

# Development of Ontology Model of Requirements to Results of Training in System of Adaptive Control of Education Quality

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## Abstract

The problem of a quality assurance of management of education systems regarding establishment of requirements to results of training by modern science is solved in line with ambiguously treated competence-based approach. Within this article authors consider the possibility of creation of such system based on ontology model. The benefit of this method of the problem resolution is possibility of harmonization of requirements, both for employers, and from representatives of the educational community. It is described as tools of research of data domain and the course of creation of this model, and results of its use for development of a frame of qualifications of professional education of the Ural region and a frame of qualifications for the IT industry.

**Keywords:** Education Outcomes, Expert Information, Ontological Model

## 1. Introduction

The modern competence-based paradigm of quality management of professional education is defined by integration processes in policy, economy and education, on the one hand, and prompt development of production, with another. For systematic consideration of a problem of quality management of professional education on the basis of competence-based approach the theory of adaptive control was used.

Development of the general concept of adaptive control by quality of vocational training on the basis of competence-based approach was based on understanding of that “adaptivity” assumes capability of educational system to correspond, on the one hand, to requests of labor market in personnel with an appropriate level of qualification, and with another, - to needs of the personality taking into account her motivational and valuable orientation in achievement of professional competitiveness and providing perspective of further professional and personal development.

Considering the designated problem from positions of the theory of adaptive control on the basis of competence-based approach, the control object, finite set of inputs and outputs (corresponding to educational levels / steps), the managing subsystem (including bank of reference models of the results of training of the personality and a subsystem of monitoring) were selected<sup>1</sup>.

Problems of development of reference models of requirements to qualifications and results of training at training of specialists in the IT industry stood long ago and are solved both at the international level, and at the national levels of the different countries. Thus, proceeding from problem definition of researches and data domains of application of competence-based approach, its methodological bases are treated by different development teams ambiguously. With respect thereto it is possible to select some aspect directions of development of competence-based approach and its results in the form of reference models or methodical instruments of establishment of requirements to results of training, for example, -level and disciplinary (as in the

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international educational Tuning projects), qualification and official (as in professional standards), qualification and process (as in a professional framework of competences), qualification (as within qualifications).

Broad interaction of educational community and labor market, and also the international cooperation belong to a common feature of implementation of the specified aspects of competence-based approach that within this article we will consider on example of implementation of qualification aspect in the direction of development of a frame of qualifications for the IT industry.

The frame of qualifications is the system and structured on level description of the recognized qualifications.

## 2. Materials and Methods

### 2.1 Selection of Qualification Levels and Descriptors

For development of such frame it is necessary to define originally descriptor level system, in this respect we will address to experience of implementation of two interconnected projects Tempus “Development of a frame of qualifications for system of the high education of the Ural region”, executed in 2008-2010<sup>2</sup> and “Adaptive control by quality of professional education on the basis of competence-based approach (on the example of the sphere of IT)”<sup>3</sup>, executed with assistance of the Russian Humanitarian Scientific Fund in 2012-2013.

At the beginning of work on the first project research of opinions of the heads and representatives of professional educational institutions of different level and the enterprises of different type concerning requirements as to results of training (to knowledge to the abilities and competencies of graduates), and to work of workers of different qualification in the field of work was conducted. Preproject research showed that education and the sphere of work differently describe qualification levels of graduates and workers. So, in the field of education approach to the requirement description to results of training is closer to the methodology accepted in the European practice oriented to competences. Taking into account such approach the state educational standards of the third generation are developed. At the same time, employers when forming requirements to work proceed not from the approaches accepted in pedagogical methodology, and from the regulating documents existing in the field of production<sup>1-24</sup>.

Project participants made a decision to perform development of such system from two points of view -

representatives of the educational community and labor market, and in the subsequent to integrate them into a single whole based on the device of ontology modeling.

Such solution is not casual: in the development area of knowledge bases the ontology is considered as language of detailed formalization of data domain of knowledge by means of the conceptual scheme and includes the dictionary of concepts, the relations and functions of interpretation<sup>22</sup>. Formation of theoretical and methodological bases of this direction is represented to one of perspective for development of information management in the field of information management<sup>4,5</sup>.

