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DESCRIPTIVE AND MULTIDIMENSIONAL INDICATORS FOR ORDERING EDUCATIONAL OFFERS[1]

Abstract. A classification of educational offers provided by 9 universities from Romania, by scores computed according to answers given by graduates is proposed. The questions investigate the adaptation to the workplace, the professional satisfaction, the quality and utility of acquired knowledge. Genuine statistical uni- and multidimensional techniques to process qualitative variables are used.

Keywords: educational process, score, educational offer, qualitative ordinal variable processing.

JEL classification: I 21, I 23, C 44.

1. INTRODUCTION

In our previous approaches [3], [4] we thought about the higher educational process (the educational offer) as an *input-output* production process where the *inputs* (i.e. students, academic staff, administrative staff, material and financial resources) are turned into *outputs* – short term performances of the students quantified as grades, ratings, results in contests, research activity gauged by research contracts and grants, etc. - as well as long term results. These long term outputs refer especially to the competencies acquired during the study and to their usefulness related to labor market demands. In this context of gauging its activity, we cannot talk about the *performance* of an educational institution, but about its rank, or the position it has when its activity (translated into inputs-outputs) is analyzed together with other similar institutions. Therefore, by analyzing the offers of several educational institutions we should be able to find ways of giving scores –

or grades – that would express the overall opinion on their activity. Once the inputs and the outputs are defined for the list of analyzed institutions, different techniques to measure the effectiveness of their activity can be used, such as non-parametric enveloping techniques (DEA) or econometric techniques [1]. One approach to the issue of giving scores to the educational activity, frequently used over the last years, is the one based on the "students'/graduates' opinions/appreciations", which are expressed by them in specially designed questionnaires in order to obtain information for this particular purpose. It is well known that qualitative variables are usually attached to most questions in a questionnaire. Consequently it is necessary to use techniques that are specific for processing qualitative variables, and, moreover, we must use modalities that are specific to the problem in order to build "synthetic indicators" which would offer an overall activity appreciation for each educational institution. Some of these issues will be dealt with next.

2. DESCRIPTIVE AND MULTIDIMENSIONAL INDICATORS OF THE DISTRIBUTION OF ANSWERS ACCORDING TO MODALITIES

First we shall mention several concepts and notations that are used in the paper. Let us suppose that in the analysis we have J educational institutions to which we want to give scores according to their activity (either to overall activity, or just for one academic year). For this purpose we use a questionnaire where Q is the number of considered questions. As we usually associate a qualitative variable to each question, we will have to process – individually or overall – Q qualitative variables. Each educational institution j uses its own sample of students, so denote by N_j the latter's volume ($j = 1, 2, ..., J$). We can also take into consideration the entire sample, made up by all the j samples put together; obviously its volume is $N = \sum N_j$.

A scheme that presents the initial information offered by the answers in the questionnaire is presented in Table 1. It is to be seen that we can make both simple processing presented in the (U_j, Q_q) cells of the table, by which we analyze in turn what answers were obtained in an educational institution (unit) to a particular question, and we can also obtain multidimensional results. The latter may refer either to the processing of the answers of a single unit U_j to all the questions, results that are marked U_j(Q_1,…,Q_Q), or to the way in which an individual Q_q question was answered, the results being marked by Q_q(U_1,…,U_J).

In the end we will be able to appreciate how relevant each question is within the entire analysis, so that we can later calculate scores for each analyzed unit, by applying a synthetic indicator.

Next we will approach in turn the possible analyses presented above.

Table 1: Possible one-dimensional and multidimensional analyses

Unit	Question				Analysis result	Volume
	Q_1	…	Q_q	…		
U_1	Median, dispersion, frequencies		Median, dispersion, frequencies		Score U_1(Q_1,...,Q_Q)	N_1
…					…	…
U_j	Median, dispersion, frequencies		Median, dispersion, frequencies		Score U_j(Q_1,...,Q_Q)	N_j
…					…	…
Analysis result	Q_1(U_1,...) D_B, δ	…	Q_q(U_1,...) D_B, δ	…	D (*total variance*)	N

2.1. Decomposition of the total variance of the answers and an indicator for the relevance of the question

Let us suppose first that we want to analyze the answers for one ordinal qualitative variable *Y* that has *K* modalities (categories of answers). Having the absolute frequencies for modalities we can easily calculate the cumulated frequencies; let F_k, $k = 1,2,...,K$ be the values of the cumulated distribution function obtained in this way. A first indicator to describe the distribution of answers for the variable is the **median** (Me). This is a centering indicator, indicating the "smallest" modality for which the cumulated frequency is at least 50%.

