Development of the Professional Educational Program by Methods of Artificial Intelligence

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E V Romanova[1], F K Klashanov[1]

[1]Moscow State University of Civil Engineering, 26 Yaroslavskoye shosse, 129337, Moscow, Russia

E-mail: romanova_e_v@mail.ru

Abstract. The article, in General, refers to the technology of training for the construction industry, and in particular the search for a more effective method of forming a professional educational program of training in the field of Computer science and technology (09.04.01). Over the past eight years, Russia has changed three state educational standards of higher education. The procedure of their implementation in the educational process is very time-consuming and takes place in a short time. In order to avoid gross errors and speed up the process of developing an educational program, it is necessary to use computer technologies, among which the most promising are the methods of intelligent systems. The article discusses the method of solving the problem with the requirements of the educational standard.

1. Introduction

The competence approach implemented in Europe and the USA at the end of the XX century changed the approach to the education system. Instead of fundamental knowledge, practical skills and the ability to use them to solve professional problems have become valuable. The science has accumulated a great experience of describing the nature, nature, structure of competences [1]. Describes the model of competences of specialists of almost all areas of professional activities, for example expert in the field of Informatics and information technologies [2], teaching activity [3], safety [4], law [5]. The ways and methods of formation of different competencies [6].

The new educational paradigm describes the results of the development of the educational program [7]. They are the basis for assessing the quality of training of graduates [8-10].

In Russia, the transition to a competence-based approach is gradual. In 2007, the concept and structure of state educational standards of higher education changed. They allowed educational institutions to adapt educational programs to the needs of the regional labor market (50% of academic freedoms for bachelor's programs and 75% for master's programs) [11]. Until 2018, Russia has changed three state educational standards of higher education. Each of the following standards was increasingly result-oriented, described through a set of competencies. But in practice, we observe the preservation of the dominant fundamental knowledge at all levels of education with the addition of the factor of professional competence [12].

Competence is a dynamic combination of knowledge and skills and the ability to apply them for successful professional activities. In the Federal State educational standard of higher education (FGOS VO 3++) [13] fixed universal competence (UC), common to all areas of training. General professional competence (GPC), professional competence (PC) associated with professional activities. UC

represent the highest level in the hierarchy of competencies, as they are interdisciplinary in nature. PC is directly focused on the decision of specific professional tasks. One of the characteristics of professional competence is the ability of professionals to solve complex professional problems through the use of appropriate context - subject knowledge, skills and relationships [14].

The education system in Russia faces enormous challenges. The introduction of a new educational standard in the educational process takes place in a short time. At the same time, each new educational standard requires the development of a new basic educational program. In the educational standard, the content is described only with "broad strokes". The main responsibility for the creation of such an educational program, which will prepare a specialist of the required qualification, falls on its developers. This task often has to be solved by people brought up in the traditions of classical education. In this regard, the construction of the educational program is not from competencies, but by linking existing disciplines to the requirements of the standard.

The educational program (EP) - a set of basic characteristics of education, which is presented in the form of a curriculum, schedule, work programs of academic subjects, courses, disciplines (modules), other components, as well as evaluation and methodological materials [15].

The algorithm of development of the basic professional educational program includes 10 steps:

1. Creation of a working group.
2. Determination of the volume of accounting of the professional standard in the educational program.
3. Analysis of generalized labor functions.
4. Analysis of labor functions.
5. Formation of the list of competencies introduced into the basic educational program in addition to the competencies of the FGOS VO.
6. The formation of the results of the development of the program taking into account the professional standard.
7. Accounting of professional standards in the development of the Fund evaluation tools (evaluation system)
8. Taking into account the professional standard when forming the structure and content of the program
9. Development of curriculum and schedule
10. Examination of the educational program [16].

The result of steps 1-8 is fixed in the Approximate basic educational program (ABEP). Step 9 each University will have to perform on their own, taking into account the industry specifics. The curriculum should be filled with such disciplines that will form all the necessary competencies and will not be excessive. The sequence of disciplines and practices should be logically sound. To meet these requirements without computer technology is extremely difficult. Currently, there are software products that allow to automate the process of forming the curriculum, for example [17]. They help the developer to comply with all the formal regulatory requirements of the FGOS VO. But the computer can not automate the content of the educational program. That is why there are numerous cases of the development of EP is not from "competence" and from "disciplines". The solution to this problem is seen in the development of EP existing methods of artificial intelligence. To do this, you should solve three problems:

- verbally describe the subject area,
- build a mathematical model of the curriculum of the educational program,
- automate the process of finding the optimal structure for this model.

To verbally describe a subject area is to describe it with narrative sentences as first-order predicates in order to create a base for the application of computer technology using two-digit logic. The subject area of this research is the educational program.

At the stage of building a mathematical model, it is required to establish functional and/or graphic connections (for example, in the form of graphs) and to form a knowledge base taking into account the requirements and limitations of educational and professional standards.

At the third stage, it is necessary to choose the appropriate method of automated search for the optimal solution, i.e. such an educational program that would meet all the requirements of regulatory documents.

