Competency-based Modular Educational Program on the “Oil and Gas Business” Specialty

Yskak Nabi, Zhamilaysh Hasanova, Galiya Saltanova, Aktoty Kasanova

Abstract**—** This topic relevance is contingent on the need to review methodological approaches to the curricula development in order to ensure the results of students ' education. This research goal is to justify and implement the competency-based approach through the example of modular educational program "Oil and Gas business". *Research methods* are as follows: literature analysis, modeling, and comparative analysis. *Results:* methodological approaches to curriculum development have been finalized in an environment where professional standards are available, difference between the concepts of competency/competence has been shown, model of curriculum for modular educational program "Oil and gas" has been developed, and reasonable and measurable results of training program have been formed.

Keywords**—** Competency, competence, curriculum, modular educational program, professional standard, specialty the “Oil and Gas business”**.**

I. Introduction

THE disadvantages having been found during analysis of the modular educational programs (MEP) developed in the higher education institutions of Kazakhstan are as follows:

1) modules are formed from 2-3 "traditional" disciplines in order to bring the module scope to 5 credits;
2) the results of training on one of them are taken as "main" ones and the results of examination on the module are assessed based thereon while the others are assessed by the "credit" mark;
3) the results of training in the module are formed in "general form", so they elude measurement resulting in lack of understanding on what particularly the exam score is set for.

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Existence of such a number of shortcomings calls into question the implementation of competency-based approach, although this approach is declared in all state documents in the field of education (The Law on Education, State Compulsory Educational standards, etc.).

Review of the Modular Educational Program up to now developed at the Atyrau Engineering and Humanitarian Institute has shown the above shortcomings (specific examples will be given in section 2)So, in the new version of e Modular Educational Program, we will implement our approaches to the development of Modular Educational Program.

In the literature there is a sufficient number of works devoted to the competency-based approach. Scientists have given definitions of this approach, revealed the essence of "competency" and "competence" concepts, classified competencies according to various features, etc. However, some definitions and interpretations turned out to be subjective, hence controversial. For example, in definitions from [1]: “Definition of competence is your skill or ability in a specific field or subject, or being able to do something well, or being sane enough to stand trial in court” in definition from [2]: ”A cluster of related abilities, commitments, knowledge, and skills that enable a person (or an organization) to act effectively in a job or situation” Competencies are called as abilities, and in definition from [3]: «System of internal mental structures and abilities assuming mobilization of knowledge, cognitive skills, practical skills, and also social and behavioral components, such as attitudes, emotions, values and ethics, motivations for successful realization of activity in a particular context” the psychological factor (mental structures) and personal qualities are added to abilities (values, ethics, motivations). In this regard, we will justify our view on the competency-based approach in education.

Draft State Program for the development of education and science of the Republic of Kazakhstan for 2020-2025 aims to increase the number of college and university graduates with in-demand skills for employment, decent work and entrepreneurship, and to implement this goal it provides for the following tasks:

- Task 1: to ensure continuity of educational programs from preschool to postgraduate education based on the lifelong learning principle.
- Task 2: to increase the social partners involvement in training according to the economic requirements. It is

emphasized that the new educational programs will focus on formation of flexible and professional skills (soft skills, hard skills) required in the rapidly changing world of VUCA (volatility-uncertainty-complexity-ambiguity) with involvement of lifelong learning.

The goal we have set in this article consists in development of such modular educational program.

By this article the authors continue their work on said problem (see [4], [5]). As we propose the uniqueness of obtained results should be evaluated not only on the basis of "novelty", but also on the basis of "innovation". We understand innovation as follows: "innovation is characterized as a result achieved in the course of certain process with observing totality of conditions as a source to improve the system effectiveness" [6]. This position is held by the authors [7]:«One of the most crucial prerequisites of an effective educational program is having codified standards which act as an impeccable criterion upon which a program can be implemented and evaluated. Hence, carrying out evaluation studies seems to be an essential mission of every successful educational program".

Novelty of the work is ascertained by the fact that for the first time in pedagogical science, the methodological approaches to development of curricula have been finalized in an environment where the professional standards are available. *Innovativeness* of the work ascertained by the fact that the curriculum model for modula educational program "Oil and gas" has been developed, and reasonable and measurable learning program outcomes have been formed that constitutes the practical result of implementing the goal of the training effectiveness improvement.