An important indicator of the spread of the answers is the **dispersion.** In statistic literature it is recommended to use the following formula to calculate dispersion:

$$D = \sum_{k=1}^{K-1} F_k\left(1 - F_k\right) \tag{1.1}$$

whose values are positive and less than $\dfrac{K-1}{4}$.

Let us suppose that the same ordinal variable *Y* is watched on the *J* independent samples. Using formula (1.1) we obtain, for each sample *j*, the median $(Me)_j$ and dispersion D_j. We can also take into consideration the entire sample made up by putting together all the *J* samples. In this context, we can talk about a global dispersion *D* calculated for the entire sample. We are interested in decomposing this global dispersion, emphasizing its two components, more precisely the dispersion between the samples – denoted by D_B, and respectively the global dispersion from within the samples – denoted by D_W.

In order to calculate the component "between the samples" we use the formula:

$$D_{\mathrm{B}} = \sum_{j=1}^{J} \pi_j Z_{2j}^2 \qquad (1.2)$$

where $\pi_j = \dfrac{N_j}{N}$ is the proportion of the sample j in the global sample, and $Z_{2j}^2 = \sum_{k=1}^{K-1} \left(F_{jk} - \overline{F}_k \right)^2$ is the quadratic index of spread for the whole sample. (This quadratic index expresses the deviation of the cumulated frequencies from the average profile $\overline{F}_k = \sum_{j=1}^{J} \pi_j F_{jk}$ of the modalities.)

As for the "within samples dispersion" D_{W}, it is calculated using the formula

$$D_{\mathrm{W}} = \sum_{j=1}^{J} \pi_j D_j \qquad (1.3)$$

and a quick calculus leads to the conclusion that $D = D_{\mathrm{B}} + D_{\mathrm{W}}$.

In statistics it is well known that the larger the dispersion D_{B} is in the total D, the more statistically relevant is the grouping of the values of variable Y in distinct classes. For this reason we can introduce an indicator of statistic relevance for the question, denote it by δ, as being the ratio $\dfrac{D_{\mathrm{B}}}{D}$. As δ takes values within the interval [0, 1], the closer its value is to 1, the larger the statistic relevance of that question is.

2.2. A multidimensional scoring indicator for the faculty

We can use different formulas to obtain indicators (scores) associated to a faculty (unit) j. If Q is the number of analyzed questions from the questionnaire, such an indicator could be a linear combination of the following type:

$$I_j^{\mathrm{SG}} = \sum_{q=1}^{Q} I_{qj} w_q \bigg/ \sum_{q=1}^{Q} w_q , \qquad (1.4)$$

where I_{qj} is the indicator associated to the question q and w_q is the weight associated to it. In the analysis that will be done I_{qj} is the location indicator – the median – $(Me)_{q,j}$ and the weight is $w_q = D_{\mathrm{B},q}$ Formula (1.4) can be obviously applied to all the analyzed questions from the questionnaire; but it is more interesting if the calculus takes into account only the questions that are relevant from a statistical point of view. In [2] there are other proposals to calculate the indicator I_{qj}.

3.   THE QUESTIONNAIRE AND THE QUESTIONS

In order to analyze the activity of the nine universities in our consortium we designed a questionnaire that was distributed to samples within universities. The target population was made up of graduates with at least on year of working experience. The questionnaire had the following main objectives:

Objective 1: *The analysis of the efficiency of academic studies from the point of view of a graduate, with the following sub-objectives: a) Assessment of the importance, from the graduate's point of view, of academic studies and the matching between the obtained specialty and his/hers abilities; b) The analysis of the knowledge got in the faculty and of the degree of its use at the workplace (on different types of knowledge); c) The degree of workplace adapting and professional satisfaction.*

Objective 2: *The relationship between graduates and the labor market, with the following sub-objectives: a) Did they have a workplace when they were students? b) Is there continuity in their activity, and how many jobs do they had? c) How did they get a workplace?*

The universities involved in this study offer specialization in different domains such as economics, technical, pedagogical and medical. They all belong to the project consortium, namely: 1) Bucharest University of Economics (ASE); 2) University of Bucharest (UB); 3) 'Carol Davila' University of Medicine and Pharmacy Bucharest (UMF); 4) 'Gheorghe Asachi' Technical University Iaşi (UTI); 5) 'Alexandru Ioan Cuza' University Iaşi (UAIC); 6) 'Babeş-Bolyai' University Cluj-Napoca (UBB); 7) 'Lucian Blaga' University Sibiu (ULB); 8) West University Timişoara (UVT); 9) 'Ovidius' University Constanţa (UOC).

