TESTING THE USAGE OF THE APPLICATIVE EXAMPLES IN UNIVERSITY MATH TEACHING

Zuzana Hajduová
The Faculty of Business Economics with seat in Košice, The University of Economics in Bratislava
Slovakia
zuzana.hajduova@euke.sk
Jana Coroničová Hurajová
The Faculty of Business Economics with seat in Košice, The University of Economics in Bratislava
Slovakia
jana.coronicova.hurajova@euke.sk
Roman Lacko
The Faculty of Business Economics with seat in Košice, The University of Economics in Bratislava
Slovakia
roman.lacko@euke.sk

Abstract: The focus of this article is implementation and improvement of teaching methods for the lessons of 'Selected Chapters of Mathematics' taught in the second semester of the first year of bachelor studies for students of economical studies. To discern the student's knowledge level we purposely avoided the use of a standardised test as it assesses mostly the current state of information knowledge. Bearing in mind the first year students come from different types of secondary schools with markedly differing curriculums, the standardised test does not provide adequate information about the quality of the taught subject. We tested students from two academic years undergoing teaching the classical way and also implementing new methods and trends in the area of math didactics and quantitative methods.

Key words: educational process, mathematic methods, statistical evaluation, quality of education, DITOR

INTRODUCTION

Measuring added value in 'MPHV' (measured added value education) has become a sought after quantitative evaluation tool of education institutions. Added value expresses certain extent of knowledge student acquired during a certain period by active participation in the educative process of the respective institution. Quality of such education is recently a much discussed topic (Harris 2011, Krpec and Burda, 2011, Kozák and Rehúš 2015, OECD 2013, Kaclík et al. 2015). Measuring added value lies in checking the student's (or a group of students, respectively) knowledge before and after the teaching process by an appropriate form of test with content adequately responding to matter taught. Acquired results get compared and evaluated using a statistical model. Required result is the information indicating the "extent" of newly acquired knowledge (Braun 2005, Rogers et al. 2011). There are several models of measured added value education (Lissitz 2005, Krpec and Burda, 2011). Correctly chosen models used for measuring added value education (Doran and Lockwood, 2006) should answer following questions:

1. What is the percentage of acquired knowledge due to school's (teacher's) input?
2. How effective is school's (teacher's) input?
3. What are the characteristics of an effective school?

In some countries the added value results are one of the criteria for a student choosing an educational institution, for example in Great Britain, Finland or Poland. At some schools the report about students' performance results can influence the post and wages of the teacher (Braun 2005, Baker et al. 2010**,** Glazerman et al. 2010, Schochet 2010, Darling-Hammond, 2012). Such type of education quality evaluation puts the school or teachers under pressure from public or parents but also offers certain possibility of progress, mainly in attaining the prestigious position.

Most of works about the added value education deal with educational process at elementary and secondary schools. As it was shown in Tam, 2001, it is possible to analyse university education as well.

METHODOLOGY OF RESEARCH

Nowadays a trend in teaching process is using innovative methods. By definition it is such methods where teacher abandons serving complete information and knowledge, where the student is not a mechanical receiver without active participation in solving the given problem.

Among such innovative teaching methods is heuristic teaching based on principle of creative problem solving (Bajtoš, 2007). It is a form of searching teaching based on supposition the student is solving the problem above his knowledge level with the help of teacher as a guide while trying to understand the problem and find an adequate solution. The role of the teacher is to guide, to advise about how to proceed and in the subsequent discussion find the solution, respectively to inform about other possible options. Heuristic teaching utilises many methods aiding creative thinking, for example TRIZ, Quickstorming, Brainstorming or synectics. At the present another heuristic method has made an appearance, DITOR. Authors are M. Zelina and M. Zelinová (Zelina 2000) and the method DITOR devised by them is based on following these steps:

- D – **d**efine the problem and outline the ideal solution,
- I – be **i**nformed about the problem, gather as much information as possible,
- T – **t**ry to come up with a solution,
- O – **o**btain evaluation of this solution and choose the best one,
- R – **r**ecreate this solution in reality and solve the problem.

