Econometric Analysis of Educational Process on the Web-Site

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Abstract. The paper describes the site "Lesson pulse". It is the tool allowing a teacher to obtain the objective information on the results of a lesson in real-time mode. However, adequate interpretation for the results of such interrogations is impossible while we do not separate true students from the others. Besides, interpretation of the results of interrogations and decision-making grounded on them demand to realize what exactly this specific group means by clearness of explanation, objectivity of marks, etc. For anonymous interrogations it means the necessity of the correlation and regression analysis of the results and an estimation of their statistical significance. So these factors require the use of econometric analysis.

Keywords. Factor, statistical, econometric, analysis, correlation, decision-making.

Key Terms. Research, Management, Model, Knowledge, Management Process, Knowledge Management Methodology, Mathematical Modeling.

1 Introduction

The site "Lesson pulse" is considered in this article. It is the tool allowing a teacher to obtain the objective information on the results of a lesson in real-time mode. However, adequate interpretation for the results of such interrogations is impossible while we do not separate true students, for which educational process is a considerable part of their life, from those who would prefer to keep far away from it [1]. Besides, interpretation of the results of interrogations and grounded on them decision-making demand to realize what exactly this specific group means by clearness of explanation, lesson atmosphere, objectivity of the marks, etc. [2]. For anonymous interrogations it means the necessity of correlation and regression analysis for the results and an estimation of their statistical significance. So these factors require the use of econometric analysis [3].

The site "Lesson pulse" allows a student or a pupil to react to a lesson course at any moment, having answered one or several questions, for example:

1. Is lesson interesting to you?
2. Is the explanation clear to you?

3. Are you tired? Are you satisfied with the rate of the lesson?
4. Do you have some questions to the teacher?
5. Are marks objective?

(Formulations of questions are defined by the teacher) (Fig. 1).

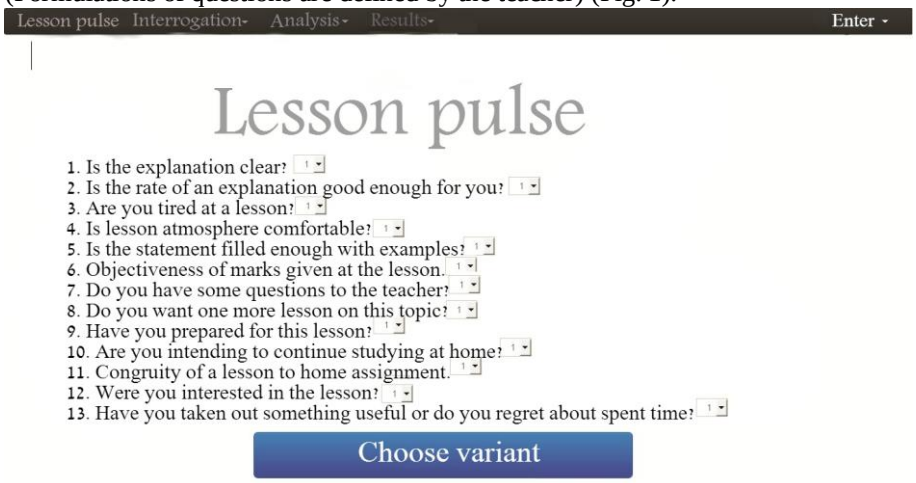

Fig. 1. Lesson pulse

The site displays average marks on responses on the screen. It is the "pulse" of the lesson in real-time mode. At any moment a teacher can ask to answer such or more profound groups of questions (their examples are given below). So, he (she) can measure the “lesson pulse” just at certain moment. Such interrogations do not demand computer auditorium: they can be carried out on a tablet or on a mobile gadget, and then results can be transferred to a site.

1) All groups of questions considered further have been chosen in result of “brainstorming”, where students of fourth year study of the Faculty of physics, mathematics and informatics at the Kherson State University acted as experts. This expert interrogation has been constructed by a technique of “six hats of thinking” by E. Bono [4], which provides the maximal openness and relaxedness of participants. All experts have solidly agreed that this set of questions is full and fair.