There were initially 21 questions, but we kept for analysis only 12 of them. These were grouped into two categories. The purpose of the first group of questions was to describe the profile of the respondent in relation to specialization choice, according to his/hers vocational qualities, concordance between education and both workplace adapting and job satisfaction. They are:

Q_2: Do you think that the courses you attended correspond to your skills? (Answer choices: *not at all, partially, totally*)

Q_11: Does your present activity correspond to the academic education? (Answer choices: *no, only partially, yes*)

Q_15: How well-adapted are you at the present workplace? (Answer choices: *not at all, little, medium, well, very well*)

Q_16: Satisfaction at your present workplace. (Answer choices: *very low, low, medium, high,* and *very high*).

It the second category of questions our purpose was to highlight the way in which the respondent perceives the role of the faculty in creating competencies, as well as

the way in which these competencies are useful and used at the workplace. These questions refer to knowledge classified as: a) basic; b) general of profile; c) specialty, and d) practical. The questions were formulated as follows:

Q_13: Do you think that the faculty you graduated covers, by means of the education you got, the knowledge that you need now at the workplace? (Answer choices: *very little, little, medium, much, very much*)

Q_14: How much of the knowledge you got during the faculty do you use now? (Answer choices: *very little, little, medium, much, very much*)

An important remark refers to how we order the categories of answers to each question. This ordering is ascending, trying to underline the correspondence between the answer and the "positive" aspect of the situation.

The number of respondents in the 9 universities involved, as well as the percentage from the total, is presented in Table 2.

Table 2: Sample volumes for each university

University	Number of respondents (sample volume)	Percentage from the total	University	Number of respondents (sample volume)	Percentage from the total
BUE	174	17.74%	UBB	210	21.41%
UB	108	11.01%	ULB	49	4.99%
UMP	107	10.91%	UVT	33	3.36%
UTI	72	7.34%	UOC	158	16.11%
UAIC	70	7.14%	TOTAL	981	

4. ANSWERS' ANALYSIS AND ORDERING THE EDUCATIONAL OFFERS

We try to exemplify the approach in Section 2 with the data obtained from the answers to the questionnaire presented in Section 3, taking into account as much as possible the scheme in Table 1.

4.1. Analysis with descriptive indicators

Here we refer to the median, used as a centering indicator of the answers, and to the dispersion, recommended as a spread indicator of the answers. As the answer choices to all questions were given in a positive sense (from the most negative to the most positive), a value 3, 4, 5 of the median indicates a placement of the answer from average towards very well. We exemplify what we said before by analyzing the answers to all questions for the sample obtained from the Bucharest University of Economics (see Figure 1):
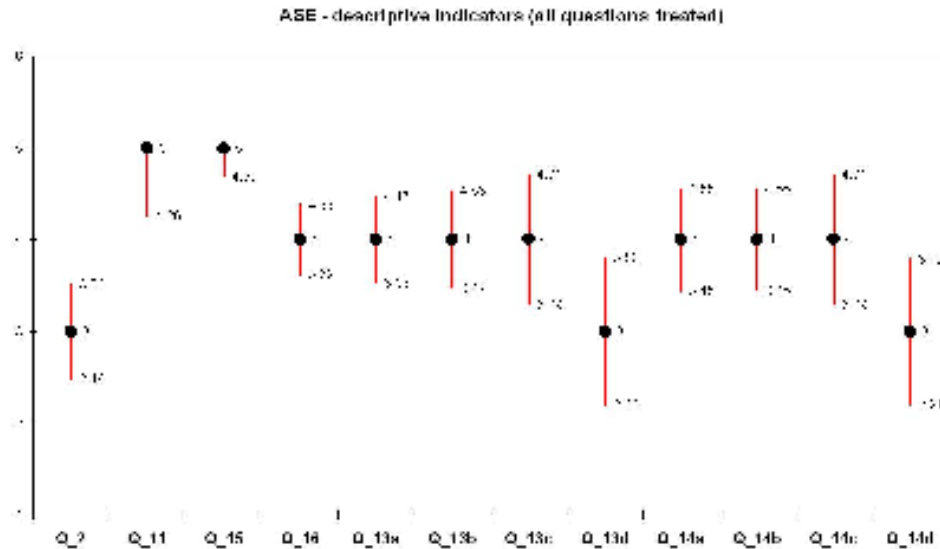
Figure 1: Descriptive indicators for an educational institution - example

