

Handbook of Research on

Estimation and Control Techniques in E-Learning Systems



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Chapter 8

The Analysis of Degree of Formation of Competences on the Basis of Model of the Expert and Cluster Approach

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ABSTRACT

New approach to integrated estimation of graduates is considered in this chapter. Control of knowledge of the graduate of institute is important part in the course of training and the more so, for E-Learning systems. It provides feedback between training and the trainee in traditional form of education and between the trainee and system of training in E-Learning. The expert's model described in terms of competences and the being base of this approach, allows to estimate the university graduate integrally. Besides, the model of the expert is considered as the tool for realization of feedback. Numerical estimation of degree of formation of competences was carried out within the developed indicator method. The concrete results of the researches conducted by authors illustrating the offered approach are given in the head. As logical development of this integrated approach possibility of inclusion of concepts of Meta concreteness in estimated base is considered.

INTRODUCTION

The system of technical and natural-science education based on formation of knowledge, skills is directed by all techniques of training and way of estimation on training of the graduates possessing defined a set of knowledge, skills. The binding to concrete specialty is carried out, mainly, by selection of a certain set of the studied disciplines. This approach had a number of undoubted advantages, and in economy of

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the Soviet Union such form was sufficient and quite effective, considering mainly distributive system of graduates and rather preferential conditions for their adaptation on a new workplace. In modern Russia employers need people the most suitable for work on this specialty. Existence only of knowledge at the graduate doesn't serve in the real conditions for the employer as a guarantee of his effective work anymore.

The employer sees on each place there is nobody the ideal expert possessing the necessary set of qualities. In this plan transition to estimation of the graduate by means of competences means recognition of the specialist person by the many-sided personality, recognition of need to form this versatility. To form is means, in particular, and to be able to estimate result of training and education. In this plan transition to system of estimation by means of competences is represented a natural and logical step. And it is besides natural that this new step led to emergence of a set of problems. For example, how to determine the level of formation of competences that it is necessary to do to improve quality of this or that competence and whether it is possible to make it, remaining within state standard in pedagogical higher education institution. The feedback mechanism by means of which it is possible to trace formation of competences is necessary for the solution of these problems that, in turn, gives the chance to analyze quality of the curriculum, standard and teaching level.

The joint analysis of formation of a large amount of competences demands use of the methods of multidimensional statistics with ambiguous subsequent interpretation. For reduction of this ambiguity, realization of feedback and for creation of a clear picture of result of work of higher education institution it is offered to use the specialist graduate's model in the field of education. Existence of such model which is some combination of levels of competences will allow carrying the graduate to a certain type of the expert and by that to realize a feedback mechanism.

BACKGROUND

The model of the expert is a description of to what has to and the expert for what performance of functions he is trained can be suitable and what qualities possesses. Models allow to distinguish one expert from another, and also levels (qualities) of training of specialists of the same type. The model acts as a backbone factor for selection of the content of education and forms of its realization in educational process.

The problem of modeling of professional activity in connection with development of the content of training was considered by a number of authors (Tatur, 2004).

The analysis of the maintenance of the competences formulated by the Federal State Educational Standard of Higher education (The Common Cultural Competences (CCC), All-professional (OPC), in the field of pedagogical activity (personal computer), in the field of the cultural and educational activity (CEA)), allowed to distribute them on four essential blocks, agrees (Shadrikov, 2010):

B1: Analytical and conceptual thinking.

B2: Social communicativeness.

B3: Self-improvement.

B4: Professionalism.

Distribution of competences on the blocks stated above is presented in Table 1. We will note that in the considered splitting the same competence can enter at the same time some blocks.