2) Then students of speciailties “Physics”, “Mathematics”, “Informatics” and “Software Engineering” of Kherson State University have been interviewed under selected questions. The respondents estimated each question from 0 (at firm “no”) up to 10 (at firm “yes”). He arbitrarily set a name of the folder containing his interrogation (i.e. his key). The volunteer – a participant of interrogation – collects all folders in one main folder and sorts them here (i.e. shuffles). Only after that the main folder is transferred to the teacher: this simple and open procedure guarantee to participants anonymity of interrogation. Alternative and technically simpler variants are answers that are seen on the web-site or could be chosen on a tablet: the variant of choice is defined by the kind of interrogation and the level of trust of an audience to the interviewing teacher.

3) Results of interrogation then are transferred to the site “Lesson pulse”, which is realized in PHP language and uses MySQL database (see [5]). The queries, realizing now on the site, give out results of the econometric analysis of interrogation. They include the plural correlation analysis of factors, the regression analysis and an estimation of the statistical importance of the received results with the use of Student and Fisher criteria ([6]).

The site interface is oriented to the user, generally speaking, knowing nothing about the econometric analysis (Fig. 2)..

Fig. 2. Site interface

2 The Analysis of Interrogations on the Results of a Lesson and Feedback Interrogations

Results of interrogation on a lesson and Feedback interrogation are, of course, absolutely various [7] depending on a lesson, a teacher, an audience, etc (Fig.3).

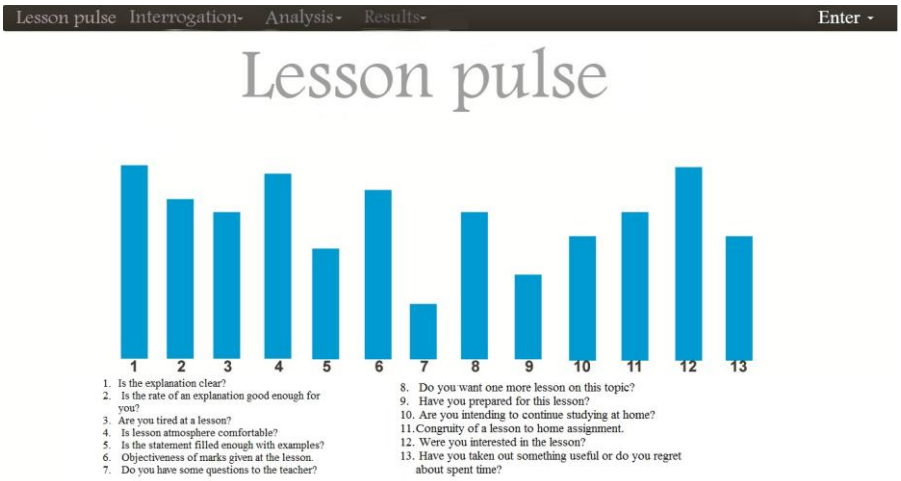

Fig. 3. Results

However, the correlation analysis of factors led to similar outcomes (at 20 % of significance level by criterion of Student). Everywhere below we use the interrogations of the group having typical results on a specialty "Mathematics" (Fig.4).

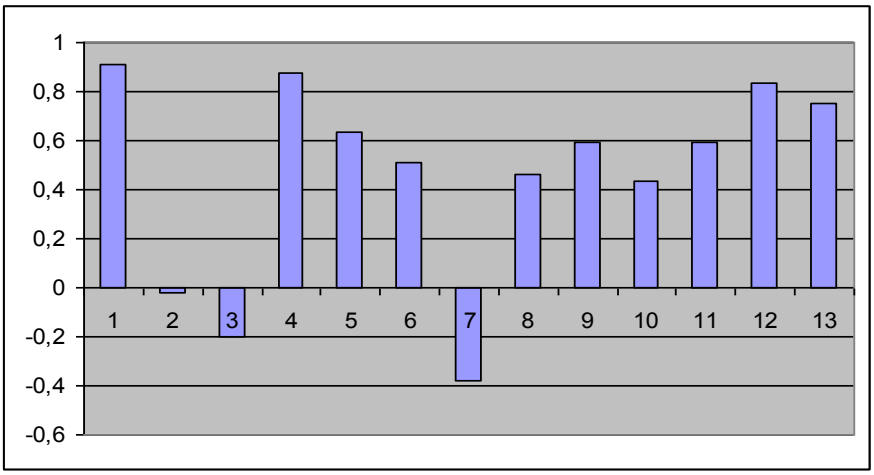

Fig. 4. Questions Distribution

Here is the histogram for distribution of correlation coefficients between answers to a question "Do you like the lesson?" and following factors:

1. Is the explanation clear?
2. Is the rate of an explanation good enough for you?
3. Are you tired at a lesson?
4. Is lesson atmosphere comfortable?
5. Is the statement filled enough with examples?