Besides teaching different areas of mathematics, the aim of the analysed subject is to develop logical thinking and the ability to learn on one's own, to solve tasks in a group and to apply the knowledge acquired even from other subjects. That is reason why we have chosen DITOR method. A lecture was organised for students opening the topic where they received tasks for individual solving. During a lab section we discussed this solutions student had prepared. The remaining part of the lab lesson was devoted to group solving, each group being given a different task. Their chosen representative presented the result to other groups and at the end we evaluated effectuality of the solution. For the evaluation of testing we employed a statistic analysis. For the purpose of research, presenting and comparison of acquired data a wide range of statistic software has become available in recent years. Among the best known and most used are SAS, GNU Octave, PSPP, ADaMSoft or BV4.1. We have decided on SAS system (Statistical Analysis System) which is a professional system used and known worldwide.

RESULTS OF RESEARCH

We tested a total of 188 students signed for the subject 'Selected Chapters of Mathematics' in the second semester of the academic year 2013/2014. An output testing was carried out on students during semester to ascertain their abilities and knowledge. The choice of subjects was specific in drastic fall in the student level of mathematical abilities in the area of quantitative methods. We tried to rectify this shortcoming by including new elements of teaching process. We statistically analysed students' results from input and output testing to discover whether the selected actions for improving student's skills and knowledge were effective or not. The available results were grades A to FX for each student. These grades were assigned a quantitative expression, grade A got 1, grade B got 1.5 and so on until grade E getting 3. Grade FX was assigned 4.

Testing 2013/2014

Moments			
N	188	Sum Weights	188
Mean	3.25797872	Sum Observations	612.5
Std Deviation	0.9213395	Variance	0.84886648
Skewness	-0.7823722	Kurtosis	-0.7485132
Uncorrected SS	2154.25	Corrected SS	158.738032
Coeff Variation	28.2794819	Std Error Mean	0.06719559

Table 1: Basic statistic characteristics for input test

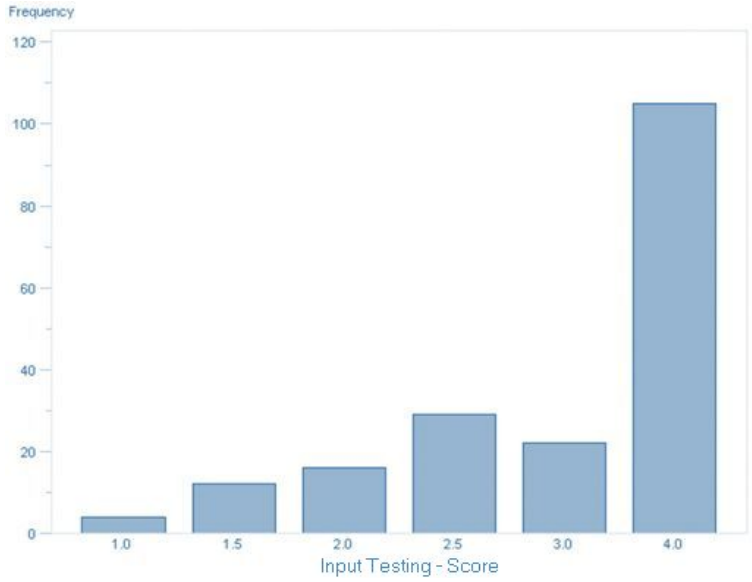
The average grade was 3.26 which is an unsatisfactory result as it fluctuates between E and FX. Standard deviation is 0.92 and dispersion is approximately 0.848. Should grade FX have value of 3.5 the overall result

would be better but value of 4 reflects better the fact point values should be markedly below 50 points. The division of our file is platykurtic (-0.749) and left sloping (-0.782). Next there is a table for confidence intervals for chosen statistical characteristics.