Table 1. Distribution of competences on blocks

Blocks of Competences	Competences
B1: Analytical and conceptual thinking	CCC: 1,2,4,6,8,10,13
	OPC: 18,21, 22
	CEA: 32,33
B2: Social communicativeness	CCC: 2,3,7,11,12,14,15
	OPC: 17,19
	PC: 25,27,28
	CEA: 30,31
B3: Self-improvement	CCC: 5,16
	OPC:17,19
	PC:27,28
	CEA:30,32
B4: Professionalism	CCC:4,5,8,9,10,11,12,16
	OPC:17,19,20,22
	PC:23,24,25,26,27,29
	CEA: 30,33

MAIN FOCUS OF THE CHAPTER

Issues, Controversies, Problems

Model

At creation of model of the expert the adapted indicator method of estimation of competences (Kataev, 2009) was used. Main idea of this method: level of formation of competences is shown via some indicators. Defining by means of testing of value of indicators, it is possible to calculate the size of each competence and then average values of competences on each allocated block. Indicators are the questions formulated so that they gave a contribution (were shown) in different competences. For example, by drawing up questions of the questionnaire for procedure of self-testing we used as a basis the MMPI test. m of versions of the answer to a question was provided, i.e., possible values of the indicator varied from 0 to $m-1$. So, for $m=4$: 0 - *no, I don't know I (am not able)*; 1 - *yes, I know I (am able), but it is insufficiently good*; 2 - *yes, I know I (am able) well*, 3 - *yes, I know I (am able) very well*. We depending on the purpose used options with $m=3$ or $m=4$. Each competence was presented in the vector form which coordinates are indications of indicators.

$$\vec{C}_i = \sum_{j=1}^{n_i} a_{ij} I_j \vec{e}_j, \quad i = 1, \dots, k, \quad |\vec{e}_j| = 1.$$

The Analysis of Degree of Formation of Competences on the Basis of Model

Where k – amount of competences, n – number of the used indicators, and a_{ij} – the weight with which the indicator with number j enters competence at number i . Thus it was allowed that the same indicator could enter various competences. Decomposition of competences on indicators was carried out by method of an expert assessment and one of options of such decomposition is given in (Kataev, 2009). The module of a vector C_i acts as the numerical characteristic of competence. To form a universal and convenient scale of measurement of competences it is necessary to normalize weight. It is possible to normalize on any number as it is convenient.

We use a 10-ball scale, i.e. the maximum value of each competence is equal 10. In this case on condition of equality of weights of the indicators entering competence number i $a_{ij} = \tilde{a}_i, j = 1, \dots, n_i$ a formula for calculation of competence will be:

$$C_i = \tilde{a}_i \sqrt{\sum_{j=1}^{n_i} I_j^2}, \quad i = 1, \dots, k,$$

For the chosen scale ($(\max(C_i) = 10, i = 1, \dots, k)$) weights are given by: $\tilde{a}_i = \frac{5}{\sqrt{n_i}}$. It is clear, that

this scale is discrete and nonlinear.

The amount of possible values of competence is defined by number of the indicators entering it. So, at such values only six, at $n_i = 5$ - ten, etc. Thus it is clear that at an assessment of competences it is reasonable to use not less than 3 competences

Each option of a combination of averages on the block of values of competences (“a competence-based portrait”), reflecting a certain ratio between degrees of formation of different competences, characterizes both professional standard of the graduate, and his tendency to performance of work of a certain type.

Having broken all competences on four described above the block, we receive four-block model which includes 24 possible qualitative variants differing from each other in the certain parity of the values of *competences average on the block* (CAB).

$$k_1 \geq k_2 \geq k_3 \geq k_4, k_1 \geq k_3 \geq k_2 \geq k_4, k_1 \geq k_2 \geq k_4 \geq k_3, \dots$$

Psychological researches give the chance to connect tendency to a certain kind of activity with each option.

The works of Klimov (1992) and (2010) showed “Block portraits” are made on the basis of types of professions on classification, who in the work depending on an object of the labor subdivides all professions into 5 types:

- Person nature type;
- Person technician type;
- Person type;
- “Person-sign systems” type;
- “Person-a artistic image” type.