Let us consider the solution of this problem on the example of EP direction 09.04.01 "Computer science and engineering" (master's level).

2. Methods

The starting point for the development of the method of automated approach to the construction of an optimal training program is the competence that a graduate of the University acquires. The input information of the analysis and decision-making is the knowledge base, which takes into account all the requirements of the standard. The solution of the problem is divided into two stages. The first stage is the structuring of the basic requirements of the FGOS VO. The second stage is the construction of logical and functional links between competencies and elements of the OP. In both cases, formalization is the basis, i.e., presentation of information so that it can be entered into the computer for further processing.

To solve the first problem it is necessary to carry out the syntactic and semantic interpretation of the requirements of the standard: to conduct a formalized description of the structure of words in the form of first-order predicate, which is well-processed on the computer. Each predicate carries a meaning expressed by binary logic. At this point, you enter parameters for each program element. Then between them establish functional-graphic connections.

If the requirements of the FGOS VO the present in the form of subject blocks, it is possible to establish between them a logical connection, taking into account relevant constraints. In the graph view, the elements of the system (in this case, blocks) are the vertices of the graph (V), which are connected by lines (L) having a direction. The graph has the form (G=<V,L>). The line connecting I and j vertices will be mathematically written as a tuple (Lij=<Vi, Vj>), where i and j are vertex numbers [18].

Let us present a set of competencies as a set of (K) information obtained in the process of learning (mastering the content of OP) in high school. According to the GEF, the content is implemented through three blocks: block 1 "Disciplines (modules)" forms a set of information (K1), block 2 "Practices" forms a set of information (K2) and block 3 "State final certification" forms a set of information (K3). Each of these blocks has limitations: (K1) ≥ 80 credit unit (K2) ≥ 21 credit unit and (K3) ≥ 19 credit unit. In the process of training for a certain time interval T they form the knowledge base (competence) of the graduate (K), which, expressed in terms of the set, will be equal to and limited in labor intensity and time of 120 credit unit Take 1 credit unit (c.u.) equal to 36 academic hours (a.h.).

As practice shows, the knowledge and competences base of the graduate (K) formed in the process of training, as a set of necessary information, exceeds the volume of competencies prescribed by professional standards, necessary for the performance of work functions in professional activity (Kp), i.e. $K \supset K_p$.

Job function (Kp) of the graduate master in 09.04.01 direction of preparation "computer science", describes the 11 professional standards. The difference between these sets $K_s = K \setminus K_p$ is additional (supplementary) information. It is necessary for the graduate to realize their own potential and opportunities for the development of production.

Graphic representation of the requirements of the standard to the structure and volume of the master's program is shown in figure 1.

The content of the EP is carried out through the establishment of a link between competencies and disciplines. The FGOS VO defines the competencies that a graduate should possess. On their basis the educational program is formed. Competencies form three sets: U-universal power - 6 $\{u_1, u_2, u_3, u_4, u_5, u_6\}$. G - General professional power - 8 $\{g_1, g_2, g_3, g_4, g_5, g_6, g_7, g_8\}$; P - professional power - n $\{p_1, p_2, \ldots p_n\}$. The set P in the FGOS VO not clearly defined. It consists of a manda-

tory and recommended parts, and can be expanded by the University on the basis of the types of professional activities of the graduate. Each of these sets should be reflected in the educational program and implemented in the educational process with the given amount of time.

The next stage is the development of the subject area that clearly meets the declared competencies. To solve this problem, the discretization of competencies is carried out. Each competence (Ki), where i is the current number of the competence type, varies from 1 to 3, is represented by a set of semantic units (SjKi). The Superscript (j) in semantic unit determines its current value. It takes a value from 1 to MKi - the maximum value of semantic units in (Ki) competence. Each competence is a set of capacity MKi, the elements of which are semantic units that carry a specific highly specialized scope of knowledge [19].