Basic Confidence Limits Assuming Normality			
Parameter	Estimate	95% Confidence Limits	
Mean	3.25798	3.12542	3.39054
Std Deviation	0.92134	0.83667	1.02522
Variance	0.84887	0.70002	1.05108

Table 2: Confidence intervals at significance level of 0.05

For this statistic group we determined also confidence intervals for average, standard deviation and dispersion. Confidence interval for the average is (3.125; 3.391). If we had the results of all the students, respectively should all the students partake in testing, the overall grade would be in this interval with 95% chance. Here is the column grid of multiplicity division of individual grades.



Grid 1: Multiplicity division of individual grades for the input test

105 students obtained the worst grade FX from input test meaning they failed. Only 4 students got the best grade A. Thus it was justifiable to consider improvements as this state was worrying.

Testing 2014/2015

The subjects' input test for new academic year was the same as in 2013/2014. The amount of students was 188. However, the approach toward teaching the subject was different employing DITOR method. At the beginning of semester students were each assigned thematic topics according to the curriculum. Their task was to briefly recapitulate basic results from the lecture and to prepare and exemplary calculate a sample from practice for their topic. This ensured the reporting had to work with respective literature and employ knowledge from previous topics as their interconnection in math is very close. The role of teacher was to guide and to correct possible errors because not all the students were able to master the topic. But implementing this method led to higher participation of all students. The preparation motivated students also because individual presentations were graded (point scale) and this was part of their overall final grade (exam). Generally speaking, almost any change of method catches the students' attentions. This particular type of teaching stimulated students' individual work within the area of a certain topic consecutively referring to practice. Specific for mathematic teaching at economic universities is that students themselves perceive basic theoretical subjects as an unnecessary burden.

Even though we utilise applied math in everyday work, its full extent can the student see only in later years of study and some "technical" subjects rather avoid using math although it would be beneficial or even necessary for the subject.

At the end of semester we again evaluated successfulness of applied teaching processes searching improvement of students' knowledge and skills, using an output test. The following table surveys a review about chosen statistic characteristics for group of grades from output tests.

Moments			
N	188	Sum Weights	188
Mean	2.49202128	Sum Observations	468.5
Std Deviation	0.90671303	Variance	0.82212851
Skewness	0.39919993	Kurtosis	-0.7049222
Uncorrected SS	1321.25	Corrected SS	153.738032
Coeff Variation	36.3846423	Std Error Mean	0.06612884

Table 3: Basic statistic characteristics for output test

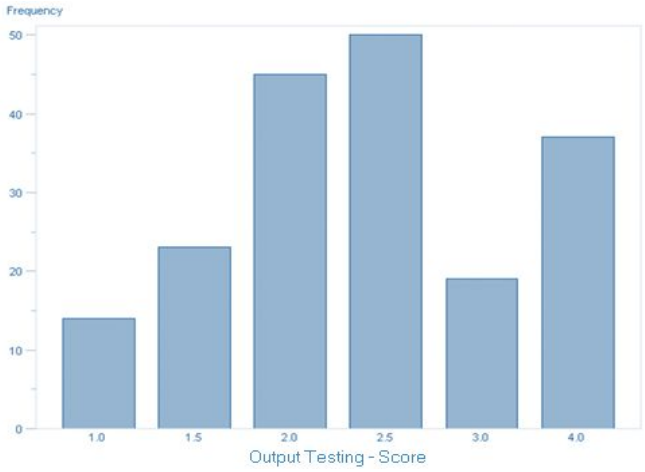
The average value of grade of students, who also underwent the first testing, was higher. From the original value of 3.26 the average grade improved to 2.49. Standard deviation and dispersion are similar with values of the input test which indicates similar variability. Group is still platykurtic compared to a normal one but the sloping changed from left to right meaning more values are situated in left half of division. Subsequently we calculated the confidence intervals for chosen characteristics.