II. Problem Formulation

A) Education on the basis of modules

The value of modular learning is well established in [8]: "The essence of modular education consists in students' consecutive assimilation of modules — complete blocks of information…. Education on the basis of modules leads to several positive effects**.** *Firstly*, student equipped with didactic materials and instructions, gains much independence in subject acquisition. *Secondly*, lecturing function of teacher is displaced by consulting one and student's share of passive perception of material decreases and he gets possibility of active discussion with teacher. *Thirdly*, there are periods of midterm control of material acquisition, coinciding with the ending of each module. This control is important both for student, and for teacher. *Fourthly*, there is easier acquisition of the whole subject through step-by-step learning of modules with complete content. *Fifthly*, the modular technology of education provides management of educational process according to imposed specialization requirements to graduate that allows to reduce and sometimes to exclude adaptation of young specialist to a certain kind of activity".

In work [4] the algorithm of development of modular educational programs consisting of three stages was developed: preparatory, basic and final.

We have indicated that the selection of competencies can be based on the industry qualification framework or professional standards (PS) or on the requirements of employers (in the absence of industry framework and PS).

We have shown that the modular training essence consists in the training content structuring into autonomous organizational and methodological units (modules). The module content and its scope may vary depending on didactic goals; profile and level of the learner's differentiation, their desire to choose the individual movement trajectory according to the educational course.

The module is a complete set of skills, knowledge, attitudes and experience (competences) required to be mastered and described in the form of requirements which the learner should meet by the module completion, and representing an integral part of more general function. Each module is evaluated and is certified usually.

The module is formed as a structural unit of specialty curriculum; as an organizational and methodological interdisciplinary structure in a form of a set of sections from different disciplines united by a thematic basis; or as an organizational and methodological structural unit in an academic discipline framework.

Based on the algorithm, we developed the MEP of the "Computer Science and Software" specialty. The peculiarity of this MEP was the lack of a professional standard of specialty, so it was necessary to conduct a survey of employers according to a specially developed methodology. This article will use the fact that the specialty standard of the "Oil and Gas business" is available. Therefore, in a fragment of algorithm shown in Fig.1 in the appendix, you can go directly to stage 2.

However, it will be necessary to answer the question about the advantages and disadvantages of these two cases.

B) Competency-based and student-centred approaches as basis for development of MEP

Analysis of the literature related to the problems of competence-based and student-centered approaches to learning showed a wide range of opinions and interpretations. Let us consider a few of them.

1) The knowledge, understanding, skills, experience and attitudes (valuable aims) are integrated at the competencies: "Statements of what a learner knows, understands and is able to do on completion of a learning process" [9];

2) Competency means "proven ability to use knowledge, skills and personal, social and / or methodological abilities, in work or training situations and for professional and personal development. In the context of the European qualifications framework, competence is described in terms of "responsibility and autonomy" [10];

3) The emphasis to student-centred learning comes from the need for a new education system that will prepare a specialist with modern thinking, focused on innovation, continuous self-development and universal values based on humanistic ideas [11], [12];

4) Student-Centred approach characterized by innovative methods of teaching which aim to promote learning in communication with teachers and students and which takes

students seriously as active participants in their own learning, fostering transferable skills such as problem-solving, critical and reflective thinking [9].

However, it is not clear from these definitions what should be taken as the basis for the development of the MEP: competence or competency. As you know, there are 2 models of competency: American and European (mainly British). A distinctive feature of the American model of competencies is that competencies are considered as a description of employee behavior, i.e. competence means appraisal of the employee's performance that he/she has to achieve results in the work. In the British approach, competencies are considered precisely as requirements for the employee from the tasks (workplace), as a kind of working standards that underlie training programs. Then it turns out that the demonstration of specific skills in practice is the result of training. We will take this approach as the basis of our approach.

C) Learning outcomes

The most complete description of the training results is given in [9]. Here are excerpts from this document:

- Competence means "proven ability to use knowledge, skills and personal, social and / or methodological abilities, in situations of employment or training and for professional and personal development. In the context of the European qualifications framework, competence is described in terms of "responsibility and autonomy" (ref. [10]). Competencies can be general or specific subjects. Skills training constitutes the subject-matter of learning process and educational program;
- Training results reflect the level of competence achieved by the student and confirmed by the assessment.

The document notes that there are no strict rules regarding the ideal number of learning outcomes at the program level.

