

The method of designing objectives and content of professional education in technical higher educational institutions based on professional standards

El método de diseño de objetivos y contenidos de formación profesional de técnico superior en instituciones educativas basadas en estándares profesionales

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ABSTRACT:

The purpose of the study is to determine the methods for designing the standard content of students' education in the university, which allows them to be trained in accordance with the requirements of the Federal State Educational Standards (GEF) and professional standards (PS). The main results of the research make it possible to scientifically justify and practically implement the methods for designing the normative content of vocational training of students in a university that meets the requirements of the GEF and with the requirements of the PS. The significance of the results is the introduction of new GEF into the educational practice of universities and their interface with the PS.

Keywords: objective, skills, professional standard, design, educational standards, content

RESUMEN:

El propósito del estudio es determinar los métodos para diseñar el contenido estándar de la educación de los estudiantes en la universidad, lo que les permite estar capacitado en conformidad con los requisitos de la ley Federal de las Normas Educativas del Estado (FMAM) y los estándares profesionales (PS). Los principales resultados de la investigación hacen posible justificar científicamente y, prácticamente, implementar los métodos para diseñar el contenido normativo de la formación profesional de los estudiantes en una universidad que cumpla con los requisitos del FMAM y con los requisitos de la PS. El significado de los resultados es la introducción de nuevas FMAM en la práctica educativa de las universidades y su interfaz con el PS.

Palabras clave: objetivos, destrezas, profesional de diseño, estándares educativos, los contenidos

1. Introduction

It is widely known that Russian educational standards have a prescriptive character. Thus, the structure of the new Federal State Educational Standards of the 3rd Generation (FSES 3++) consists of three sections and contains almost no list of disciplines. FSES indicates that a program must have such academic disciplines (modules) as philosophy, history (Russian history, World history), foreign language, civil defense, physical education in Section 1. The educational institution itself, based on the results of mastering the educational program i.e. formed competencies, defines the list of other educational disciplines. Moreover, FSES 3++ provides only general professional competencies. Professional competencies, defined by the program, are based on Professional Standards (PS) and must contain all the required professional competencies from the list of Exemplary Educational Programs (EEP). One or more professional competencies may also be determined by an educational organization independently. Thus, when defining the list of disciplines and content of the training one must take into account the requirements of Professional Standards. The relationship between PS and FSES are discussed in a number of research works (Blinov et al., 2015; Senashenko 2015; Karakozov, Petrov & Huzhina, 2015; Danilina, 2016; Surkova, 2016; Bulanova, 2017; Fartash et al., 2018; Davoudi et al., 2018). As noted by V.S. Senashenko (2015), V.N. Blinov et al. (2015), the issues of ensuring the required compliance with educational and professional standards "cause some tension" in the educational environment. Therefore, the development of methods of syllabi content designing, taking into account PS, is becoming more relevant.

2. Research Methodology

According to many researchers, "Education quality depends on the precision of objectives selection" (Blinov et al., 2015). The needs of the organizations and associations of employers can serve as a source to achieve the required professional education quality needs and interests of students. The involvement of the former in determining training objectives is achieved by using PS.

There are several works devoted to the determining the objectives of education (Khutorskoy, 2007; Kraevskiy, 2011; Lebedev, 2012). A.A. Verbitsky (2017) points out that "The main purpose of modern education is general cultural, social and professional development of personality of a future graduate of a school, college, university; along with mastering practical and professional activities" (Verbitsky, 2017).

The analysis of these works and recommendations (Khutorskoy, 2017) reveal the following patterns of learning objectives:

- Harmonization and coherence of different level goals (e.g. government, students, and the needs of organizations and employers' associations) are the basis for achieving the required quality of education;
- Participation of students and employers in setting learning objectives, determining the trajectory for their achievements, the personal component of education content and practices will contribute to the qualification requirements of a future specialist;
- Stepwise definition of the objectives and their achievement is determined by the level of achievement of the purposes of the preceding stage based on the self-development of students.