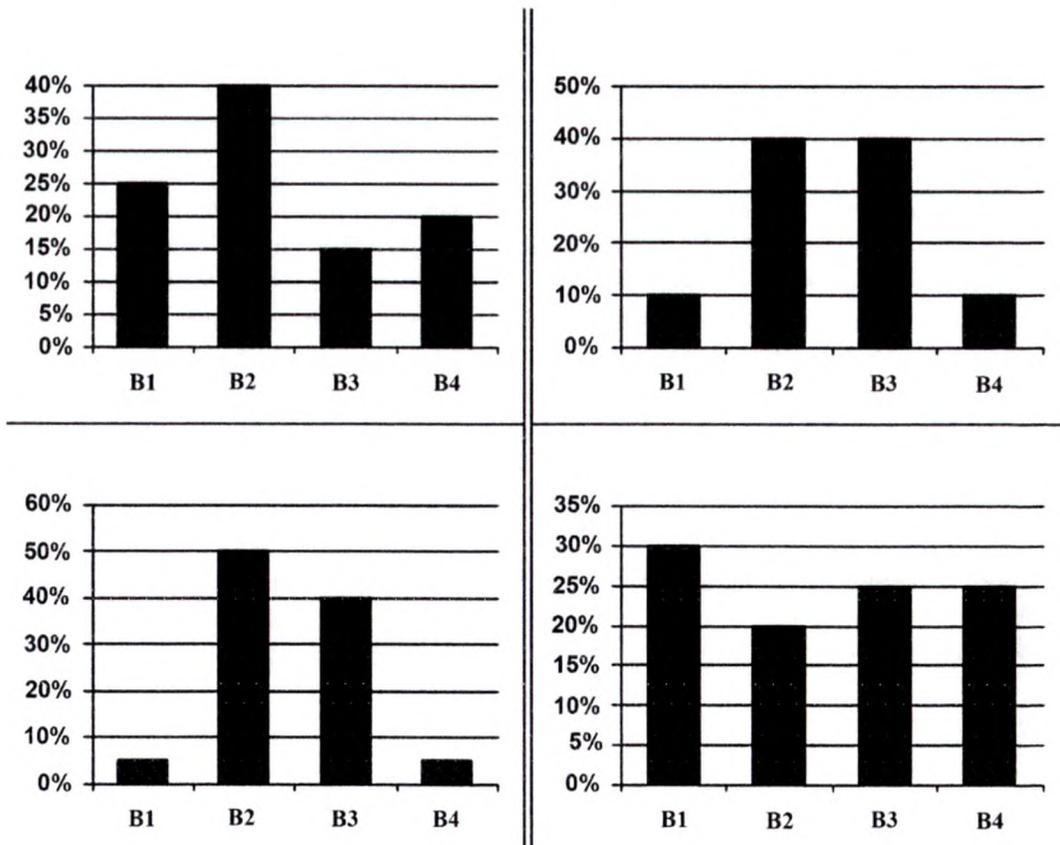
As an example, 4 options of “competence-based portraits” on the basis of data, which can conditionally be connected with the following kinds of activity, are given in Figure 1: teaching, business, public service and services industry.

Thus, within the stated approach it is possible to deliver to each graduate in compliance that profession which it approaches in the best way, realizing about convention of similar procedure when it is about the certain individual. And giving the chance to gain an impression about all collective in general procedure of preliminary classification of students for block competences is more informative. In work for this purpose the method of revealing of structures (Kataev, 2012) belonging to methods of the cluster analysis which allows to break all set of the studied objects (students) into a small number of classes was used, using as criterion of reference of objects in one class, proximity of average values of block competences.

Solutions and Recommendations

Objects of our research were pupils of schools of the city of Tomsk and students of TGPU. The age of the investigated made 15-25 years. Ratios between average values of competences for pupils of the 7th and

Figure 1. Ratio between block competences for four kinds of activity



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9th classes of the Eureka of Development school are given as the first example in Figure 2. Comparing behavior of competences for different age, it is possible to draw the following qualitative conclusions.

1. With age communicative competence doesn't change;
2. Develops (and it is realized by school students) ability to analytical thinking;
3. Self-assessment level decreases;
4. Growth of own knowledge is realized.

