Practical implementation of the algorithm for designing additional professional education programs using the competence-based approach

Rushana Anamova[1,*], *Leonid* Bykov[1], and *Dmitri* Kozorez[1]

[1]Moscow Aviation Institute (National Research University), 4, Volokolamskoe shosse, Moscow, 125993, Russia

Abstract. The paper defines the methodology for designing professional retraining programs, taking into account the requirements of professional standards and applying the "one discipline—one competence" approach as its basis. The use of the described design methodology makes it possible to formalize the designing process itself and reduce it to coordinating the requirements of the professional standard with the customer's requirements to the contents of the disciplines included in the professional retraining program.

1 Introduction

The term "additional professional education programs" refers to professional development programs and professional retraining programs [1]. The professional development programs are designed to improve the professional level of the student within a previously obtained qualification and have the duration of 16 academic hours. The contents of a professional development program are normally composed of 2 or more sections, as well as a final certification in the form of a test/exam/final assignment. The professional retraining programs are designed to prepare a student for obtaining a new qualification or carrying out a new type of professional activities and have the duration of 250 academic hours. Similarly to those of the higher education programs, the contents of the professional retraining programs are composed of several disciplines and final certification in the form of a final exam or defense of a final certification paper.

This paper is devoted to the particularities of designing professional retraining programs.

Designing the contents of a professional retraining program is a difficult and time-consuming task, since it necessitates simultaneous consideration of several sets of requirements, which are often contradictory: the requirements of the Customer (an individual or a legal entity initiating the training), the requirements of the regulatory documents (professional standards, qualification reference books, Federal State Educational Standards, etc.), as well as the actual features of the future professional activity of the students.

References [2, 3] describe an algorithm for designing professional retraining programs using a competence-based approach. The list of competencies to be obtained by a student upon completion of the training is determined based on the regulatory documents and agreed upon with the Customer. The algorithm proposed by the authors [2] implements a modular principle for building the contents of a professional retraining program, namely: a profes-

*e-mail: anamova.rushana@yandex.ru

sional retraining program is made up of modules, which themselves constitute professional development programs, and the selection of modules is carried out taking into account the competencies they form. Thus, for a professional retraining programs, the terms "discipline" and "professional development program" are identical: therefore, we will use the term "discipline" throughout the further text.

2 Methods

The competence-based approach involves building the contents of a training program, taking into account the work functions described in the corresponding professional standard. In the relevant section of the university information and analytical system, a competence base is created, which is composed of the competencies generated within the framework of studying the disciplines, meaning that each professional development program corresponds to a single competence. When designing the professional retraining programs, the necessary competencies are selected from the competence base, resulting in the generation of a list of professional development programs involved in the formation of the specific competencies. Therefore, the number of disciplines included in the structure of the professional retraining program becomes equal to the number of competencies formed during the learning process, which are selected by the methodologist and agreed upon with the Customer. Besides, it should be borne in mind that some additional competencies can be formed as a result of mastering certain disciplines within the retraining program.

Let us analyze the procedure applied to build the contents of a professional retraining program, using the ''Organization of research and development of aviation equipment'' program as an example. The trainee category is: people with higher education (specialty, master's degree).

Stage 1. Determination of the professional standard, according to the requirements of which the program contents will be formed, as well as the name of the qualification awarded (if any). In accordance with the program subject matter, the professional standard "Specialist in research and development" (approved by order of the Ministry of Labor and Social Protection of the Russian Federation No. 121n dated March 4, 2014) can be selected [4]. It should be noted that this professional standard has a code of 40.011, meaning that it belongs to the group of professional standards for cross-disciplinary professional activities in the industry.

The name of the qualification to be awarded upon completing the professional retraining program should be based on the name of the professional standard and can be formulated as follows: "Specialist in research and development of aviation equipment".

Stage 2. Determination of the list of competencies to be acquired by each student upon completion of the program. The list of competencies is formed based on the job functions (generalized job function) taken from the selected professional standard and agreed upon with the Customer.

Let us choose from the specified professional standard the generalized job function "Carrying out research and development activities within the subject matter of the organization" (code C, qualification level 6), which, in turn, includes the following job functions:

- JF-1 "Scientific management of research based on individual tasks" (code C/01.6, qualification level 6);
- JF-2 "Management of the results of research and development activities" (code C/02.6, qualification level 6).