Some conclusions:

1) Over 50% of the respondents from Bucharest University of Economics have now an activity that corresponds to their academic education. However, these answers have a rather big dispersion with many answers *partially* and even *not at all.*

2) Over 50% from the BUE respondents got very well 'adapted' at their workplace, the dispersion of this answer being rather small.

3) Over 50% of the BUE respondents have an activity only '*partially*' according to their studies, but they took advantage of their other skills; the answers here have a rather big dispersion with enough answers such as *not at all* and *totally*.

4) According to the BUE respondents, the practical knowledge acquired during faculty and used at the workplace are at a *medium* level, at least 50% of them answering this level. These answers have too a rather large dispersion.

Obviously, we can do this analysis to each educational institution. We can also analyze the way in which a question was answered in all the educational institutions. Figure 2 exemplifies the answers to question Q_15 (How well-adapted are you at the present workplace?).
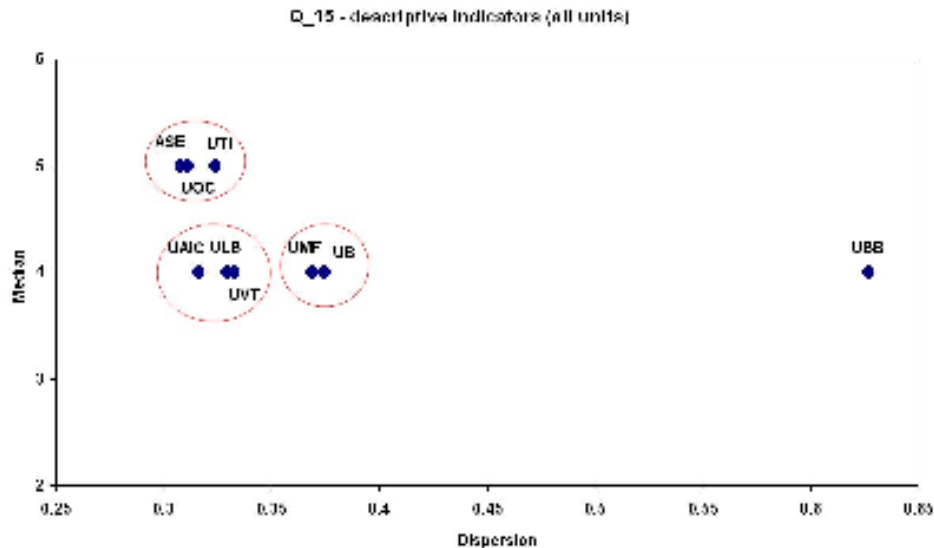
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Figure 2: Descriptive indicators associated to a particular question

According to the answers given, we can find out that our 9 educational institutions are grouped into four "relatively" distinct classes:

a) ASE-UTI-UOC class, distinguished by the fact that over 50% of the respondents got adjusted "*very well*" at the workplace, the dispersion of these answers being rather small (between 0.3 and 0.35);

b) UAIC-ULB-UVT class, characterized by the fact that at least 50% of the respondents got adjusted "*well*" at the workplace, the dispersion of these answers also being rather small (between 0.32 and 0.36).

c) UMF-UB class, characterized by the fact that at least 50% of the respondents got adjusted "*well*" at the workplace, but the dispersion of these answers is larger, towards 0.4.

d) UBB class, made up of only one university, characterized by the fact that at least 50% of the respondents got adjusted "*well*" at the workplace, but with very large dispersion of the answers (many of the respondents answering "*medium*" and "*little*").