6. Objectiveness of marks given at the lesson.
7. Do you have some questions to the teacher?
8. Do you want one more lesson on this topic?
9. Have you prepared for this lesson?
10. Are you intending to continue studying at home?
11. Congruity of a lesson to home assignment.
12. Were you interested in the lesson?
13. Have you taken out something useful or do you regret about spent time?

The most significant factors had appeared (in decreasing order) **1** (0,91), **4** (0,87), **12** (0,83), **13** (0,75) **5** (0,63), **9** and **11** (0,59). Objectivity of marks is only further (0,51) and inverse correlation – 0,39 for **7** specifies that a good lesson for the majority is the one after which there are no questions remained to the teacher.

The real importance of examined factors for the lesson estimation is finally established by the regression analysis. At first, we use the most essential factors mentioned above. Then we obtain such linear model:

$Y = 0{,}845454\ x_1 + 0{,}556967\ x_2 + 0{,}32442\ x_3 + 0{,}19571\ x_4 + 0{,}269908\ x_5 + 0{,}24677\ x_6 + 0{,}19877\ x_7$, where the variable x_i corresponds to the factor i ($1 \le I \le 7$). The determination factor for such model is equal to 0, 84572. Using all the factors except insignificant factors **2** and **3**, we obtain the following model:

$Y = 0{,}657012x_1 + 0{,}282476x_4 + 0{,}1349x_5 + 0{,}01807x_6 - 0{,}1097x_7 - 0{,}063159x_8 + 0{,}00809x_9 + 0{,}033186x_{10} + 0{,}126973x_{11} + 0{,}192209x_{12} + 0{,}1266x_{13}$

with the determination factor 0,93647 (Fig.5).

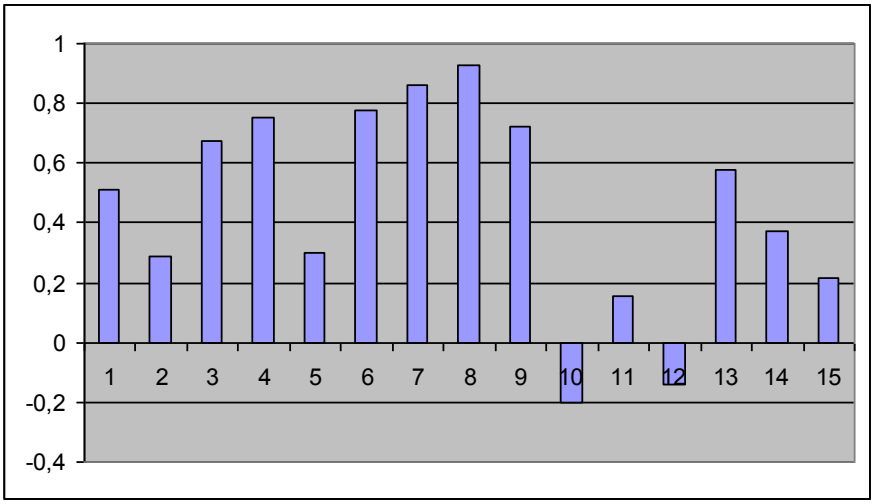

Fig. 5. Questions Distribution

Here is the histogram for distribution of coefficients' correlation between answers to a Feedback question "Do you like your teacher?" and following factors:

1. Do you like the lesson?
2. Student's estimation of the knowledge received at the lesson.
3. Is an explanation clear?

4. Were students' answers clear and adequate?
5. Weather the explanations are filled enough by examples.
6. Using of various approaches during studying.
7. Does the teacher aspire to interest and motivate students?
8. Lessons atmosphere: is it comfortable, is it pleasant to you at the lesson?
9. Availability of the teacher, his inclination to listen the students, to lead a discussion with them.
10. Teacher's competence.
11. Insistence (regular and frequent control of knowledge).
12. Punctuality (comes in time at lessons).
13. Possession of an audience (students are interested in subject and do not make too much noise at the lessons).
14. Objectivity in the teacher's estimation of the student. Are the criteria of estimation in all subgroups identical?
15. Correspondence of the lesson's material to control tasks.