There is a widespread way to formulate learning outcomes based on three main elements:

–Use an active verb to Express what students are expected to know and be able to do (for example, graduates can "describe", "apply", "generalize", "evaluate", "plan");

- Specify what this result refers to (an object, a skill, for example, is able to explain the "hard disk function"; can present a "living room design project made by hand";
- Specify how the achievement of training results can be demonstrated (for example, "make a brief overview of the materials most commonly used in electrical engineering"; "develop a research algorithm using current scientific methods", etc.).

Based on the above and the experience of our practical activities, we have developed guidelines for the formation of learning outcomes:

1) Become familiar with the Dublin descriptors. Relying on Dublin descriptors allows for the formulation of learning outcomes to distinguish between competencies at different levels of education: undergraduate, graduate, etc., while it should be borne in mind that it is not necessary to reflect all of them in the learning results.

2) Formulate the purpose of teaching the discipline. Since we implement a competency-based approach to learning, the purpose of training is not to teach, not to teach, etc., but "mastering", "possession", "acquisition of ability", etc., i.e. what the learner must show, demonstrate, etc. when formulating the goal after the above words is actually the name of the module. It should be noted that if the name of the module is made incorrectly, then there may be difficulties.

3) the content of the module for formulating learning outcomes for the module needs to allocate big blocks, and to exclude such considered in the course of questions like "introduction", "objective", "methods" of discipline, etc. In the content they are certainly necessary, however, for learning outcomes, they do not play a determining role.

4) when formulating the results of training should not use the words "must know", "must be able", etc., they should be addressed to the learner in the form of: "identify", "solve", "demonstrate", etc.

5) the Content of large blocks is almost completely reflected in the "A" section of the Dublin descriptors in the form "specify", "tell" , etc.

6) This content is almost entirely reflected in the "B" section of the Dublin descriptors, but in the form of "solve", "demonstrate", "use knowledge for...", etc. In section "C" the student must show the ability to generalize, compare, analyze, synthesize, etc. on the material of the discipline (he can write an essay, essay, make a report)

In the section "D" it is necessary to formulate the results of training outside of knowledge and skills on the material of the discipline. It should be a competence that allows the graduate to establish contact with people, be a leader, be able to work in a team, etc.

7) In the section "E", the results of training should be formulated on and off the module material. On the module material, this is something similar to "traditional" skills (almost automatic execution of actions). Outside of the module material, the ability to self-study and continuous professional development should be identified (these are the key competencies).

D) Model of a Curriculum

Modeling is the study of an object by the method of constructing and studying its model. It is implemented with a specific purpose and consists of replacing the study of the original with the study of a model and widely used in science for representation and transformation of objects, phenomena or processes that do not yet exist or for some reason unavailable. The developed model allows operating by them, to determine stable properties, the individual essential aspects of designed objects, phenomena and processes, to highlight and to expose them to a more thorough logical analysis. Modeling object is a broad concept that includes objects of animate or inanimate nature, processes and phenomena of reality. The main task of modeling process in socio-pedagogical researches is a selection of a truest and correct model of the original and the transfer of research results on the original. Modeling in socio-pedagogical researches is closely connected with such categories as abstraction, analogy, hypothesis, etc. Modeling as a research method has long ago proved its effectiveness in the study of sociological processes, including the educational process. Modeling in pedagogy helps graphically displaying

the complexity of the educational process and contributes to the solution of arising problems, therefore, it is considered to be one of the primary and most effective pedagogical tools [13].

J. Šedivý mentions that "Modeling is a method that is often used in professional and scientific practice in many fields of human activity. The main goal of modeling is not only describing the content, structure and behavior of the real system representing a part of the reality but also describing the processes. The process can be understood as series of transformations that changes the input values to output values. From the system point of view the process is dynamic system in which the values of the characteristic of the system elements are changed under the influence of the external elements. The models are always only approaching of the reality, because the real systems are usually more complex than the models are." [14].

The model should include the materialistic reflection principle and be understood as means of reflecting or reproducing a particular part of reality. In principle, this is a kind of artifact similar to the object (or phenomenon) under study, but visualized as a diagram, signs, formulas, etc., so conditionally displaying the structure, properties, relationships and interrelations between this object elements. Ideal models, reproducing the same phenomena as material ones, exist only in the consciousness of the knowing subject and "function" only through mental operations thereof. In this sense, they are susceptible to rapid transformations.