Objectives, being the underlying factors, define the following principles of learning content (Khutorskoy, 2017):

- The principle of social conditions and requirements of PS consideration;
- The principle of conformity of syllabi to the objectives of the chosen model of education;
- The principle of structural integrity of the content at the interdisciplinary level;
- The principle of content unity and procedural activity of parties;
- The principle of accessibility and naturality of education.

Given the above, we shall show how to determine the content of academic disciplines, based on requirements of PS.

Note that for the transition from a PS to the content and objectives of studying particular disciplines it is required to perform a significant amount of work, involving trained performers.

The following prerequisites lie at the heart of this work:

- After graduation, a graduate will work in a particular field of professional activities in accordance with FSES.
- Professional Standard in its structure contains a list of functions and employment actions that are assigned to perform by an employee.
- List of functions and work action set skills specific to this specialty.

These skills should be reflected in the content of professional training.

As we have noted above, the new Federal State Educational Standards of the 3rd generation (FSES 3++) do not contain a list of academic disciplines. These disciplines are defined by an educational institution itself, based on the results of mastering the educational program i.e. formed competencies. The implementation of this still remains difficult. However, while designing the content of education, one must take into account the requirements of professional standards. Let us show how to determine the content of disciplines, based on the requirements of PS.

Relying on the work of A.M. Alekseyuk et al. (1993), let us consider the didactic basis of determining the objectives and content of academic disciplines. It is known that the profile of a specialist is determined by the skill system that one possesses during practical activities. In turn, skills are manifested in actions for the intended transformation of raw materials to specified products. The list of professional skills is reflected in the professional standard of a specialist.

Professional standard is the basis for the reflection of a specialist profile in the educational process. Typical tasks of a specialist, reflected in FSES, may serve as a didactic basis for translating these standards into syllabi. Such translation means the clarification of study objectives to the language of skills and standard (core) tasks of professional activity. Task expression of learning content requires a corresponding revision of the necessary body of knowledge since knowledge never exists by itself – it is always an element of some activity. Therefore, forming the skill system, we simultaneously form a system of appropriate skills knowledge.

Considering a task approach as the didactical basis of professional training improvement, it is necessary to have a complete list of specialist skills, reflecting one's academic major.

In this regard, making up a list of typical skills is the first step in the way to the training scheme, which is able to provide the high quality of training. Let us consider the application of this method for curricula designing on the example of Russian PS titled "A Specialist of Tooling Designing» (PS, 2014) (the type of PS doesn't matter and may be of any kind). We will also consider the recommendations in such works as Korchagin (1996, 1999, 2003); Korchagin & Bikchentaeva (2002); Korchagin et al. (2017); Kvon et al. (2018).

The Professional Standard, we picked, corresponds to the professional activities of graduates who have completed the bachelor program titled "Design and Technological Support of Engineering Production" (FSES, 2017).

Let us note that each educational standard is connected with a set of professional standards that define the field of future professional activity of graduates.

When choosing a professional standard for developing training programs one must take into consideration that the proposed content of a program may meet the following:

- One professional standard that has the same or synonymous name;
- Part of professional standard (for instance one of the generalized work activities);
- Several professional standards, each of which reflects the specificity of activities in a particular industry or describes one of the qualifications, included in the study of the

3. Results

According to the Professional Standard, possible job positions of such specialist are as follows: technician-designer; engineer-designer.

PS structure includes generalized work function, labor function, labor actions, required knowledge, and skills.

For example, the PS contains such work activities as 3.1. General labor function: Developing of templates and simple designs of technological equipment and special tools; 3.1.1. Job description: The production design and other technical documentation. Changes in the design documentation.

In turn, job descriptions 3.1.1. Include the following

- Labor actions:

Development and production of design documentation in accordance with standards, and instructions of development and design.

Monitoring work projects and drawings, as well as any amendments made to them.

Making changes to the developed design documentation.

- Necessary skills:

Perform technical drawings, assembly drawings, detail drawings, and general arrangement drawings in accordance with Unified System of Design Documentation (USDD).

Draw simple designs.

Make schemes, specifications, and various statements and tables.

Use CAD systems.

Use regulatory documentation and guidance material.