The most significant factors appear (in decreasing order):

8 (0,92), **7** (0,85), **6** (0,775), **4** (0,75), **9** (0,72), **3** (0,675), **13** (0,58).

Only further with factor of correlation 0,51 follows **1** - Do you like the lesson?

Corresponding linear regression model is:

$$Y = 0{,}048604x_1 + 0{,}17976x_3 + 0{,}22221x_4 + 0{,}076545x_6 + 0{,}35703x_8 + 0{,}800305x_9 + 0{,}280308x_{10} + 0{,}23398x_{14} + 0{,}150449x_{15},$$

where the variable x_i corresponds to the factor i ($1 \le i \le 15$). The determination factor for such model is equal to 0,8463.

And major factors of estimations of the teacher and lesson are considerably differing. Further the histogram of differences between factors of correlation for questions "*Do you like your teacher?* and "Do you like the lesson?" is resulted (Fig. 6):

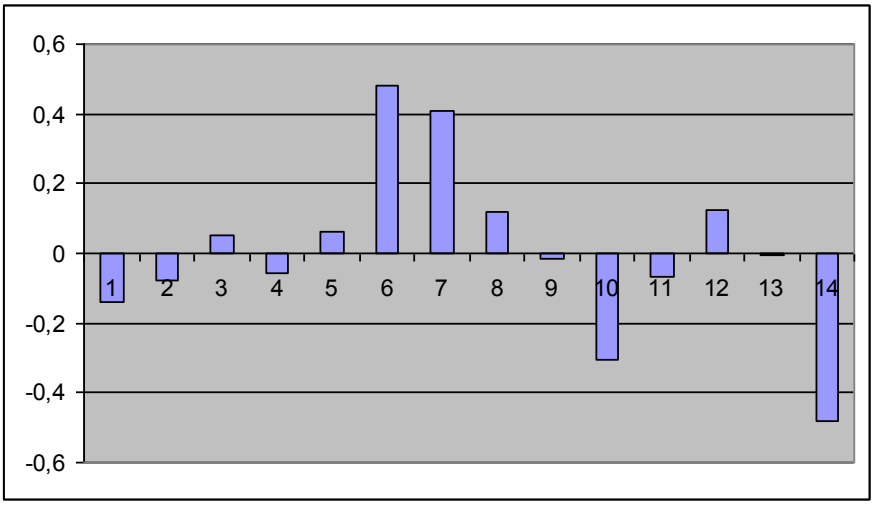

Fig. 6. Questions Distribution

The factors much more essential at an estimation of a teacher, than a lesson are **6** (using of various approaches at training) and **7** (teacher's aspiration to interest and motivate students). On the contrary, at an estimation of a lesson it is much more essential factors **14** (accordance of a lesson's material to control tasks) and **10** – insistence (regular and frequent control of knowledge): probably, according to students, insistence is good at the lesson and it is not so good for the teacher.

Certainly, the correlation matrix contains decomposition on factors also for each of 15 questions. So it is found out that **5** (explanation filled enough by examples) is most closely connected with **15** (accordance of a lesson's material to control tasks); **3** (are you tired at a lesson) with **7** (questions to the teacher); **13** (possession of an audience) with **14** (objectivity in estimation of the student).

It is interesting to compare **12** (is it interesting to you at a lesson) with **13** (have you taken out something useful at a lesson) from interrogation about results of the lesson (Fig. 7).