Basic Confidence Limits Assuming Normality			
Parameter	Estimate	95% Confidence Limits	
Mean	2.49202	2.36157	2.62248
Std Deviation	0.90671	0.82339	1.00894
Variance	0.82213	0.67797	1.01797

Table 4: Confidence intervals at significance level of 0.05

The average grade for input test would be in interval (2.362; 2.622) with 95% chance. That is a significant improvement against the input test. The following grid portrays the multiplicity division of individual grades.

From the Grid 2 it is obvious that the number of grade FX dropped from 105 to 37. Grid is more similar to the normal division. The most common grade is grade D numbering 50 with grade C numbering 5 less (45). Also the best grade A numbered 10 more than previously.



Grid 2: Division of multiplicity of individual grades for the output test

COMPARISON AND CONCLUSION

Supposing both groups spring from normal division – possible because there were more than 100 observations – parametric paired t-test can be used. It statistically compares difference between two averages at significance level. Our zero hypothesis is the allowed difference between input and output tests can be -0.75. Alternative hypothesis is the difference does not equal -0.75 (such improvement is possible, it is more than one grade better). The results are in the following table.

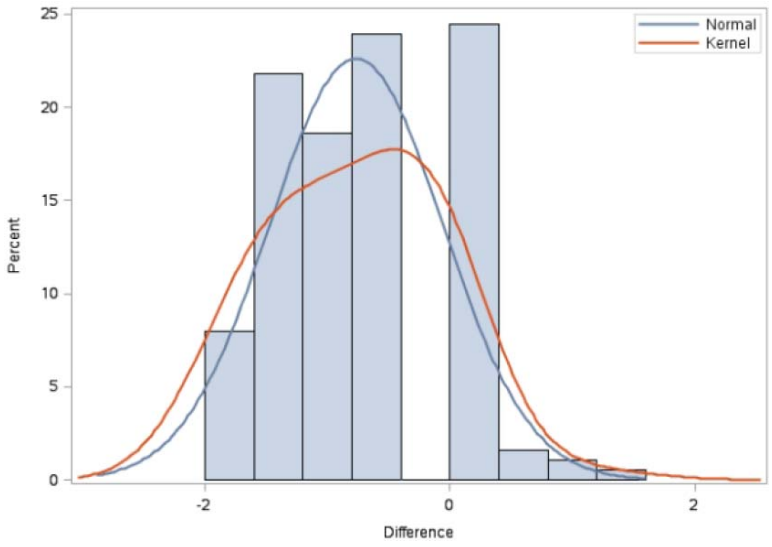
N	Mean	Std Dev	Std Err	Minimum	Maximum
188	-0.7660	0.7060	0.0515	-2.0000	1.5000

Mean	95% CL Mean		Std Dev	95% CL Std Dev	
-0.7660	-0.8675	-0.6644	0.7060	0.6411	0.7856

DF	t Value	Pr > |t|
187	-0.31	0.7570

Table 5: Results of the comparison using paired t-test

Average difference between input and output tests is 0.766. This difference between averages will be in interval (0.8675; 0.6644) with 95% chance. Standard deviation for these averages is 0.706. P-value equals 0.757 which is not less than the chosen significance level of 0.05 and the hypothesis that the average of grade differences between input and output tests equals -0.75 cannot be rejected. The following grid shows the division of improvement multiplicity for participating students.



Grid 3: The distribution of difference between input and output tests

As it can be observed from the grid, in the absolute formulation more students improved their grades (more students achieved minus differential values so they improved). For the amount of students the most deteriorated by 1 degree. So it could be assumed that chosen teaching methods and teaching process we have achieved greater success in output than in input.

It can be concluded that the significantly better result of innovated teaching methods was achieved via chosen teaching methods DITOR and aided with teaching process. We evaluate this process and its results as positive.

The arrangements based on the existence of a compulsory additional subject ‘Mathematics For Economists’ are still ongoing. This subject deals with mentioned taught issues based on subject ‘Mathematics’ and is a supplementary subject for this core subject of university studies.

It is very important to recognise innovation of the teaching process of individual subjects. Our experiment showed that also subjects of quantitative character can be organised in the form of lab practice lessons where the student participates in applying math into practice.

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