The fulfillment of the job function JF-1 involves conducting the following job activities in accordance with the professional standard:

- JA-1 "Development of plans and methodological programs for conducting research and development on a specific topic";
- JA-2 "Arrangement of collection and examination of scientific and technical information on the topic";
- JA-3 "Analysis and theoretical generalization of scientific data in accordance with the research objectives".

The fulfillment of the job function JF-2, in its turn, involves conducting the following job activities in accordance with the professional standard:

- JA-4 "Analysis of the results of trials and observations";
- JA-5 "Implementation of the research and development results";
- JA-6 ''Supervision over the correctness of the results obtained by the subordinate employees''.

Therefore, for the successful fulfillment of JF-1, a student must have the following competencies (formulated based on job activities JA-1–JA-3 for the "Organization of research and development of aviation equipment" professional retraining program):

- C-1 Preparedness to develop plans and methodological programs for conducting research and development on aviation topics;
- C-2 Ability to arrange the collection and examination of scientific and technical information on the research topic;
- C-3 Preparedness to conduct analysis and theoretical generalization of scientific data in accordance with the research objectives.

For the successful fulfillment of JF-2, in its turn, a student must have the following competencies (formulated based on job activities JA-4–JA-6):

- C-4 Ability to analyze the results of trials and observations;
- C-5 Preparedness to introduce the results of research and development into production;
- C-6 Ability to monitor the correctness of the results obtained by the subordinate employees.

Stage 3. Determination of the list of disciplines forming competencies C-1–C-6. In general, a single discipline forms a single competence. There are cases when a single competence is formed by several disciplines; then, several variable professional retraining programs can be created, in which one or more disciplines differ.

The disciplines forming the specified competencies (C-1–C-6) are shown in table 1.

The discipline contents are formed based on their learning outcomes, which, in turn, are planned according to the required competence, taking into account the knowledge and skills specified in the professional standard for performing a particular job activity. For example, the learning outcomes for the "Fundamentals of Scientific Research in Aircraft Engineering" discipline can be formulated as follows:

1) K-1: know the methods of conducting research and development (wording from the professional standard for the job function JF-1);
2) S-1: be able to document the results of research and development activities (patents, scientific and technical documentation) (wording from the professional standard for the job function JF-1);
3) S-2: be able to apply the current regulatory documentation in the field of aircraft engineering (formulated based on the wording from the professional standard for the job function JF-1 "Apply current regulatory documentation in the relevant knowledge area").

Table 1. Disciplines forming the specified competencies

Competencies	Disciplines	Alternative disciplines
C-1	Fundamentals of Scientific Research in Aircraft Engineering	—
C-2	Organization of Scientific Research Activities	—
C-3	Methodology of Scientific Research	—
C-4	Methods of Mathematic Modeling	System Analysis
C-5	Fundamentals of Production Organization	Modeling of Production Processes, Production Management Systems
C-6	Quality Management Tools and Methods	Project Team Management, Project Management Strategy and Tactics

A single program section can be designed to generate one or more learning outcomes. It is also true that several sections can generate a single learning outcome. For example, the learning outcome K-1 is achieved after studying the "Methods of conducting research and development" section, the learning outcome S-1 is achieved after studying the "Patenting and protection of intellectual property" section, and the learning outcome S-2 is achieved after studying the "Industry (aviation) standards" section.

The learning outcomes and possible names of sections for other disciplines are given in table 2.

Table 2. Learning outcomes and possible names of sections for disciplines

Item	Discipline name	Competence/ Job function	Wording of the learning outcome	Name of the program chapter
1	Fundamentals of Scientific Research in Aircraft Engineering	C-1/JF-1	Know the methods of conducting research and development in the field of aircraft engineering	1.1. Methods of conducting research and development during the designing of aviation equipment
			Be able to document the results of research and development activities (patents, scientific and technical documentation)	1.2. Patenting and protection of intellectual property
			Be able to apply the current regulatory documentation in the field of aircraft engineering	1.3. Industry (aviation) standards

Table 2. (Continue)