The formation of these skills should constitute the content of professional training.

The following list of skills can be defined as a list of skills of the first level. First level skills comprise comprehensive learning objectives of a specialty. Their characteristic features being:

- Implementation of skills is normally confirmed by a design or technical document of a product;
- Activities of a specialist are mainly determined by regulatory documents;
- Each first level skill consists of a large number of skills of the second, of the third and other levels that must be identified as goals of acquisition in each academic discipline.

Let us consider how to reduce the characteristics of the first level skills of an engineer-designer to determine the specific objectives of training for major-oriented academic disciplines (e.g. materials science).

We introduce the following notation: the first digit is the ordinal number of the first level skill out of the list given above; after the decimal separator (point) there should be the sequence number out of the list of the second level skills etc. For example, 1.4 – the ordinal number of the first level skills is "1" and the second level skills is represented by "4" etc.

Example 1. Let us consider the ability described as "Make up technical drawings, assembly drawings, detail drawings, and general arrangement drawings in accordance with USDD". Let us denote it as the ability of the first level (item 1).

Part drawing is a design document containing a drawing and other data necessary for its manufacturing and control (Russian State Standard (SS) code 2.108-68). For the development of the part drawing one needs to learn the skills of the second level, namely:

1.1. Make up the part drawing.

1.2. Determine the size of the part.

- 1.3. Specify tolerances and position of surfaces.
- 1.4. Define roughness of surfaces.
- 1.5. Choose material from which the part is made.
- 1.6. Identify and designate coating, its surfaces, and other types of part treatment.
- 1.7. Formulate supporting text of a drawing, specification, and additional requirements for the production, control, operation, or repairment of product.
- 1.8. Make the sheet format and fill additional fields.
- 1.9. Draw graphical and textual part, in accordance with the USDD standards.
- 1.10. Make adjustments according to results of drawing control in compliance with the USDD standards.

The list of the second level skills includes actions that represent an objective in training for academic discipline and actions that can only be learned during the study. For example, the ability to determine part dimensions and the ability to specify tolerances of form and position of surfaces (Items 1.2 and 1.3) can serve as targets for several academic disciplines. The dimensions of the parts can be determined only when you learn material strength calculation, the calculation of mechanism kinematics and the calculation of a size, given the requirements of interchangeability, etc. In addition, sizing is affected by the manufacturing technology of a part. This means that one must learn to determine the size of a given fabrication process (casting, stamping, machining, welding, etc.). One should be able to set this size, which can be controlled during manufacturing process.

We can see that the content of the second level skills is quite complex.

Skills of the third level can be defined in different ways, for example, composition analysis of the professional activities to make a product. So, for skills of the third level, when determining the size of the parts (item. 1.2), calculation methods are characterized by the following skills-action (Russian State Standard code 2.106-68):

- 1.2.1. Design of sketch or diagram of a calculation.
- 1.2.2. Defining the purpose of the calculation.
- 1.2.3. Search the source data for the calculation.
- 1.2.4. Defining of calculation conditions
- 1.2.5. Calculation.
- 1.2.6. Making up and registration of an explanatory document.

The calculation ability (item. 1.2.5) is formed during acquisition of academic disciplines.

For example, action items as 1.1, 1.8, 1.9, and 1.10 are the objectives of such academic discipline as Descriptive Geometry. Moreover, these actions are complex and include the following, third level, formed directly during the study of this discipline. Thus, for the action 1.1 skills of the third level are required, namely:

- 1.1.1. Make up the image of the part.
- 1.1.2. Draw the necessary views, sections, and cross-sections.
- 1.1.3. Apply explanatory notes.
- 1.1.4. Give appropriate information of the part shape within the text section of the drawing.
- 1.1.5. Denote the conditional elements of parts (e.g. threads, slots, etc.).
- 1.1.6. Replace the images with symbols.

By performing the similar analysis of other actions of the second level skills (items. 1.8, 1.9 and 1.10), it is possible to obtain a complete list of skills that must be mastered by a student during the course of Descriptive Geometry. This list of skills should constitute the basis for determining the content of a discipline, types of lessons (e.g. lectures, workshops, seminars).