As descriptors from educational, community were initially selected: basic knowledge in different areas, professional knowledge<sup>16</sup> information and analytical abilities, projective abilities, communicative abilities, motivation and valuable orientations, reflexive qualities, culturological qualities, basic personal qualities, the adaptation and developing qualities.

As descriptors from representatives of the labor market were selected: professional knowledge, managerial knowledge, normative knowledge; the abilities which are characterized by criterion “complexity of the performed work”; competences of four types: Adaptivity, responsibility, autonomy and motivation.

For development of systems of descriptors by both working groups the projects implemented for today in the direction of upgrade of national system of qualifications of the Russian Federation (research of the European fund of education and the Center of studying of problems of professional education, Federal institute of a development of education and National agency of development of qualifications of the Russian Union of Industrialists and Entrepreneurs), and also research of the certain scientists, for example, considering questions of forming of readiness for research activity<sup>20</sup>, requirements of professional standards<sup>6</sup>, features of creation of effective model of educational information environment of training of the specialist<sup>13</sup>, features of system of professional development of bachelors and masters<sup>19</sup>, features of preparation of separate groups of specialists<sup>8,21,17</sup>.

Eight qualification levels, which correspond to levels of educational programs of formal training of the Russian Federation are selected.

### 2.2 Poll of Experts

The structure, structure and the content of the results of training within the selected descriptors and levels were

defined and specified during studying of opinions of the heads and representatives of professional educational institutions of different level (149 professional educational institutions of Chelyabinsk region), and also the enterprises of different type (33 enterprises with the total number of workers more than 116 000 people). Structurally selection on the enterprises corresponded to structure of distribution of the population by types of economic activity: 1. 18 enterprises (55%) represented the industry, including 9 enterprises of mechanical engineering, 7 - building industry and 2 - metallurgy; 2. 11 enterprises (33%) represented agro-industrial complex of area, including 4 poultry farms, 2 milk plants, 2 enterprises for production and processing of meat, and also 3 enterprises for production of vegetables, grain and other agricultural products; 3. 4 enterprises (12%) represented small business in the different industries.

For studying of opinions of experts forms of interview separately were developed for representatives of an education system and labor market. It is informative the form of interview for representatives of an education system included four blocks of questions: The I block - questions answers on, which allow to receive information on the expert and about the specifics of educational institution; The II block - questions which allow to define a circle of the defects which are available in certain fields of activity of an educational institution; The III block - questions,

Answers on, which allow to receive the opinion of experts on descriptors; The IV block - the questions allowing to receive information on the results of training and levels of preparation on the selected descriptors.

For representatives of labor market forms also contained four blocks of questions I the block - questions answers on which allow to receive information on the expert and about specifics of activity of the enterprise; The II block - questions answers on which allow to receive opinion of experts on descriptors; The III block - the questions devoted to studying of regional features in requirements of the sphere of work to workers at the enterprises of Chelyabinsk region; The IV block - check of compliance of analysis results of regulatory base of a real situation in the enterprises of Chelyabinsk region.

Apparently, special attention was paid to studying of a correctness of selection of descriptors, importance of their accounting and correctness of understanding of their contents (the II block of questions in forms of interview).

For example, two representatives of educational community the following question was set. Evaluate the

importance of accounting of each descriptor as far as it is suitable for an assessment of results of training on your educational program? (Versions of answers: completely approaches, partitioning approaches, does not approach).

According to the answers to the matter percentage distribution of answers which example is provided in (Table 1) was calculated.

Similar work was carried out on studying of opinions of representatives of labor market (employers). Thus, as when studying the opinions of employers, and representation of an education system special value was made by answers to questions of public type which served correction of systems of description, their more exact determination and understanding of the contents.

In general, for change of the contents and name of descriptors 64% of respondents, supported changes of number (enlargements of descriptors are more often) - 36% of respondents.