In the theory of pedagogical design there exist prognostic model, conceptual model, pragmatic model, instrumental model, monitoring model, reflexive model. Models in terms of the way they are built are divided into figurative, symbolic and figurative-and-symbolic ones. Educational models are classified as follows: a) descriptive, which give an idea of the tasks, structure, and main elements of educational practice; b) functional, reflecting education in the system of its relations with the social environment; c) prognostic model that, forms a theoretically justified picture of the future state of educational practice. Based on consideration of the kinds of models we can conclude that the future model of a Curriculum will be immaterial (ideal), as it will exist only on paper; conceptual, because it will reflect the general approaches (in particular, the competence approach); figurative and symbolic, as it will be visualized in the form of letters and numbers; descriptive, because it will give the insight into objectives, structure and main elements in educational practice.

E) Professional standard of the specialty "Oil and Gas Business"

A professional standard establishes in the field of professional activity "oil and Gas business" requirements to the content, quality, working conditions, qualifications and competencies of employees. In particular, the economic activities kind (professional activities sphere) is defined as the activities in the spheres of drilling, exploration and development of oil and gas fields, with the main goal of economic activity kind are: drilling, exploration and development of oil and gas deposits, geological modeling, interpretation of seismic data, and geophysical research of wells.

The requirements of the standard relate to the activities kinds and the following professions in this sphere:

-driller;
- seismic interpreter;
- petro physic;
- petroleum geologist;
- supervisor (master) for oil and gas production;
- mining engineer.

For example, consider the profession supervisor (master) for oil and gas production. The PS establishes the activities kinds as "Organization and maintenance of oil and gas production, preparation and transportation".

At the same time, the requirements for education and experience of the supervisor (master) in oil and gas production of the 5th level of the branch qualifications framework are as follows: higher education and required work experience are 4 years at level 4.

Thus it turns out that the graduate must have 4 years of experience at level 4 having a higher education. At this level the PS establishes the kinds of activities, "Drilling for oil and gas», which requires an advanced level of professional or technical education and practical experience.

In Kazakhstan the qualification of professional or technical education can be obtained as a result of training at a college.

F). Analysis of the first MEP version of the "Oil and Gas Business" specialty

Curriculum for the first *MEP* version of the "Oil and Gas Business" specialty contains 131 Kazakhstan credits (KZC) of theoretical training and 20 KZC of practice. To convert KZC to ECTS credits, you need to multiply them by 1.75 (in the credit technology adopted in Kazakhstan, theoretical training and practice are separated according to the time of passing thereof). Curriculum includes 12 modules containing 44 disciplines, so the modules consist of 2-4 disciplines. For example, the RNGM 4306 module consists of the disciplines named "Oil and Gas Field Development" and "Modeling of Oil and Gas Field Development Processes". The TTMPNOP 4307 module consists of the disciplines named "Engineering and Technology for Enhanced Oil Recovery" and "Technology for Intensification of Oil and Gas production"; content thereof and learning outcomes are given in Table 1.

Table 1. Content and learning outcomes module TTMPNOP 4307

Content	**Learning outcomes**
Equipment and technology of methods used to enhance oil recovery Types of residual oil reserves and its properties. Classification of methods and factors that determine their effectiveness. Engineering and technologies of impact on the oil deposit. Maintaining	*should know:* modern methods of inflow intensification and methods of enhanced oil recovery; physical and hydrodynamic processes in the reservoir and bottom-hole zone when applying the methods; *should be able to:* select the applicable methods

reservoir pressure by water injection. Water supply of reservoir pressure maintaining system. Technology and engineering of using the deep water for reservoir pressure maintaining Indicators of efficiency of oil recovery from reservoirs during their flooding. Secondary methods of oil production. Reservoir pressure maintaining by gas injection. *Technology for intensification of oil and gas production* Modern oil and gas industry. The main tasks of its development. Classification and composition of machinery, equipment, structures and tools for oil and gas production. Structures and metal structural components of drilling rigs. Production well equipment. Equipment for operation of wells by fountain and gas lift methods.	and means to increase the flow of oil based on the physical and geological, technical and economic conditions. acquire practical skills – in the selection and application of methods for modeling the processes of oil and gas inflow to wells, in solving computational and analytical problems in oil and gas production.

We present the learning outcomes due to the fact that in the next section we will compare it with the training results of the newly developed module. Consideration of the training results in this module shows that the methodological recommendations given above are not met, namely:
1) there are only requirements "to know" and "to be able", i.e. the formed competence on the module is limited;
2) active verbs are not used;
3) the Dublin descriptors are not taken into account for identification of the ability to "apply", "generalize", "evaluate", etc.;
4) it is not specified what a certain result refers to;
5) it is not indicated how the achievement of learning outcomes can be demonstrated .