The setting of the actions, listed in the third level is a difficult task – the content of it is multi-disciplinary and interdisciplinary.

The action itemed as 1.5 is no less difficult – the ability to choose the material from which to manufacture the part.

The ability to choose the material is, in fact, the ability to solve the problem of finding an unknown object satisfying the given condition that binds to an unknown object (a necessary material) with the initial data of this task.

The content of basic actions, aimed at the choice of material, from which a part is to be manufactured, involves the formation of a large number of skills of the third level, namely:

1.5.1. Ranking of the problem of choice of part material. For example, the definition of priorities in terms of operation, manufacturability of parts and feasibility of manufacturing, maintenance, and repair.

1.5.2. Search of available materials and compilation of a list of objects of choice.

1.5.3. Choice of the main condition, which must meet the requirement of a material.

1.5.4. Selection of the list of materials that meet the first condition of the problem.

1.5.5. Entering of the following conditions.

1.5.6. Selection of materials that meet the requirements of the second condition, etc. These actions must continue until you select the material that meets all the requirements. The registration records, i.e. actions 1.8 and 1.9, should complete the choice of material.

The writing of main and additional inscriptions on the part drawing includes the following skills:

1.9.1. Find a corresponding State Standard (SS) for the selected material. This means the ability to work with literature, catalogs in the digital library. Searching the State Standard for the material is a hard task. For example, all metals and alloys have about 100 standards, whereas non-metallic materials have more than 200. It appears that this work should be appropriately methodically provided. For example, a list of standards for materials used in a particular industry should be composed. The list should be issued to students as handouts.

1.9.2. The definition of the requirements of the standard on the material by the record in the title block on the drawing, i.e. its designations.

1.9.3. Designation of material details in column 3 in the sheet format (SS 2.104-68).

From the above list of abilities, necessary for material selection, we may conclude that their formation contributes to the development of abstract logical thinking of students. Indeed, the material opting is a hard task, unless mental operations of analysis, synthesis, and comparison are carried out. As a result of performing these operations, the students form judgments as a simple act of thinking about the relations between objects and their characteristics. Several judgments form a new judgment, i.e. the transition from individual judgments to a more general conclusion.

We should note one feature of the second and third level skills acquisition that is important for professional skills to develop part drawing skills: based on the activity, details can shape the professional tasks – tasks for most academic disciplines. Thus, the development of detailing can be a task for such disciplines as materials science, technical mechanics, standardization of measurements, technology, etc. It is important that the purpose of the task should contribute to the formation of the ability of the first level. In order to reduce the time for developing a drawing, the task of developing a sketch of the part can be given. Thus, it is possible to directly form another professional activity i.e. the ability to draw service machine parts. Moreover, this important ability for the designer will be formed on the achievement of other goals (for example, the definition of waviness, roughness of surfaces, etc.).

Out of the skills of the third level, the abilities of the fourth and fifth levels can be defined. Let us consider, for example, the ability 1.2.6. The composition and registration of the explanatory document.

In the general case, the Explanatory Document (ED) is a design document that contains the device description and principle of operation of the developed product, as well as the rationale, adopted during its development of technical and techno-economic decision-making

(SS 2.102-68).

In the practice of Russian engineering higher educational institutions, ED is a common document, the product of learning activities of students during doing coursework and project designs. However, in many cases, the "academic" part of this design document little does contribute to the development of professional skills. Meanwhile, the development of the ED contributes to the formation of the following abilities of the fourth level (SS 2.106-68):

- 1.2.6.1. Ability to make the introduction, i.e. the ability to justify the relevance of a development; ability to be introduced to the problems of development using a comparison, retrospective analysis, etc.
- 1.2.6.2. Ability to identify the purpose and scope of the designed product.
- 1.2.6.3. Ability to describe specifications, determine their list, numeric values of acceptable deviation.
- 1.2.6.4. Ability to justify the chosen design and describe the rationale.
- 1.2.6.5. Ability to make calculations confirming the efficiency, reliability and other characteristics of the product.
- 1.2.6.6. Ability to describe the organization of labor, concerning the application of the developed device, i.e. the ability to anticipate actions and predict their results.
- 1.2.6.7. Ability to define not only technical but also economic, social (including environmental) efficiency of the designed product.
- 1.2.6.8. Ability to define and achieve the required level of unification and standardization of the component parts of the product.