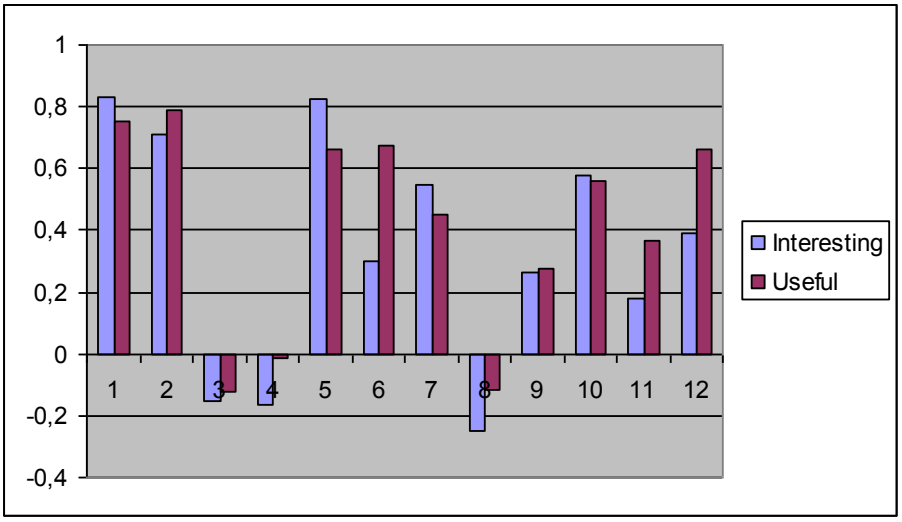

Fig.7. Comparative results

As we see, from the student's point of view, what is interesting and what is useful is not the same. So **4** (lesson atmosphere) correlates with the factor 'interesting', while factor **5** (is the statement filled enough by examples) – with **11** (accordance of a lesson's material to home assignment).

3 The Analysis of Interrogations on the Factors Influencing the Lesson

Unlike interrogations about results of lesson and Feedback results of interrogations about the factors influencing the lesson course [8] are close enough in different

groups. The histogram for distribution of interrogation requisites on the relation to lesson is below (Fig. 8, Fig. 9).

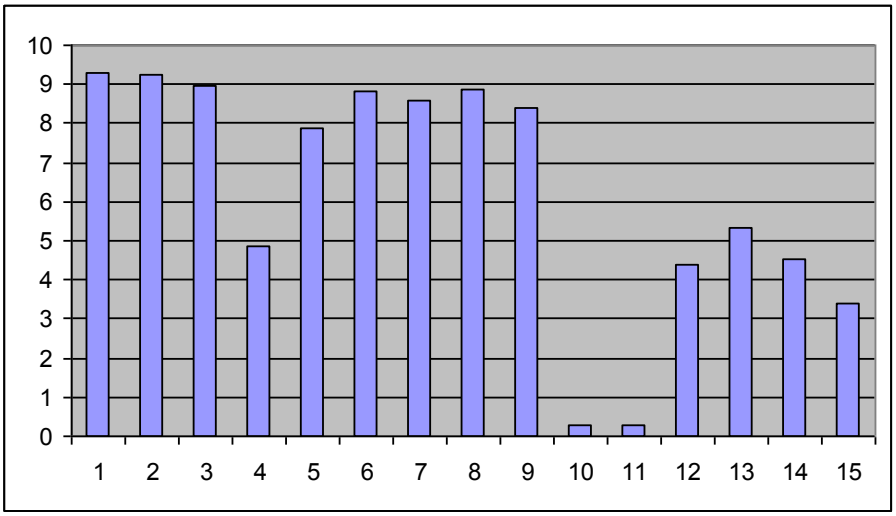

Fig. 8. Questions Distribution

Here:

1. Do you like the lessons? Is the study interesting to you?
2. Do you believe that education is “the road to the future”?
3. Is your speciality interesting to you?
4. Does the training program for your speciality satisfy you?
5. Are you satisfied with your teaching level?
6. Have you chosen university and a speciality on your own?
7. Would you like to change your speciality or enter another university?
8. Do you attend lessons regularly?
9. Are you often prepared with your homework?
10. Did you have any conflicts with teachers?
11. Were you afraid of an elimination from the university?
12. Are you willing to take part in scientific work, in Olympiads on your speciality?
13. How often do your classmates address to you for the help?
14. Do you wish to enter postgraduate study after you studying ends?
15. How much time do you spend for preparation for lessons (hours per day)?