It, of course, very general conclusions concerning only age changes. Use of the cluster analysis allows receiving more detailed information.

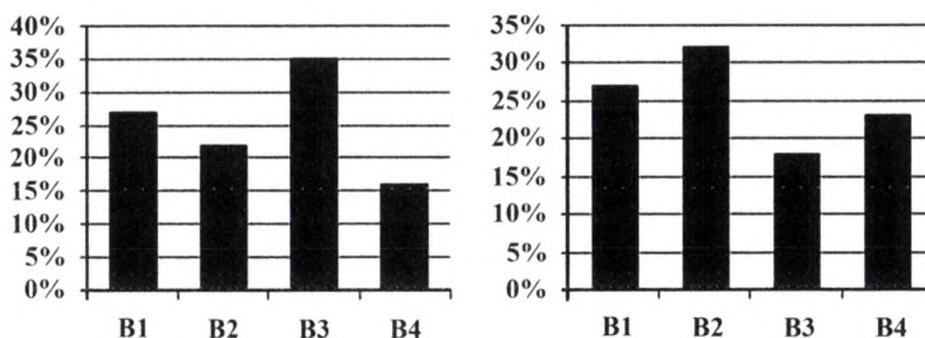
Results of application of the stated approach for one of groups of economics department of TGPU, are only 25 people. For calculation of competences the system of indicators intended for a self-assessment of students, and which are the questionnaire containing 35 questions was chosen. On each question four versions of the answer ordered on preference were provided (0, 1, 2, and 3). After processing of results of questioning the array (CAB) in whom as a result of classification of these data 4 classes were revealed was received. Results of processing are presented in Table 2 and in Figure 3, and they well illustrate usefulness and informational content of procedure of classification.

Actually, if to be guided by average values of block competences for all collective (the last line in Table 2), it is possible to draw a conclusion that in this group all competences are developed approximately equally. Actually it is fair only for one even if the most numerous, fourth class, and about 30% of all groups possess other competence-based portraits.

Similar research was conducted and for school students of the senior classes of 13 gymnasiums of Tomsk, only 56 people. Results of processing are presented in Tables 3 and in Figure 4 respectively. It agrees (Vinnichenko (2010), in the studied group the following professions prevailed: actor, tutor, social worker, architect, psychologist, tailor, engineer, accountant and hairdresser. We will emphasize once again convention of reference of this or that portrait to a certain profession.

Results of work allow to draw a conclusion that this approach can be especially useful at its regular application at different grade levels as it gives the chance to track dynamics of development of competences, both the certain pupil, and all collective.

Figure 2. Ratios between CAB for pupils of the 7th class (at the left) and the 9th class (on the right) the Eureka of Development schools of Tomsk