Item	Discipline name	Competence/ Job function	Wording of the learning outcome	Name of the program chapter
2	Organization of Scientific Research Activities	C-2/JF-1	Know the means of planning research and development	2.1. Software methods and means for planning research projects
			Be able to formulate a scientific and technical problem and identify the stages of research activities	2.2. Statement of scientific research goal and objectives
			Be able to search, collect, and store scientific and technical information	2.3. Scientific search systems
				2.4. Patent search
3	Methodology of Scientific Research	C-3/JF-1	Know the methodological fundamentals of scientific knowledge	3.1. Methods of obtaining scientific knowledge
			Know the methods and particularities of theoretical research	3.2. Structure, models, and methods of theoretical research
			Know the methods and particularities of experimental research	3.3. Methodology and planning of trials
			Know the methods of processing scientific and technical information	3.4. Processing of the experimental research results
4	Methods of Mathematic Modeling	C-4/JF-2	Know the basic concepts and methods of solving computational and optimization problems using computer tools	4.1. Basic concepts and terms of mathematical modeling
				4.2. Approaches to mathematical modeling
			Be able to develop physical and mathematical models of the processes, phenomena, and objects being examined	4.3. General principles of constructing mathematical models
				4.4. Designing of various types of mathematical models
			Be able to analyze the solution obtained using computer tools	4.5. Evaluation of the results of the analysis of computational and optimization problems

Table 2. (Continue)

Item	Discipline name	Competence/ Job function	Wording of the learning outcome	Name of the program chapter
5	System Analysis	C-4/JF-2	Know the essence of the systems approach	5.1. Basic concepts of system analysis and systems approach
			Be able to apply the methods of research and development results analysis	5.2. Methods of system analysis
				5.3. Mathematical methods of decision making
6	Fundamentals of Production Organization	C-5/JF-2	Know the main production processes at the aviation industry enterprises	6.1. Characteristics of the main production processes
			Know the methods of introducing the results of research and development activities into production	6.2. Calculation of the economic efficiency of introducing the results of research and development activities into production 6.3. Methods for introducing the results of completed scientific research into production
			Know the principles of production organization and planning	6.4. Organization of production preparation 6.5. Planning of production preparation
7	Modeling of Production Processes	C-5/JF-2	Know the concept of a production system and a technological process	7.1. The concept of a production system 7.2. Technological process and production set
			Know the typical production processes	7.3. Typical production processes and their characteristics
			Know the tasks of production process optimization	7.4. Cost theory
			Be able to assess the feasibility and risks of introducing the results of research and development activities into production	7.5. Introduction of new developments into the production process flow

Table 2. (Continue)

Item	Discipline name	Competence/ Job function	Wording of the learning outcome	Name of the program chapter
8	Production Management Systems	C-5/JF-2	Know the principles of the production process organization	8.1. Organization of the production process in terms of space and time
			Know the composition and relationship of functional blocks of the enterprise production management	8.2. Information systems of enterprise management
			Know the methods of introducing the results of research and development activities	8.3. Introduction of new processes at an enterprise
9	Quality Management Tools and Methods	C-6/JF-2	Know the main stages of product quality planning	9.1. Product quality planning 9.2. Lean production
			Know the basic methods of analyzing the process failures and defects	9.3. Analysis of failure causes and consequences
			Know the process verification criteria Know the methods of verifying the results of research and development activities	9.4. Checklists
			Possess the tools for functional and cost analysis of business processes and designs	9.5. Functional and cost analysis
10	Project Team Management	C-6/JF-2	Know the methods of organizing, planning, and monitoring team work	10.1. Basic rules for managing people and small groups 10.2. Team performance assessment
			Be able to enhance the motivation of subordinates and resolve conflict situations	10.3. Motivation and conflict resolution in teamwork

Table 2. (Continue)

Item	Discipline name	Competence/ Job function	Wording of the learning outcome	Name of the program chapter
11	Project Management Strategy and Tactics	C-6/JF-2	Know the methods of making strategic and tactical decisions in project activities	11.1. Features of strategic and tactical project management
			Be able to collect and analyze information, draw conclusions about the causes and problems during the implementation of project activities	11.2. Project execution monitoring 11.3. Selection of a project strategy

The choice of disciplines forming the same competence (disciplines 4 and 5 from table 2, as well as the groups of disciplines 6–8 and 9–11), is performed upon an agreement with the training Customer.