Similar results of interrogation on external factors are the further:

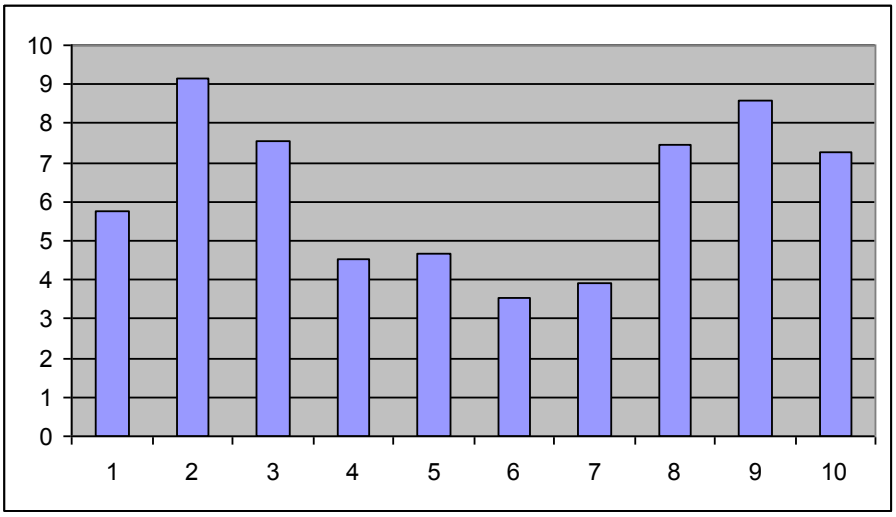

Fig. 9. Questions Distribution

Here:

1. Close interaction with teachers.
2. Accessibility of the Internet at university.
3. Preparedness of an auditorium for a lesson (working projectors, computers, the software; comfort of an auditorium).
4. Presence of enough points for the centralized feeding.
5. Accessibility of contacts with the future employers.
6. Accessibility of summer recreation.
7. Participation in scientific work.
8. Teaching level at the university.

In a correlation matrix under all these factors there are only few factors which correlations are close to 1. These are factors:

1. Do you attend lessons regularly? with factors
   1) are you often prepared with your homework (0,87)
   2) teaching level at the university (0,84)
   3) participation in scientific work (0,63)
   4) have you prepared for this lesson (0,59)
   5) accessibility of summer recreation (– 0,5).
2. Are you often prepared with your homework with factors
   1) do you attend lessons regularly (0,87)
   2) teaching level at the university (0,815)
   3) have you prepared for this lesson (0,66)
   4) participation in scientific work (0,56)
   5) accessibility of summer recreation (– 0,52).
3. Teaching level at the university with factors
   1) do you attend lessons regularly (0,843)
   2) do you regularly prepare homework (0,815)

3) have you chosen university and a speciality on your own (0,65)
4) have you prepared for this lesson (0,59)
5) participation in scientific work (0,56)
6) accessibility of summer recreation (– 0,55).

Besides them correlation factors above 0,7 appear still only twice: between factors *Did you have any conflicts with teachers* and *Were you afraid of an elimination from the university* (0,85); and between factors *participation in scientific wor*k *and Are you satisfied with your teaching level* (0,74). Occurrence in such line the *factor teaching level at the university* is, probably, the best compliment for Faculty of Physics, Mathematics and Informatics of the Kherson State University for all its history. Our main task is to use the mental orientation, fixed thus in the correlation analysis of factors, for separating true students, for which educational process is a considerable part of their life, from those, who would prefer to keep far away from it. Using already cited data and the following table 1:

Table 1 Data

Factor	**Average value**	**Root-mean-square deviations**
Teaching level at the university	7,2	2,17
Regularly attendance of lessons	8,85	2,3
Regularly prepare homework	8,4	2,6

we choose as a differentiating sign between groups the factor *regularly of homework preparedness*. In this case mutual correlations of defining sign are closer to 1; and the dispersion is more, that testifies about more variability of respondents under this factor. Besides, among others selected it corresponds more to such sign in common sense.