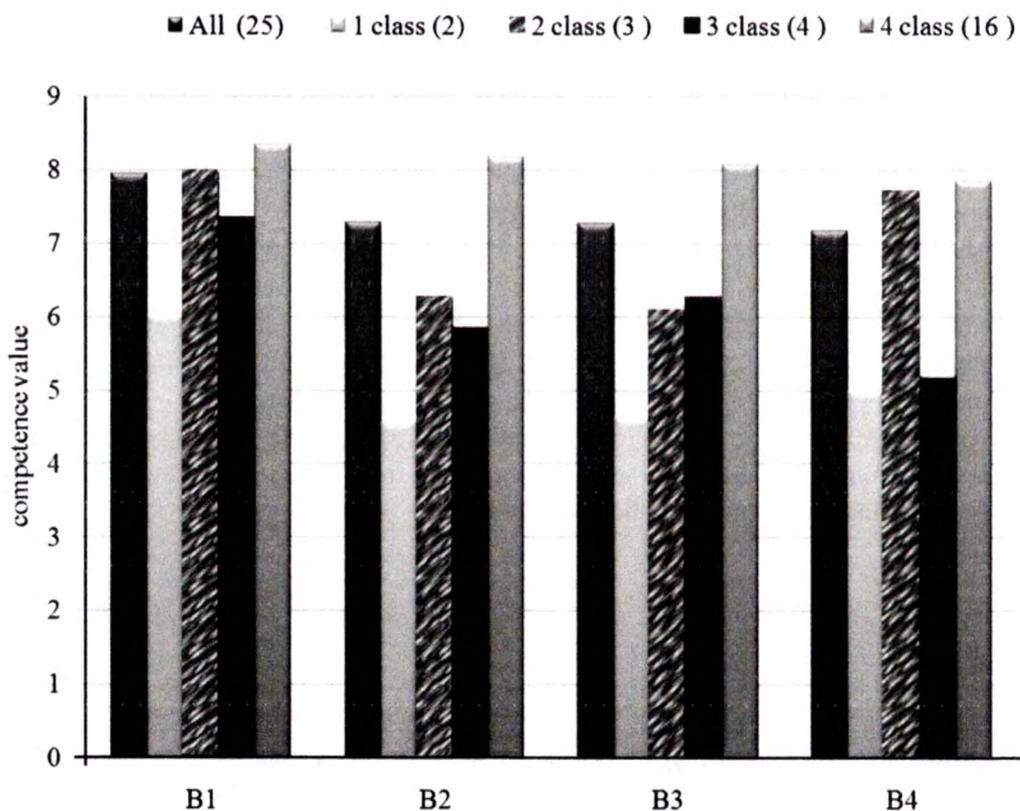


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Table 2. Result of splitting into classes of group of students of economics department (4th course TGPU) and class average values of block competences. Average values for all groups of students are given in the last line

Class	Amount of objects	B1	B2	B3	B4
1	2	6,02	4,59	4,64	5,00
2	3	7,97	6,25	6,07	7,70
3	4	7,34	5,83	6,25	5,16
4	16	8,34	8,18	8,08	7,85
All	25	7,95	7,28	7,27	7,17

Figure 3. Visualization of Competence-based Portraits presented in the tab. of 2 groups possess other competence-based portraits



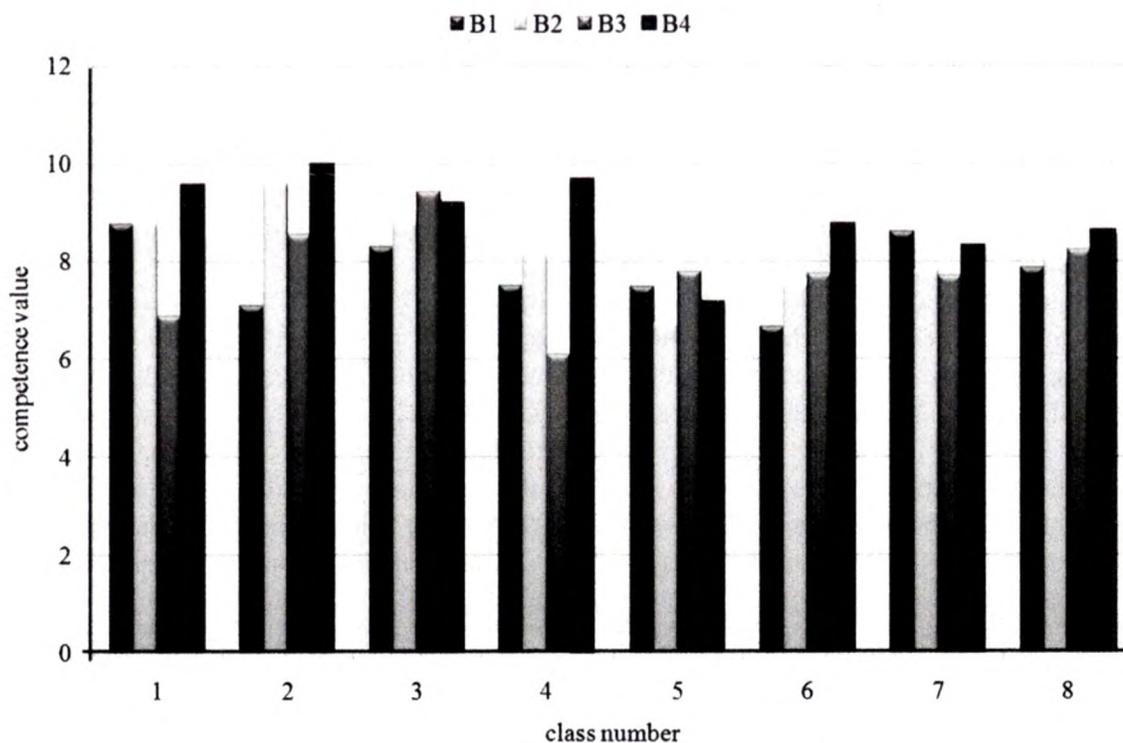
It is obvious that the offered approach needs completion and further development as unresolved is number of problems. For example, it is supposed that competences have to be estimated by the teacher, i.e. separately in subjects though on the idea put in them they reflect joint action of many subjects and teachers. Partially this problem is solved in self-testing procedure, but in it there is a big subjective component. All this is especially actual for distant education when control is exercised in absentia and complexity to estimate the pupil without personal contact.