### 3. Results and Discussion

#### 3.1 Ontologic Model of a Frame of Qualifications

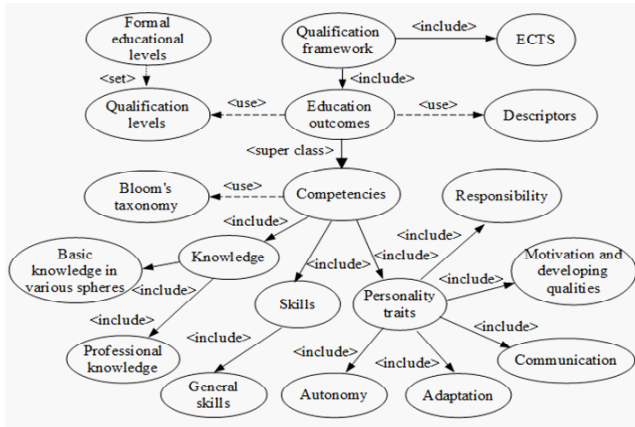
Results of studying of opinions of experts served the development of a uniform ontology model of a frame of the qualifications which is presented in (Figure 1).

In this model of an arc mean different types of the relations: <use>, <set>, <include>, <super class>.

The provided model possesses a number of the useful properties caused by application of ontologic approach to modeling of a frame of qualifications by formalization of basic categories of data domain namely: the model is applicable at the different detail levels - from the top

**Table 1.** Distribution of answers to a question of applicability and importance of accounting of a descriptor "Basic knowledge in different areas" (in %)

Answers	Higher education	Secondary professional education	Primary professional education
Completely approaches	60,34	67,57	60,00
Partially approaches	36,21	32,43	38,67
Does not approach	0,00	0,00	1,33



**Figure 1.** Ontologic model of a frame of qualifications of the Ural region

level of the description of basic categories, to the level of design of analytical applications; the model is easily adaptable and supplemented, thus depth of study of separate aspects is defined by practical need and is not regulated by methodology; visualization of model simplifies understanding of structure of a frame of qualifications, facilitates her perception and work with a large number of the interconnected objects due to ensuring transparency of use of mechanisms of aggregation and detailing at the different conceptual presentation layers; the model integrates concepts of the different points of view on what has to be the frame of qualifications, and systematizes a conceptual framework; the ontologic model is available to understanding and adjustment by different user groups and offers verbal representation of the relations of many categories of data domain. An additional benefit is machine readability and a transliruyemost of ontologic model in other universal languages.

Further we will show these properties of the developed model.

In compliance with model, the final system of descriptors looks as follows:

1. Basic knowledge - declarative and procedural knowledges in relation to a scientific picture of the world. Such knowledge can be gained in the empirical way from practical or educational professional experience, and, first of all, by formal training.
2. Professional knowledge is a set of knowledge of structure of work, the methods of implementation of professional activity received in the training activity. This knowledge is mainly procedural.

3. The generalized abilities are the abilities connected with implementation of educational activity and labor functions.
4. Autonomy - development, relative independence and independence of activity of an individual or the organization.
5. Communicativeness - in an unusual way the capability for communication which is shown in the field of education and professional and scientific interaction.
6. Responsibility - a duty and readiness of an individual to be responsible for perfect actions, acts and their effects.
7. Adaptivity - capability of reaction in the conditions of change of technologies, market requirements of work, the organization of work, i.e. the adaptation to the changing external or internal factors of the professional environment.
8. The motivation, capability to development is a system of the internal and external factors causing and directing the behavior of an individual oriented to the achievement of the goal (Ovchinnikova, etc., 2011).

On the basis of opinions of expert reference set-theoretic models for the description of the content of knowledge, abilities and competences were made.

So, knowledge is described by attributes of the following train:

$$K_n = \{W, L^{kn}\}, \tag{1}$$

Where

- The width characterizing a scope of the available representations, i.e. declarative aspect.
- The level of proficiency representing a procedural aspect.

Abilities, are described by attributes of the following train:

$$S_k = \{C^{sk}, R, L^{sk}\}, \tag{2}$$

Where

- Informative filling of abilities;
- The role defining an activity rate of an individual;
- Level of complexity of the solved tasks.

Qualities of the personality, are described by attributes of the following train:

$$C_h = \{C^{Ch}, Kontext, L^{Ch}\} \tag{3}$$

- Informative feeling of quality of the personality;
- The context defines a frame (area) in which there is an updating of the considered quality;

-Level of manifestation of the considered quality of the personality.