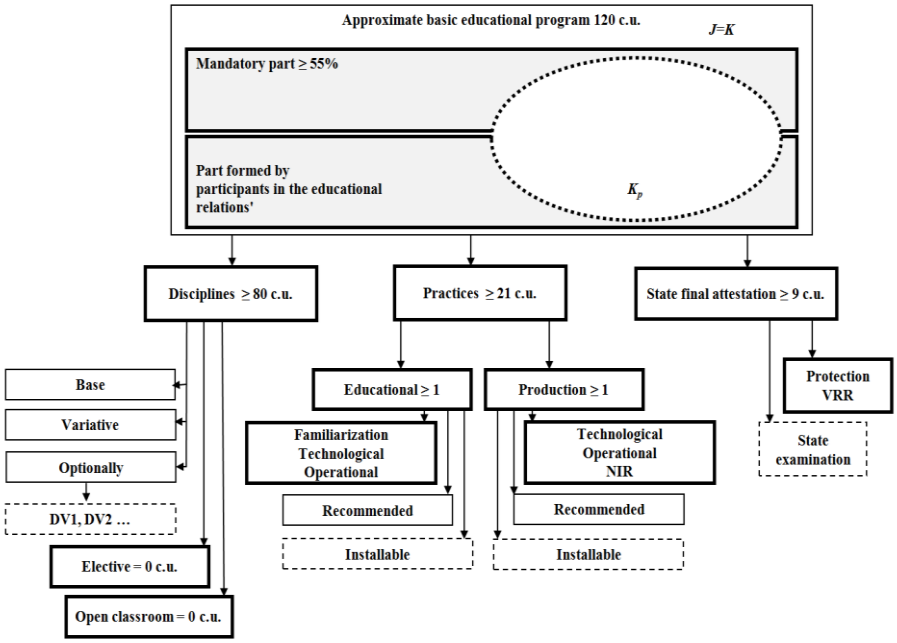

Figure 1. Graphical representation of the OP structure, where regulated by the FGOS VO, the ABEP is assigned, selected by the University.

Similar semantic units can be distinguished in disciplines (modules) and practices. Thus, the disciplines form a set of MD, consisting of MD modules. Each module (discipline) in its turn consists of a finite number of semantic units. Since the education system has experience in a certain program, it is necessary to audit the existing disciplines for their compliance with competencies. Thus, the first step in the development of the EP will be to establish a correspondence between the semantic units of competencies and disciplines. In identifying the possibility of forming the necessary competencies of existing disciplines, the following four outcomes are possible:

The first case is an applied discipline fully satisfy the criteria of occupancy of the competencies. In this case, to change anything in the disciplinary part is not necessary.

The second and third cases - the applied disciplines do not fully meet the criterion of competence occupancy – either semantic units are lacking or their surplus. In this case it is necessary to revise the content of the disciplines.

The fourth case is that there is no discipline containing semantic units that meet the criterion of competence occupancy. In this case, it is necessary to develop a new discipline containing the missing semantic units.

This analysis on the content of competencies should be carried out by a computer using the method of expert systems.

3. Data, Analysis, and Results

In this study, the data for analysis and processing, i.e. the source information was the knowledge base that meets all the requirements of the FGOS VO the field of training 09.04.01 "Computer science and technology". Its analysis was carried out in two stages: structuring the basic requirements of the standard and building a logical and functional relationship between the competencies and modules of the educational program. In both cases, the basis is formalization, i.e. the presentation of information so that it can be entered into a computer.

The result, which should be given by the computer after the appropriate processing-the degree of fullness of competences corresponding to the semantic units of disciplines. The solution is implemented by an expert system, which includes: a base of rules (knowledge), working memory and a rule interpreter (solver), which implements a certain mechanism of logical output.

Any rule contained in the knowledge base, consists of two parts: antecedent and consequent. The antecedent is a rule premise (conditional part) and consists of elementary sentences connected by logical connections "and", "or". A consequent (conclusion) includes one or more sentences that Express either some fact or an indication of a certain action to be performed. Production rules are usually written in the form of antecedent-consequent [20].

The proposed method of developing the EP allows you to create a curriculum with the maximum preservation of positive experience and such disciplines that will form all the necessary competencies and will not be redundant.

4. Discussions

As an example, let us consider the content of the General professional competence (GPC-2). In FGOS VO this competence as follows: "able to develop original algorithms and software tools, including the use of modern intelligent technologies for solving professional problems".

In this competence, the following semantic units: algorithm construction ($s_{i=2}^{j=1}$), software development ($s_{i=2}^{j=2}$), intelligent technology ($s_{i=2}^{j=3}$), subject area ($s_{i=2}^{j=4}$), the formulation of professional problems ($s_{i=2}^{j=5}$), the solution of professional problems ($s_{i=2}^{j=6}$).

Semantic unit (s_i^j) has two indices: the lower index the number of the competence in its class, and the upper number of the semantic unit for the given competence. Then, according to the semantics of this unit, we will select a set of modules (disciplines) that close its content, i.e. cases where the semantic unit of competence (s_i^j) is put in an unambiguous correspondence to the set of semantic units of disciplines (d_i^j). This procedure is implemented for each competence.

Since the amount of information processed is large, it is advisable to solve this problem by one of the methods of intelligent systems, namely, the method of expert systems, since the knowledge base has already been developed.

5. Conclusion

The article presents the method of optimal formation of professional educational program by methods of artificial intelligence on the example of FGOS VO 3++ and educational program in the direction of training 09.04.01 "Computer science and engineering". The correct process of development of the educational program is presented for the case when the initial information is fuzzy and not complete, and it is necessary to find a rational solution. The presence of a variety of solutions requires the use of modern methods based on the methodology of artificial intelligence.

To implement this method, it is proposed to give a verbal description in the form of predicates of the first order. The set, consisting of a set of predicates and rules of their processing, forms a knowledge base that satisfies the FGOS VO 3++. One of the well-proven methods of intelligent systems

using the knowledge base is an expert system based on the use of computer technology. In this case, it can be used to build an optimal basic professional educational program.

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