Let us now analyze the answers given to the two questions Q_13 and Q_14. It is rather difficult to compare the answers given by the respondents from the nine universities for each type of knowledge. Obviously, we would like to obtain synthetic indicators for the given answers. For each type of knowledge, taking into account the five answer choices "*very little*", "*little*", "*medium*", "*much*", "*very much*", we will calculate a weighted mean of the frequencies of answers using the weights in the Table below (where there is exemplification for the "basic" type of knowledge. Value 1 indicates the total concordance between the expectations and

the quality, value −1 indicates the total discordance, and value 0 indicates a neutral situation).

Knowledge	Basic				
Modality	Very little	Little	Medium	Much	Very much
Weight	**−1**	**− 0.5**	**0**	**0.5**	**1**

The synthetic indicator can be calculated for each type of knowledge and each unit (see Figure 3)
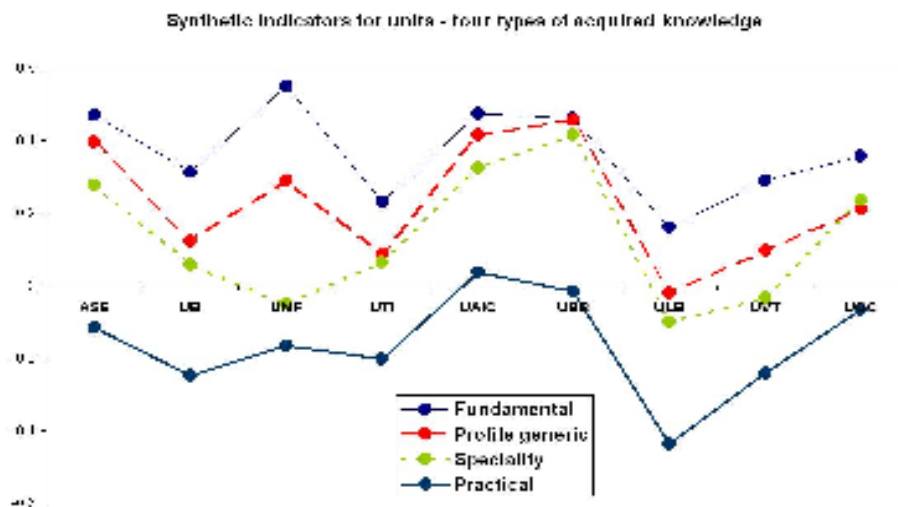

Figure 3: Synthetic indicators for each educational institution

Some conclusions:

1) The UMF respondents consider that they acquired basic knowledge from the level "*much*" towards "*very much*".

2) The general profile knowledge acquired goes from "*much*" towards "*very much*" in UBB, UAIC and ASE.

3) Specialty knowledge acquired goes from "*much*" towards "*very much*" in UBB.

4) Practical knowledge is acquired at a "*medium*" level in UAIC, and in all the other faculties, according to the respondents, it is acquired at the levels "*little*" and "*very little*".

4.2. Ordering the questions and giving scores

To order the questions based on the answers to the questionnaire we will use the relevance indicator presented in Section 2. We use the formula $\delta = D_{\mathrm{B}}/D$ applied

to each question, where D_B is the "between dispersion" for the 9 universities considered with answers separated on samples, and D is the global dispersion of the answers to the question. Using this formula for all questions we obtain the following relevance indicators for the 12 questions:

Question	δ	Question	δ
Q_2	**18.84%**	**Q_13c**	**7.21%**
Q_11	8.73%	Q_13d	3.13%
Q_15	**12.85%**	Q_14a	2.86%
Q_16	2.60%	Q_14b	4.63%
Q_13a	2.75%	Q_14c	3.60%
Q_13b	6.71%	Q_14d	2.04%

The widest variety of answers was to question Q_2: *Do you think that the courses you attended correspond to your skills?* Its indicator of statistic relevance is 18.84%. Next comes question Q_15 *How well-adapted are you to the present workplace?*. The least relevant, from a statistic point of view, is question Q_14d: *How much of the practical knowledge you got during the faculty do you use now*?; also there is little statistic relevance for question Q_16: *Satisfaction at the present workplac*e that has an indicator of statistic relevance of only 2.60%, which means that there is not a variety of answers to this question. In order to make a comparison, we can look at the median and the dispersion for the two questions Q_2 and Q_16. To question Q_2 in most units the median was on modality 3, but there are units (UMF and UOC) where the median is on modality 5. The answers to question Q_16 were more homogenous, most of the respondents from the 9 universities selected modality 4 (which is high satisfaction at the workplace) as the answer.