4 Results of Interrogations about Lesson and Feedback on Subgroups

To the selected differentiating sign among 20 respondents of group the 12 participants is allocated, who for a question *Are you often prepared with your homework* have answered with 10 or 9 points. The additional subgroup consists of 8 respondents. Do such subgroups correspond to required division into true students and the others? Below there is the histogram for average results of interrogation on the lesson on the allocated subgroups (Fig. 10, Fig. 11).

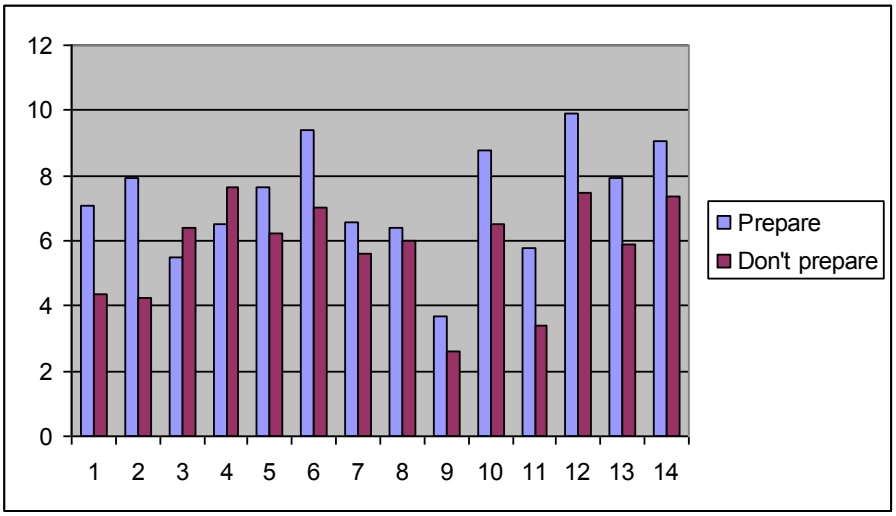

Fig.10. Comparative results

So, the factors considerably different in subgroups (in decreasing order of modules of differences between average values in subgroups) are:

2 Is an explanation clear? (7,92 – 4,25 = 3,67)

1 Do you like the lesson? (7,1 – 4,38 = 2,72)

12 Accordance of a lesson to home assignment. (9,91 – 7,5 = 2,41)

6 Is the statement filled enough by examples? (9,41 – 7 = 2,41)

10 Have you prepared for this lesson? (8,75 – 6,5 = 2,25)

13 Is it interesting to you at a lesson? (7,92 – 5,87 = 2,05)

14 Have you taken out something useful at a lesson? (9,1 – 7,4 = 1,7)

5 Lesson atmosphere (7,66 – 1,25 = 1,41)

9 Do you want one more lesson on this topic? (3,66 – 2,65 = 1,01)

The averages of additional group are more only twice, there are:

4 Are you tired at a lesson? (6,5 – 7,62 = – 1,12)

3 Is the rate of an explanation good enough to you? (5,5 – 6,37 = – 0,87)

Last result seems strange at first sight, but it is steady for all groups and it is easy to explain this phenomenon psychologically: the less the student is adjusted for the study, the more he would like to speed up lesson's time.

Further there are similar results for Feedback interrogation.

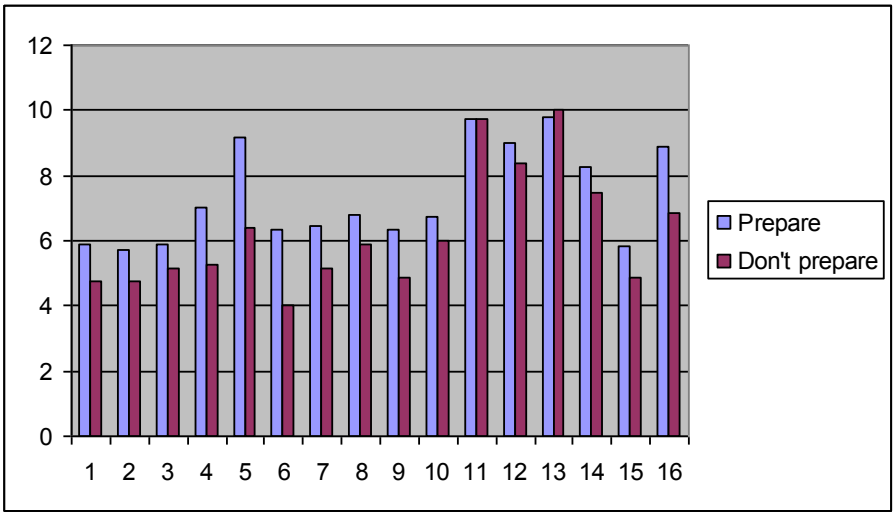

Fig.11. Comparative results

Here are the factors considerably different in subgroups:

5 The explanation is filled enough by examples (9,17 – 6,37 = 2,8)

6 Using of various approaches at studying (6,36 – 4 = 2,36)

16 Accordance of a lesson to control tasks (8,9 – 6,87 = 2,03)

4 Are the answers clear enough? (7 – 5,25 = 1,75)

9 Lesson atmosphere (6,36 – 4,85 = 1,51)

The obtained data corresponds to a hypothesis about required division into groups, anyway they don't contradict it.

5 The Latent Division in Group

The site "Lesson pulse" offers also group division into classes with a given value of mutual correlation: between two respondents from one class it is possible to find a chain of respondents of this class in such a way, that the correlations of answers between consecutive respondents of this chain is not less than the given value. Such division into subgroups allows finding out distinctions in the group, which are not appreciable directly.

At mental interrogation about factors of influence on lesson and the set minimum level of mutual correlation 0,6 in test group 421 splitting into 3 classes has turned out: from 4, from 5 and from basic subgroup of 11 respondents. Let's compare averages of the basic class to averages of the first and the second subgroups under those factors in which appreciable differences have come to light (Fig. 12).

1) Is the program of training for your speciality satisfying you?
2) Would you like to change the speciality or enter another university?

3) Are you willing to take part in scientific work, in Olympiads on your speciality?
4) Do you wish to enter postgraduate study after training end?
5) Participation in scientific work.
6) Preparedness of an auditorium for a lesson.
7) Accessibility of summer improvement.
8) Accessibility of contacts with the future employers.

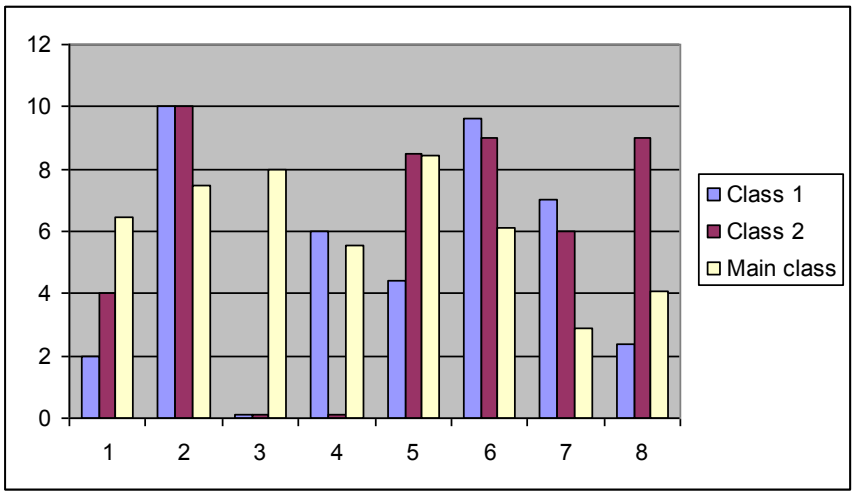

Fig.12. Comparative results

Respondents from classes 1 and 2 much less than the basic group are satisfied by the program of training of the speciality (point 1). They would like to change the speciality or to receive additional higher education much more than the basic group (point 2). Their difference clearly comes to light in point 3: unlike the basic group they do not wish to take part in scientific work or in the Olympiads on the speciality at all. So, apparently, the speciality has lost now its appeal for them. Respondents from class 2 are not interested in the postgraduate study (point 4), however, they are not against taking part in scientific work (point 5). The main thing, they have the most interest in contacts to employers (point 8). Apparently, it is search for their employment out of the speciality. Respondents from class 1 are focused differently: they have a little interest in scientific work and employers (points 5 and 8), but they wish to enter postgraduate study (point 4).

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