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Table 3. Result of splitting into classes of group of pupils of 10th and 11th classes the 13 gymnasium of Tomsk and class average values of block competences. Average values for all groups of students are given in the last line.

Class	Amount of objects	B1	B2	B3	B4
1	3	8.75	8.75	6.88	9.58
2	3	7.08	9.58	8.54	10.0
3	20	8.29	8.78	9.41	9.19
4	4	7.50	8.12	6.09	9.69
5	15	7.47	6.71	7.79	7.16
6	5	6.66	7.50	7.748	8.75
7	6	8.61	7.81	7.70	8.33
Bce	56	7.86	8.00	8.23	8.62

Figure 4. Visualization of competence-based portraits presented in the table of 3 groups possesses other competence-based portraits



Therefore authors see that there is a need to develop stated above idea. And one of options is based on operation of integrated nature of competences. This property does possible estimations of competences with use of concepts of met knowledge and met concreteness.

FUTURE RESEARCH DIRECTIONS

Metaitem and Competition Approach

As it was already noted in Russia now the new Federal State Educational Standards (FSES) developed both for average and for the higher school are entered. They are based on competence-based approach. At the same time, new programs pay special attention to introduction of meta subject approach in educational process, on formation at pupils of met subject results. Now formation of met abilities becomes the central problem of any training (Fisenko, 2012). In this regard, the questions connected with studying of various aspects of the called approaches are actual.

Most of scientists and teachers recognize that met subject and competence-based approaches are connected among themselves and are modern effective approaches in education. But neither the contents, nor formal definition of these approaches aren't finalized today. Some authors even speak about "met subject competence" with what we don't agree since it is volume and self-sufficient concepts and to reduce one to another or to express one through another it isn't possible. We won't define competence and competences of this paragraph, i.e. much attention in various works is paid to this question, however we will dwell upon concept of metaconcreteness since this question is discussed rather recently in relation to competences and is more difficult for understanding and introduction in educational process. The terms "metasubject", "metaconcreteness" in modern education are declared as reference points of new educational standards. However various schools of sciences treat these concepts differently. Two main schools of sciences developing approaches to metasubject training are allocated are Yu.V. Gromyko's and A.V. Hutorsky's groups.

So at Yu.V Gromyko the met subject contents is understood as the activity which isn't relating to a concrete subject, and, on the contrary, providing process of training within integration of subjects (Skripkina, 2011; Gromyko, 2007).

Now group of scientists under the leadership of Gromyko N. V. consider that the purpose of development of met subject approach in education and, respectively, met subject educational technologies in solving a problem of dissociation, isolations from each other of different scientific disciplines and, as a result, subjects. Met subjects are subjects other than subjects of a traditional cycle, it is a new educational form which is built over traditional subjects, the type of integration of a training material thus is its cornerstone conditions are created in order that the pupil started realizing own process of work: what exactly it mentally did as moved, to what results came. The training material of the met subjects "Knowledge", "Sign", "Problem", "Task" (Gromyko, 2009) developed by group under the leadership of Yu. Gromyko, "over subject" also has universal character.