The-level component of knowledge, abilities and qualities of the personality forms a set

$$L = \{L^{kn}, L^{sk}, L^{Ch}\} \quad (4)$$

which elements are defined by a cognitive component of taxonomy of Bloom<sup>1,2</sup>.

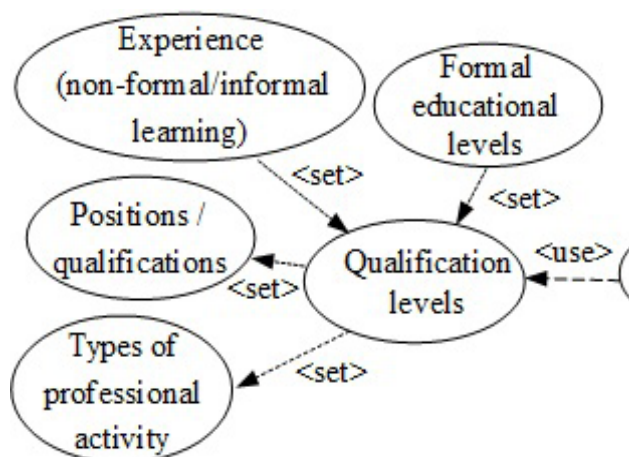
### 3.2 Formalization of Requirements to Results of Training

The developed model and its description were the basis for formalization of requirements to results of training, thus succession on selected qualification was potentially provided two levels.

The fragment of the received frame of qualifications is provided in (Table 2).

**Table 2.** Frame of qualifications of the Ural region (fragment)

Descriptors	4 level (corresponds to the graduate of a bachelor degree)	6 level (corresponds to the graduate of a magistracy)
Basic knowledge in different areas	Systematized facts promoting understanding of a complete scientific picture of the world	Knowledge of a scientific picture of the world at the level of their use of a solution of the delivered research problem
Professional knowledge	The generalized theoretical and practical knowledge, and also knowledge of the standard and help and leading documents, the administrative knowledge necessary for understanding of essence of the organization and an operating control of own educational professional activity and activity of collective	Scientific knowledge, knowledge of regulating and administrative documentation, methodical and normative materials, the managerial knowledge, necessary for understanding of entity of the organization and an operating control of own educational professional activity and activity of collective, necessary for an assessment and process optimization, implementation of innovations and management of work of subordinates in unpredictable situations of professional activity
Generalized abilities	Set of the abilities demanded for setting and a solution of complex challenges on the basis of independent search, selection and an assessment of information necessary for this purpose	Set of the abilities necessary for a solution of complex non-standard creative and organizational and managerial challenges on the basis of independent generalization, the analysis and synthesis of information
Autonomy	Consciously uses instructions and normative legal documents, is capable to organize the workplace, takes part in work of team	Organize the activity and/or work of group on a scientific basis, for a solution of complex non-standard challenges; independently executes scientific search in the field of professional activity under the scientific manual, performs a result assessment
Communicativeness	Uses oral and written language in a state language as means of business communication and representation of results of educational professional activity, has initial preparation for cross-cultural communication	States accurately and clearly the point of view on a research problem, takes part in public statements, has basic preparation for cross-cultural communication within professional activity
Responsibility	Responds for the activity determined by normative legal documents; is able to give the complete written report including analysis elements both on the work, and on work in group	Bears the responsibility determined by normative legal documents for the activity and activity of group; makes decisions in situations of high risk and complexity and bears for them the personal liability; it is capable to give the analytical report
Adaptivity	Performs professional activity in the conditions of updating of its contents	Guides in the conditions of change of the purposes and the content of professional and/or scientific activity, and also in the conditions of uncertainty
Motivation, capability to develop	Evaluates the role and makes an active contribution to organize activity, selects the perspective directions of personal and professional development taking into account own vision and requirements, is engaged in self-education	Realizes the role in collective and achievement of goals of the organization. Aims at professional recognition and creative self-realization



**Figure 2.** A fragment of ontology model of a frame of qualifications for the IT industry

### 3.3.A frame of Qualifications for the IT Industry

Within the “Adaptive Control by Quality of Professional Education on the basis of Competence-based Approach (on the example of the Sphere of IT)” project the task of development of a frame of qualifications for the IT industry was set. The ontology model of a frame of the qualifications of the Ural region was the basis for its development. As it was already noted, this model was easily adapted for a new task by addition to a conceptual “Qualification levels” through the relation <set> of concepts “Experience (Informal and extra formal training)”, “Types of professional activity”, “Position/qualifications” (Figure 2).