III. Results

A). Clarification of methodological approaches to the development of Curriculum

As noted above, we will use the British competency model as the basis for our approach. Then we can conclude that competence is a normalized concept, so it should be laid down in regulations, in particular, professional competencies should be reflected in the professional standard.

In our opinion, from here the possibility of delimitation of the concepts of competency/competence comes: if the first concept is a normalized value, then competence is the possession of competencies, i.e. it is already a personality phenomenon, namely personality experience of activity. In this regard, we will formulate competencies based on a professional standard, and we will express the required competence in the training results of in the program. The authors ' opinion [15] is additional confirmation of this position correctness: they call describing content based on competencies among other tools for development and arrangement of learning content (courses, modules, topics).

B). Curriculum of Modular educational program "Oil and Gas business"

Now we will rewrite the tasks from the table PS "Description of units of labor activity» (Table 2)

Table 2. Tasks of labor activity

Cipher of labour activity	Tasks
F1	1-1) Operation and monitoring of oil and gas production facilities
	1-2) Control over observance of production discipline and correct operation of technological equipment
	1-3) Establishment of the reasons of malfunctions in work of pipeline systems and the technological equipment, adoption of measures for their elimination
F2	2-1) implementation of technical control and quality management of oil and gas products
	2-2) Assessment of production and non-production expenses for product quality assurance
	2-3) Analysis of the state and dynamics of production facilities using the necessary methods and tools

From the analysis of the tasks, we conclude that it is necessary to introduce such modules with a volume of 8 credits together with the production practice:

1-1 “Oil and gas equipment”,
1-2 1-2 “Labor protection and safety in the oil and gas industry”,
1-3 “Equipment and technologies in the oil and gas industry”,
as well as modules of 6 credits together with production practice:
2-1 “Automation in the oil and gas industry”,
2-2 “Product quality assurance in the oil and gas industry”,
2-3 “Analysis of the state and dynamics of production facilities”.

In practice, the curriculums in the education system of the Republic of Kazakhstan established the so-called “entry control”, when the requirements for the qualification of University graduates were laid down in the qualification characteristics of the graduate before his training. We establish the required competencies at the beginning of training, i.e. we

establish the assessment of professional qualities at the "exit" of the educational process. Therefore, we first establish in the curriculum the professional modules corresponding to professional competencies at the end of training (in the 8th semester), and the remaining modules are formed on the basis of professional modules.

A modular educational program was developed by relying on the above approaches (Table 3).

Table 3. Curriculum "Modular educational program the "Oil and Gas business"

Blokes	Semesters							
	8	7	6	5	4	3	2	1
	Credits							
Final control	12							
Professional Modules 1	18	30						
Professional Modules 2			24					
Basic Modules			6	25	26	25	16	6
General educational modules				4	4	7	14	23
Sum	30	30	30	29	30	32	30	29

Let's reveal the contents of the blocks.

As mentioned above, the final control and Professional Modules 1 (PM 1) are set according to the professional competencies. Block PM2 must be concordant with the content of training in college. The content of the basic and general educational blocks is established based on this. For example, the modules "Foundations of geology", "Economics of enterprises", "Construction business", "Standardization and certification", "Automation" are necessary for mastering the blocks of Professional Modules, and the modules "Foundations of economic theory, theory of finance, management, entrepreneurship and taxation" and others are introduced in the MEP in order to expand the level of interdisciplinary knowledge of students. Because this is only the foundations of the relevant sciences, then their content should not be overloaded with special topics, but it should ensure the possession of knowledge and skills in areas not directly related to the field of activity. The content of the "traditional" module "STEM" (higher mathematics, chemistry, probability theory, etc.) should be supplemented with modules specific to technical specialties.

C) Learning outcomes of Modular educational program "Oil and Gas business"

As an example, we present a fragment of the results of the training module "Technique and Technology in the oil and gas industry" (Table 4). It is close in content to the TTMPNOP 4307 module, which will allow us to compare the formulations of the learning outcomes to the two modules.