For example, when studying the met subject "Sign" at school students ability of a schematization is formed. They learn to express by means of schemes that understand, that want to tell, that try to comprehend, that want to make. It is work further allows pupils to use more consciously those graphics which they learn within traditional subjects. Within other met subject — "Knowledge" — is formed ability to work with concepts, with systems of knowledge, ability to build idealization. Certain technicians allow pupils to allocate a zone of "ignorance". It allows operating process of knowledge. Studying a structure of key scientific concepts, reproducing them in own thinking, pupils master universal technicians of work with concept on any subject material.

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Studying the met subject “Problem”, school students learn to discuss questions which have character opened, still of unresolved problems. On the met subject “Problem” pupils learn to allocate problems and to work with them, they develop abilities of a problem, a goal-setting, self-determination, etc.

On the met subject “Task” pupils receive knowledge of different types of tasks and ways of their decision. When studying the met subject “Task” at school students abilities of understanding and a schematization of conditions are formed, they get acquainted with process of modeling of object of a task, designing of ways of the decision, with development the technician of the transfer of problems to tasks etc. Authors of this development consider that studying these met subjects the child develops such abilities as understanding, imagination, thinking, a reflection, action.

A bit different approach to the solution of this problem at Krayevsky & Khutorskoy (2008) discuss the school of sciences realizes met subject educational activity, including the met subject contents in subjects more than two decades. Khutorskoy (2008) is characterizes met concreteness as “an exit for subjects, but not leaving from them. The met subject is that behind a subject or several subjects, is on a basis and at the same time in root communication with them. Met concreteness can’t be torn off from concreteness” (Khutorskoy, 2012). According to Khutorsky’s position, met concreteness is an integral part of any educational environment. But still separate concrete met subjects are legislatively not entered into educational process, and their introduction presents a number of difficulties, it is already possible to apply now at concrete lessons the elements of met subject approach developed by A.V. Khutorsky.

Met subject methods are a special type of cognitive methods of training which represent the metaways corresponding to the met content of heuristic education:

1. Method of semantic vision;
2. “Adaptations” method;
3. Method of image vision;
4. Method of graphic associations;
5. The method of phonetic associations combined;
6. Method of symbolical vision;
7. Method of hypotheses (working, real);
8. Method of supervision;
9. Method of comparisons;
10. Method of heuristic conversations;
11. Method of mistakes;
12. Regression method.

Met subject technologies are pedagogical modes of work with thinking, communication, action, understanding and a reflection of pupils. The met subject technologies included in subject teaching will transform subjects and pedagogical style. Use them in teaching traditional subjects gives the chance to show to pupils processes of formation of scientific and practical knowledge, to reorganize training courses, including in them modern questions, tasks and problems, significant for youth.

Studying on concrete material (physics, chemistry, history, etc.) certain subject concepts, with use of met subject methods, the pupil starts realizing not only certain concepts, and a way of the work with this concept on different subject material. Conditions are created in order that the pupil started comprehending own process of work. As a result pupils understand that, despite different subject materials, identical actions were done.

The met subject technologies included in subject teaching will transform subjects and pedagogical style. Use of met subject technologies in teaching traditional subjects allows to show to pupils processes of formation of scientific and practical knowledge, to reorganize training courses, including in them modern questions, tasks and problems, significant for youth (Khutorskoy, 2012).

There is an opinion (Puryшева, 2012) that formation of met subject results can be reduced to formation of the universal educational actions (UEA) of pupils. At such approach estimation of results of educational achievements becomes simpler since UEA can be formulated more definitely.

Both met subject results and various competences are formed not in the course of studying of one subject, and a number of various subjects. However each subject forms both met subject knowledge, and competences with a certain weight coefficient. And this aspect and some other define a number of difficulties in the organization of diagnostics of achievements of results of training.