	Q_2		Q_16			Q_2		Q_16	
	Me	d	Me	d		Me	d	Me	d
ASE	3	0.517	4	0.379	**UBB**	3	0.495	4	0.498
UB	3	0.553	3	0.482	**ULB**	3	0.495	4	0.434
UMF	5	0.463	4	0.416	**UVT**	3	0.500	4	0.397
UTI	3	0.401	3	0.463	**UOC**	5	0.673	4	0.423
UAIC	3	0.554	4	0.403					

Using formula (1.4) we can calculate a score for each educational institution, looking at the global appreciation of their activity. In the following table we present two possible classifications based on scores that were calculated in the following two ways:

a) Including in formula (1.4) only questions Q_13d, Q_14d, Q_15 and Q_16 that refer to the acquisition and use of practical knowledge, as well as to the adaptation to and satisfaction at the workplace.

b) Including in formula (1.4) all 12 questions. (The order of the educational institutions does not change if we take only the first 4 questions that are more relevant.)

	Score related to the answers concerning practice	Score related to all the questions		Score related to the answers concerning practice	Score related to all the questions
ASE	**4.2**	**3.9**	UBB	3.6	3.5
UB	3.3	3.4	ULB	3.3	3.4
UMF	3.6	**4.1**	UVT	3.6	3.5
UTI	**3.9**	3.2	**UOC**	**4.2**	**4.1**
UAIC	3.6	3.7			

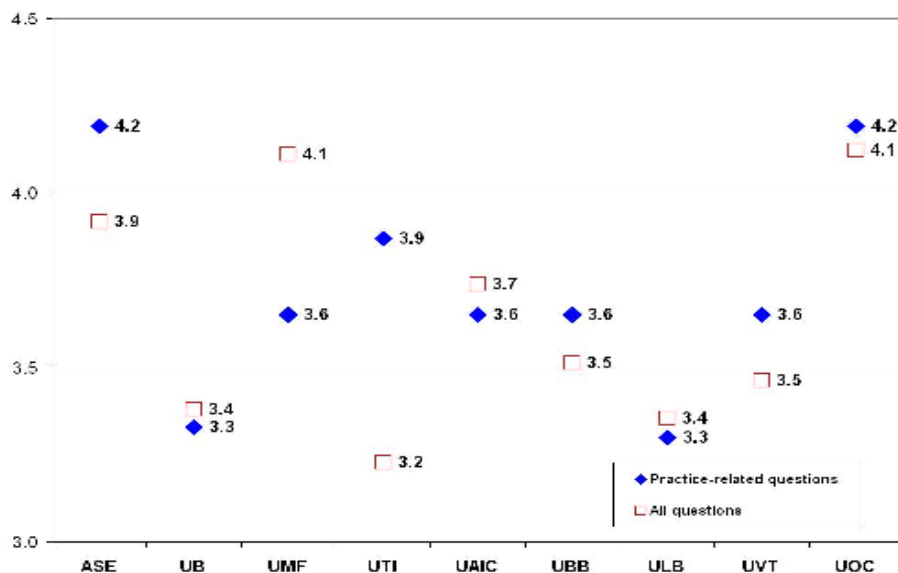These scores are presented in Figure 4.

Figure 4: Comparison of the scores of educational institutions

Some conclusions concerning the scores obtained:

1) A good score in both classification variants was obtained by UOC. This good position is due to the fact that the respondents in the respective sample have on the ordinal scale a positive (above 4) opinion.

2) ASE has a good score (4.2) when we take into consideration the questions related to the practical knowledge acquired, the adaptation to and the satisfaction at the workplace, but it has a slightly lower score (3.9) in the "all questions" variant.

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3) UMF also has a good score (4.1) in the classification according to the answers to all 12 questions, but in the classification according to the questions concerning practical knowledge its place is at a neutral level (3.6).

4) The most striking scores in the two classification variants belong to UTI, its score according to the questions concerning practice (3.9) giving it quite a good place.

5) The lowest scores in the classification related to the questions concerning practical knowledge were obtained by UB and ULB. According to the opinion of the respondents from these educational institutions, much more attention should be paid to the practical knowledge.

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