In the developed frame of qualifications for the IT industry succession of results of training is provided on

**Table 3.** Requirements of an industrial frame of qualifications to results of training 4 qualification levels

Descriptors	Practice - focused orientation	Research orientation
Basic knowledge in various areas	Just as in a frame of qualifications of the Ural region (Table 5)	Systematized facts promoting understanding and understanding of a complete scientific picture of the world
Professional knowledge	Knowledge within the executed activity, and also knowledge of normative and help and regulating documents, the knowledge necessary for understanding of the entity of the organization and an operating control of ownership and collective professional activity	Generalized theoretical and practical knowledge, and also the knowledge of normative and help and regulating documents necessary for the organization and an operating control of own research activity and activity of collective
Generalized abilities	Set of abilities, within professional activity demanded for statement and the solution of complex challenges on the basis of independent search, selection and an assessment of information necessary for this purpose	Set of abilities demanded for setting and the solution of complex challenges demanded for setting and a solution of complex challenges on the basis of independent search, selection and an assessment of information necessary for this purpose on the basis of methods of independent search, selection, systematization, information analysis, confirmation of the reliability of the received results
Autonomy	Consciously uses instructions and normative legal documents, is capable to organize the workplace, takes part in work of the team, can organize	Performs the research work under the direction of which is combined with independence in a choice of methods and methods of carrying out research
Communicativeness	Ready to submit the report on results of professional activity, can execute a role of the mentor	Meet to present results of research activity in an oral and written form
Responsibility	Just as in a frame of qualifications of the Ural region (Table. 5)	Just as in a frame of qualifications of the Ural region (Table. 5)
Adaptivity	Performs professional activity in the conditions of change in the IT environment	Performs research activity in the conditions of development of the IT environment
Motivation, ability to development	Evaluates the role and makes an active contribution to organization activity from positions to organization development from positions of production requirements and an optimality of performance of works, selects the directions of personal and professional development oriented to increase of level of professional qualification, is engaged in self-education	Evaluate the role and makes an active contribution to activity of development of innovations in the IT environment, selects the directions of personal and professional development oriented to increase of research level of the activity and enhancement of intellectual property of the organization, is engaged in self-education

**Table 4.** Requirements of an industrial frame of qualifications to system of training

The orientation of the identity	Ways of achievement of qualification of an appropriate level	Main recommended work types
Professional oriented	<i>Formal training:</i> according to programs of higher education on the basis of the mastered program not below the secondary (complete) general education	Operational Mounting and setup Service and operational Production Technology
Scientific	<i>Informal Training:</i> professional retraining and professional development based on not below secondary professional education <i>Extra formal training:</i> training in a workplace, corporate training based on secondary professional education	Experimental and research Design Scientific and pedagogical Research Analytical Innovation and entrepreneurial

the basis of-level approach. The description of the results of training and requirements to system of training for different qualification levels is executed taking into account a possible orientation of training according to the interests of the personality. For example, at the fourth qualification level are selected practice - focused and research orientation (the example is provided in Tables 3,4); at the fifth qualification level - practice - focused, management and research; at the sixth qualification level - managerial and research.

The received requirements to results of training formed the basis of development of a subsystem of monitoring of system of adaptive control of quality of professional education regarding as fulfillment of requirements of qualification levels by the personality, and for an assessment of perspectives of further training and career growth of graduates of educational institutions and experts specialists that is reflected in works<sup>3,9,10,12,14,15</sup>.

## 4. Conclusion

The provided research is oriented to using of both its results, and methodical experience of their obtaining in the projects devoted to the development of system of qualification, and also development of requirements

to results of training during implementation of the international educational projects.

The implemented ontology model can form a basis for the design of the knowledge base which is an integral part of system of adaptive control of quality of professional education and process of vocational training on the basis of the harmonized requirements of employers and educational community to results of training in the form of a frame of qualifications.

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