevant structure of forming the educational program content.
The educational program for bachelor’s degree contains approximately 60 disciplines. If each discipline contains 50 new didactic elements, their total number will be 3000 elements. It is very difficult to establish the links between them manually. Therefore, some errors occur, for example, the same didactic element is studied repeatedly while others are not studied at all.

This causes the following problems:

- There is a bad mutual connection between the content of disciplines;
- It is difficult to determine the required and allowable volume of material for each discipline;
- It is impossible to get a general idea regarding what exactly knowledge the students get at the end of training;
- It is difficult to form the interrelated documents – curriculum, work programs, training material, assessment tools (examination questions, tests, etc.).

All these problems can be solved with the application of information technologies at automated design of the educational program.

2. Automation of educational process design

To automate the design of the educational program, it is required to use the automated information systems for decision-making support.

The overall design automation process includes the following stages.

- Input competencies are divided into the components – input didactic elements (figure 2).
- Output competencies are divided into the components – output didactic elements (figure 2).
- The areas of knowledge (mathematics, computer science, electrical engineering etc.) based on the analysis of output didactic elements are distinguished.
- The groups of experts on the selected areas of knowledge are formed.
- For each knowledge area:
  - the experts form many elements that need to be studied in order to master the output competencies;
  - the mutual links between the knowledge elements within the relevant area are established and the corresponding graph is formed (figure 4).
- All knowledge elements are combined into a common set.
- The received set is analyzed and the graph is built – a tree of concepts.
- The received graph is analyzed taking into consideration the time to study the separate elements and is divided into the segments by semesters – these segments become separate disciplines, they are given names and are placed in the curriculum.
- Many didactic elements within the discipline are converted into the work program discipline with the distribution of elements between the lectures, seminars and independent study.
- Based on the obtained sets, the questions for examinations and assignments as well as the tests are developed.

In the proposed algorithm the most difficult thing is to define the set of didactic elements corresponding to the output competencies and to establish their interrelations. This work is carried out by experts based on their experience. The further work can be automated.

Each didactic element is formed from other didactic elements (figure 4).
A didactic element formation (figure 4):

- $D_1, \ldots, D_3$ are input didactic elements;
- $D_4$ is an output didactic element;
- $G$ is the method of converting the input didactic elements into the output didactic elements.

Competencies contain knowledge, skills and practical skills. They have their own didactic elements with the characteristic features.

Knowledge is understanding the essence of the phenomenon being studied.

A skill is the ability to choose and use the knowledge required to solve the specific problem.

A practical skill is the ability to apply the ready-made decisions in specific situations.

Each type of didactic elements has its own organization methods:

- the knowledge element, for example, the Pythagoras’ formula – forms the knowledge regarding how the hypotenuse and the legs of a right triangle are connected;
- the skills element, for example, the Pythagorean theorem – forms the ability to prove the theorems using the applied method;
- the practical skills element, for example, calculations according to the Pythagorean formula – forms the ability to calculate one side of the triangle by the values of the other sides using the indicated mathematical actions.

The method of forming the output didactic element depends on its type:

- a didactic knowledge element is the definition of a new concept through the known ones (the terminological methods);
- a didactic skills element is a comparative analysis and the comparison of various knowledge including the coordination of the task and the chosen method, the ability to form a sequence of actions to obtain the planned result;
- a didactic practical skills element is a ready algorithm to obtain the result, the possession of auxiliary tools.

Each method is also formed from didactic elements. Therefore, it is required an array of didactic elements for all types.

The fragment of the didactic element graph (figure 5, figure 6) contains 12 input didactic elements and 4 generated new elements. Initially they have their local numbers (figure 5) but then all the elements are renumbered (figure 6).
Figure 5. Fragment of the graph of new didactic elements formation based on the known didactic elements.

Figure 6. Renumbering of didactic elements.

The elements \( D_1, D_2, D_3, D_4, D_6, D_7, D_8, D_9, D_{11}, D_{12}, D_{17} \) and \( D_{18} \) are input elements. The elements \( D_5, D_{10}, D_{13} \) and \( D_{19} \) are output elements. During transformations some output elements become input: \( D_5 = D_{14}, D_{10} = D_{15}, D_{13} = D_{16} \). The elements renumbering is performed automatically taking into consideration the graph structure.

In addition, the correct sequence of studying the elements is automatically revealed: there should be no feedbacks in the received graph when to study a new element the subsequent elements are required. The problem of feedback occurrence is typical for the manual creation of the educational program. The ways to solve it are different, but the main thing is to identify such links.

The proposed sequence of formation of the educational program content (figure 7) is inverse compared to the applied one (figure 3) and can be characterized as the movement from the particular (from the didactic elements) to the general (curriculum).

Figure 7. Proposed structure of forming the educational program content.
The curriculum formed in this way covers the whole complex of knowledge, skills and practical skills included in the output competencies.

In the event of input or output competencies change, the system automatically changes the content of the curriculum and its parts.

3. Conclusion
The proposed method of the educational program formation can be automated based on the automated information system for decision-making support which increases the efficiency of the obtained results.

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