Process of estimation of formation of competences can be connected with estimation of met subject results since met concreteness is formed on the basis of available at trained certain competences. In this article process and methods of formation of met subject results isn't considered, and the emphasis is placed on estimation of achievements of pupils.

Estimation of formation of competences as it was noted, a difficult question and significantly differs from traditional methods of estimation of achievements of educational results (Skripko & Barmashov, 2011). Probably, therefore various approaches are offered, but all of them have a number of visible shortcomings. Estimation of met subject results started being investigated a little later therefore also it is less than approaches in this direction. However all of them are also insufficiently developed.

Various forms of diagnostics of formation of met subject results at trained are offered and investigated. A number of teachers and scientists consider that besides habitual subject examinations it is necessary to carry out the met subject diagnostic works made of the competence-based tasks demanding from the pupil not only informative, but also regulatory and communicative actions. Diagnostics of met subject results offered by the program "School 2100" is pedagogical. Any teacher can use it (unlike psychology and pedagogical diagnostics which is carried out by the school psychologist). Also for estimation of met subject results the estimated sheets of met subject knowledge a little different according to the contents at different researchers, a method of an accumulative assessment, complex tasks on an inter subject basis, etc. are used. So, in work Lukinykh (2014) results of diagnostics which allow to make the conclusion about structure and quality of formation of met subject abilities of the students who are important for successful training in higher education institution are presented. It is possible to consider some more approaches offered for definition of formation of met subject results. However all of them have certain shortcomings and defects.

As the teachers developing competence-based approach consider, as the main object of an assessment of met subject results the formation at trained regulatory, communicative and informative universal actions, i.e. such intellectual actions which are trained which are directed on the analysis and management of the cognitive activity serves. Therefore estimation of met subject results needs to be connected with definition of formation at pupils of certain competences. If to correlate the content of the metasubject results presented in work (Chuprova & Shumovskaya, 2012) with the competences given in FGOS, it is possible to see that many of them on sense in many respects coincide. We will provide some of them in Table 4.

It is possible to give some more the similar examples showing similarity of formulations or meanings of the met subject results and competences formed at students.

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Table 4. Metasubject results and competences which students in the Pedagogical education direction have to possess

Metasubject Results	Competences
Mastering skills of independent acquisition of new knowledge, the organizations of educational activity, statement is more whole, planning, self-checking and an assessment of results of the activity, abilities to expect possible results of the actions;	Ability independently to get by means of information technologies and to use in practical activities new knowledge and abilities, including, in the new fields of knowledge which are directly not connected with a field of activity (OC-5);
Acquisition of experience of independent search, the analysis and selection of information with use of various sources and new information technologies for the solution of informative and cultural tasks;	Readiness for use of modern information and communication technologies and mass media for the solution of cultural and educational tasks (PC-20);
Formation of abilities to work in group with performance of various social roles, to represent and defend the views and belief, to conduct discussion".	Readiness for interaction with colleagues, to work in collective (OC-7); Readiness for interaction with pupils, parents, colleagues, social partners (PC-6);

CONCLUSION

Analyzing the presented material, it is possible to tell that the stated ideas demand further development and specification. By results of work it is possible to draw the following conclusions:

1. In the E-Learning system when control is exercised in absentia, there are certain difficulties of estimation of pupils without personal contact.
2. At estimation of block competences and creation of a competence-based portrait of the expert, it is necessary to consider their integrated character that does possible inclusion of concepts of met concreteness in estimated base.
3. There is a wish to emphasize that in this work the idea of approach is stated. Stages of approach aren't attached to a method of estimation of competences, splitting competences into blocks, and also creation of block portraits.

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KEY TERMS AND DEFINITIONS

Competence-Based Portrait: Estimations of competences.

Indicator Method of Estimation of Competences: Indicator method of estimation of competences.

Meta Concreteness: Special subject of research in pedagogy.

Meta Subject: Special subject of research in pedagogy.

Specialist Graduate's Model: Model of the expert the adapted.