3 Discussion and results

The disciplines presented in table 2 can be used to compile several variants of professional retraining programs with different sets of disciplines can be compiled (table 3 contains 3 examples).

Table 3. Examples of professional retraining programs with different sets of disciplines

Item	Competencies	Option 1	Option 2	Option 3
1	C-1	Fundamentals of Scientific Research in Aircraft Engineering	Fundamentals of Scientific Research in Aircraft Engineering	Fundamentals of Scientific Research in Aircraft Engineering
2	C-2	Organization of Scientific Research Activities	Organization of Scientific Research Activities	Organization of Scientific Research Activities
3	C-3	Methodology of Scientific Research	Methodology of Scientific Research	Methodology of Scientific Research
4	C-4	Methods of Mathematic Modeling	System Analysis	Methods of Mathematic Modeling
5	C-5	Fundamentals of Production Organization	Modeling of Production Processes	Production Management Systems

Table 3. (Continue)

Item	Competencies	Option 1	Option 2	Option 3
6	C-6	Quality Management Tools and Methods	Project Team Management	Project Management Strategy and Tactics

The approach applied during the designing of the professional retraining program is called a modular one. This approach allows the formation of the same set of competencies using different sets of disciplines. It should be noted that disciplines 1–3 are repeated in all three options shown in table 3; therefore, they can be combined into a single module. The advantage of the modular approach is the ability to change the set of competencies upon a Customer's request, choosing the disciplines required for the formation of the specified competencies from the list of disciplines.

4 Conclusion

Combined with the competence-based approach [5–11], the modular approach allows to design the content of an additional professional education program with minimal effort and maximum efficiency.

The algorithm for designing a professional retraining program includes the following stages:

1) determination of the professional standard, according to the requirements of which the program contents will be formed;

2) determination of the list of competencies to be acquired by a student upon completion of the program;

3) determination of the list of disciplines forming the competencies;

4) determination of the discipline contents.

An example of the variable content formation for the "Organization of research and development of aviation equipment" professional retraining program demonstrates that the application of the modular approach to designing additional professional education programs allows to reduce the program development labor costs, as well as to adapt to the Customer's requirements as much as possible.

The methodology for designing additional professional education programs, proposed in the paper, will be useful for the methodologists involved in the development of additional professional education programs, employees of training departments at enterprises, and other individuals, participating in the organization of training under additional professional education programs.

References

[1] Federal Law No. 273-FZ dated December 29, 2012 "On Education in the Russian Federation", URL `http://www.consultant.ru/document/cons_doc_LAW_140174/` (access date: 2021-10-04)

[2] R.R. Anamova, L.V. Bykov, D.A. Kozorez, Education Sciences, **10(8)**, 1 (2020)
[3] R.R. Anamova, L.V. Bykov, D.A. Kozorez, TEM J., **8(3)**, 978 (2019)
[5] Professional standard, URL https://profstandart.rosmintrud.ru (access date: 2021-10-12)
[5] N. Simone, Empir. Res. Vocat. Educ. Train., **12**, 13 (2020)
[6] C. Hofmann, K. Häfeli, X. Müller, A. Krauss, IJRVET, **8** (2021)
[7] J.J. Michael, Empir. Res. Vocat. Educ. Train., **13**, 7 (2021)
[8] I. Eegdeman, C. Klaveren, M. Meeter, Empir. Res. Vocat. Educ. Train., **12**, 9 (2020)
[9] E.L. Sorokina, Y.A. Yelinskaya, in Materials of the All-Russian scientific and practical conference Science and Society, **XII** (2019), URL https://cyberleninka.ru/article/n/osobennosti-razrabotki-i-realizatsii-programm-dopolnitelnogo-professionalnogo-obrazovaniya (access date: 2021-06-24)
[10] O.V. Fetisova, V.V. Shekhovtsov, Humanities of the South of Russia, **5** (2017), URL https://cyberleninka.ru/article/n/spetsifika-dopolnitelnogo-professionalnogo-obrazovaniya-v-sovremennoy-rossii (access date: 2021-06-24)
[11] A.W. Iftikhaar, K.M. Hakim, Int. J. Humanit. Soc. Sci. Invent., **3**, 71 (2014)