Table 4. Fragment of learning outcomes for the module «Engineering and technology in the oil and gas industry»

Descriptor	Learning outcomes of the module
A	Demonstrate knowledge of - basic physical-and- chemical and operational properties of oil and petroleum products, basic concepts, definitions and professional terminology, - methods used to calculate the main technical devices and installations; - technique and methods for oil and gas preparation, transportation and storage - basic technologies and process charts of well products in the processes of collection and preparation thereof; - causes of complications in the collection and preparation of well products and ways to prevent and exclude them; - methods and technologies for enhanced oil recovery
B	Show the ability to apply knowledge, select the most effective and resource - saving technologies for solving problems related to production, collection, preparation, transport and storage of hydrocarbons; guide professional review for selecting the energy-efficient control over operation of the oil and gas complex equipment
C	Show the ability to plan work in the scientific and technical activities; conduct technical and technological analyses; develop a course work (project) on the introduction of processes and technology at one enterprise
D	Defend the course work (project), prove the feasibility of the decisions taken and implemented
E	Prepare reports on selected topics from the portfolio, showing the ability to independent learning by means of information technology and use in practice the new knowledge and skills in new areas of knowledge that are not directly related to the field of activity

IV. Discussion and Conclusion

Resting upon the British model of competency made it possible for us to differentiate the concepts of competency/competence and clarify our position in relation to the competency approach.

Consideration of the case when for the development of MEP we relied on professional skills shows that we had an advantage, because the competences came from the work functions. However, the drawback of this case is that professional standards are revised 5 years after approval, so the competences embedded in them may become obsolete after some time.

The disadvantage of developing MEP without PS, as noted earlier, in carrying out additional work on the functional study

of the labor market, but it makes it possible to quickly respond to changes in the requirements for specialists, which is a great advantage.

Nevertheless, the developed MEP of specialty the "Oil and Gas business" at this stage provides advance in engineering education, because it have such a distinctive property that we first identified the names of professional modules, and only then moved to the blocks of basic modules and the general educational modules.

We can show the similarity of the content of developed MEP to the curriculum on "Oil and Gas Engineering" specialty used at the University of Calgary [16]. Indeed, this curriculum includes such modules as Mathematics, Engineering, Chemistry, which are included in the "STEM module included in the new MEP version, and such modules as "Geology", "Petroleum Engineering" and others are similar to the "Foundations of geology" module and blocks of Professional Modules.

At the same time, it should be noted that the issue of MEP results' introduction in the educational process has not yet been resolved. This is still a difficult problem. We agree with the authors [17] who write: "Although the available benefits are favorable, immediate results are not to expect. Continuous attention and capability for flexible interventions are required for being able to refine the course content and the teaching methods applied". These questions constitute the subject of further research, but in general we may conclude that this article goal has been achieved.

APPENDIX

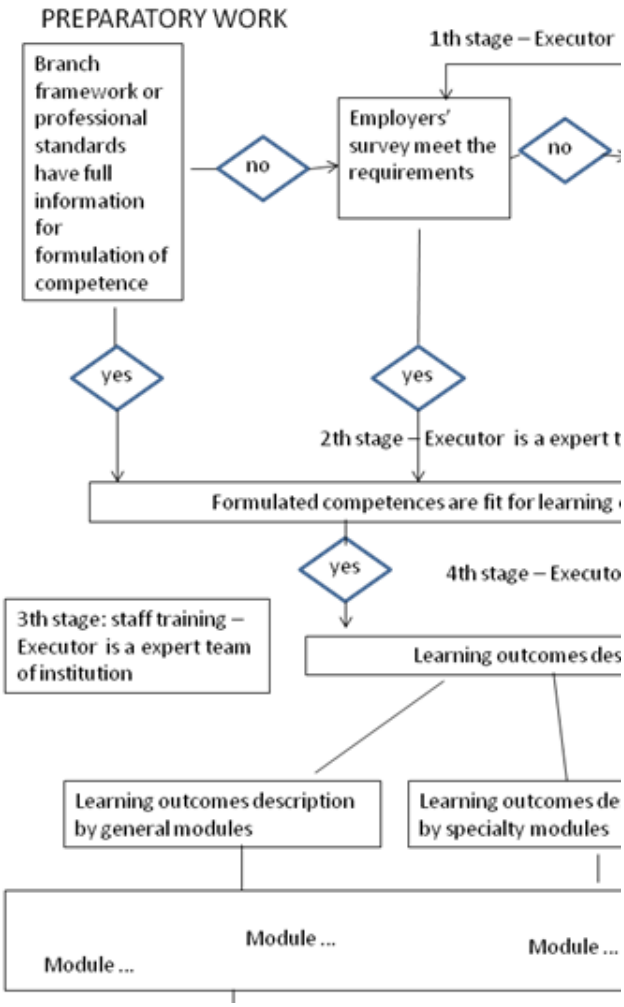

Fig.1 The fragment of algorithm of development of modular educational programs.

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