The content of each fourth level skills includes fifth level skills that can be independent objectives of learning a particular academic discipline. For example, the ability 1.2.6.6 i.e. a description of the organization of work activities with the application of the developed device is an integral set of the fifth level skills i.e. the purposes of training in specific academic disciplines, concerned with mechanics, related to the operation, maintenance and repair of equipment. The fifth level skills that are necessary to describe the organization of work activities with the developed product are as follows:

- 1.2.6.6.1. Preparation techniques and methods of operating the device in different modes and conditions.
- 1.2.6.6.2. Description of techniques and methods of work with product in the form of an explanation, and prescription (where necessary).
- 1.2.6.6.3. Description of procedure and means of transportation of product.
- 1.2.6.6.4. Description of procedures and methods of installation and commissioning.
- 1.2.6.6.5. Description of methods and procedures of preservation and storage of product.
- 1.2.6.6.6. Assessment of interchangeability of product elements.
- 1.2.6.6.7. Definition of serviceability level.
- 1.2.6.6.8. Evaluation of product maintainability.
- 1.2.6.6.9. Characterization of product stability of the external environment.
- 1.2.6.6.10. Data describing the qualifications and number of staff.

The skills of the fifth level are defined by skills the sixth level. For example, ability to assess the maintainability of a product (item. 1.2.6.6.8) means that it is necessary to master:

- 1.2.6.6.8.1. Ability to identify indicators of maintainability.
- 1.2.6.6.8.2. Ability to set the list of characteristics of maintainability.
- 1.2.6.6.8.3. Ability to determine the length and complexity of certain operations of maintenance and repair.
- 1.2.6.6.8.4. Ability to choose the range and number of used tools, equipment, and materials.
- 1.2.6.6.8.5. Ability to evaluate such indicators of maintainability as the number and

qualifications of maintenance and repair.

These skills of the sixth level are the objective for a certain academic discipline – "Repair and maintenance of equipment».

4. Discussions

According to the authors (Blinov, et al., 2015), "Using professional standards in education is a complex but feasible task". This complexity is determined by the differential interpretation of the qualifications within the field of education and work activities. Federal Education Standards, taking into account the requirements of PS more fully than any other documents, substantially contribute to the convergence of these concepts. This facilitates initial juxtaposition of PS and FSES, as a specification of the professional work in FSES 3++ corresponds to specifying of the professional activity areas. For example, FSES for "Civil Engineering" educational program indicates the following areas of professional activity: education and science; architecture, engineering, surveying, and design; construction and housing and utilities; transportation; electric power industry; nuclear industry (FSES 3++, 2017). In the Appendix to FSES 3++ a list of 42 PS for the forming of professional competencies is given.

New edition of educational standards provides the possibility of continuous updating of professional competences of the bachelor along with the requirements of employers and professional standards, as their development has not yet completed. As it was pointed out by S.A. Pilipenko et al. (2016), "The created mechanisms of interaction will allow the educational and professional community not only to speak the same language but also to conduct an equal dialog» This circumstance, according to A.A. Shekhonin et al. (2017) makes it possible to overcome differences in the content of qualifications in education and workplace. This is possible only "Due to the introduction of an adaptation period for graduates which is necessary for in-depth exploration of specific requirements to the selected employee's qualifications and successful completion of qualification exam".

5. Conclusion and recommendations

The given examples show that the analysis of professional skills, their decomposition, and detailing allow one to create a coherent hierarchy of objectives of training – from academic majors to the learning objectives in every academic discipline along with appropriate learning content. The basis of constructing a hierarchical structure of goals lies in the targeted analysis of the skills and actions content needed to build a product. In the course of it, the most important principle of didactics is realized i.e. its connection with everyday life activities. The article can be useful for teachers involved in the designing of syllabi and curricula.

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