Bulletin of the *Transilvania* University of Braşov
Series V: Economic Sciences • Vol. 8 (57) No. 2 - 2015

A model for analysing factors which may influence quality management procedures in higher education

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Abstract: *In all universities, the Office for Quality Assurance defines the procedure for assessing the performance of the teaching staff, with a view to establishing students' perception as regards the teachers' activity from the point of view of the quality of the teaching process, of the relationship with the students and of the assistance provided for learning. The present paper aims at creating a combined model for evaluation, based on Data Mining statistical methods: starting from the findings revealed by the evaluations teachers performed to students, using the cluster analysis and the discriminant analysis, we identified the subjects which produced significant differences between students' grades, subjects which were subsequently subjected to an evaluation by students. The results of these analyses allowed the formulation of certain measures for enhancing the quality of the evaluation process.*

Keywords: *academic performance, evaluation, cluster analysis, discriminant analysis*

1. Introduction

The education process represents a teaching-learning-evaluation activity which is intended, performed in an educational institutionalized space, by means of given didactic technology, with certain anticipated and attained results. The sides of the education process are: teaching, learning and evaluation. The efficiency of the education process is given by the dynamic interaction between teaching, learning and evaluation. Each of the three sides of the education process must be correlated with the others in order to have a real and efficient interaction.

As compared to the traditional didactics, which separates teaching and learning from evaluation, modern didactics favours the integration of evaluation in the education process, with a view to supporting the decision-making as regards the good organisation and progress of the entire process, to facilitating the improvement and adjustments required along the teaching and learning process (Dinu C., 2011).

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Teaching has been known in traditional didactics as a communication activity, by means of which information is conveyed and content is delivered by teachers. In the modern approach, teaching represents a complex of functions which extend from the communication or conveyance of information, to the drawing up and management of activities, the organisation and guidance of learning, the control and innovation of the education process, the didactic creation.

Learning appears as a change, an alteration in the individual behaviour attributed to the experience actively lived by the subject, as a response to the influences from the environment.

Encyclopaedia Britannica defines learning as follows: "the continuous alteration of behaviour as a result of prior individual experience".

Vâgotski stated that learning represents "all the changes of the inner or outer behaviour, resulting from experience".

Skiner considered that learning meant "the building of the new behaviour".

Gagne (1965) defines learning as follows: "a change in human disposition or capability which can be retained and which is not simply ascribable to the process of growth; the change called learning is visible as a change in behaviour".

The psycho-pedagogical literature offers several classifications of the learning types: B. Bloom, R. Gagne, R. Titone, D. Ausubel, E. Noveanu, N. Oprescu, I.T. Radu.

Evaluation, which results from the characteristic of the education process as a self-regulating process, is the common activity of teachers and students (self-evaluation), which ends the circuit teaching-learning.

By means of the feed-back, the teacher gets information regarding the results of the learning activity (knowledge acquired, capabilities built) and adjusts the subsequent activity in accordance with this information. Knowing the performance obtained, the failings, their causes, represents the benchmarks for assessing the teacher's performance.

The evaluation process must take place from both directions: the students' evaluation by the teacher and the teacher's evaluation by students.

The concept of teacher evaluation by students has represented the core of global debates for a long time. The first studies which consider students' evaluation as a valid indicator for diagnosing the university teachers' efficiency date back in 1920 (Remmers, 1928; Brandenburg and Remmmers, 1927).

Recent surveys show student evaluation is the most popular evaluation instrument in the United States (Hamilton J. et al. 1997, Seldin P. 1998, Young, S. et al 1999), as compared to other instruments such as chairperson evaluation, peer evaluation (Chism, N. 1999) and self-evaluation. From the management point of view, student evaluation not only serves as one instrument for job appraisal of instructors, but may also express the management's view on what constitutes a good quality education, providing guidance for instructors in the future (Viriyavidhayavongs and Zhimin, 2000).

2. Methodology

The objectives of the study were the following: to build a model for analysing the evaluation teachers perform to students, in order to identify those subjects which produced significant differences in the results obtained in exams; an analysis model for the evaluation performed by students for the academics teaching those subjects during the semester under consideration.

The first part of the paper focuses on the analysis of the grades obtained by 1st year students in the 1st semester, with a view to identifying those subjects which generated significant differences between results in exams. The grades were retrieved from the student management application for FSEAA students, in all programmes of study.

Out of the 441 students, 62 studied International Business, 39 Business Administration in English (BA), 51 **F**inance and Banking (FB), 26 Business Information Systems (IE), 65 **M**arketing (MK), 57 **M**anagement (MN), 51 **E**conomics of Trade, Tourism and Services (ECTS), 74 Accounting and Management Information Systems (CIG).

From the category of multidimensional analysis methods, we applied k-Means classification methods and the discriminant analysis. The k-Means analysis aimed at establishing two clusters of students who passed the exams in the 1st semester of the 1st year: one comprising the students with the best performances and one those with the weakest performances for all the subjects analysed in the model. The subjects analysed were: Introduction to Business Information Systems, Business Law, World Economics, Mathematics applied in economics, Microeconomics, Management, Economics of the Firm and others, depending on each programme of study.

Cluster Analysis - The cluster analysis aims at describing a group of individuals or of objects characterized by a group of attributes, by means of their regrouping in classes.

The input data are organized in an individual-variable table. The groups are established according to two big categories of procedures which make use of hierarchical or non-hierarchical methods using the rectangular or Euclidean distances.

$$d_{ij} = \|X_i - C_j\|^2 = \sum_{q=1}^{Q} (x_{qi} - c_{qj})^2 \qquad (1)$$

where *X*i is the vector of encoded input fields for record *i*, *C*j is the cluster centre vector for cluster *j*, *Q* is the number of encoded input fields, *x*qi is the value of the *q*th encoded input field for the *i*th record, and *c*qj is the value of the *q*th encoded input field for the *j*th record.

For each record, the distance between the record and each cluster centre is calculated, and the cluster centre whose distance from the record is the smallest is assigned as the record's new cluster.

When all records have been assigned, the cluster centres are updated.

Discriminant Analysis - One of the objectives of the discriminant analysis is to see which of the explicative variables contributes to the characterisation of the classes the most. The techniques for the discriminant analysis are based on the decomposition of the total variance V into the two components, i.e. W (within the classes) and B (between classes), meaning V= W + B

The Coefficients of the discriminant function are given by the vector which results from the equation $\left(W^{-1}B-\lambda I\right)v=0$.

The quality of the discrimination can be measured by means of Wilks' λ statistics, calculated for the discrimination axis Δ. The more $\lambda \rightarrow 0$, the stronger the discrimination power.

Given that the variable to be explained has only two modalities, only one discrimination function results. In order to select the subjects with the greatest discrimination power, the stepwise method was used. Discriminant functions resulted at the level of all programme of study and of the subjects which produced the greatest differences between students' grades.

After grades have been analysed and discriminant subjects identified, the questionnaires for evaluating teachers were designed and compiled. Several questions were retrieved from questionnaires considered as standard in several western universities, and they were completed with questions focusing on identifying students' background and the field of the high school graduated. The questionnaires, translated and adapted into Romanian, were loaded on the open source platform Limesurvey, so as for full-time education students to be able to fill them in online.

After the questionnaires were filled in, the data were exported from Limesurvey in SPSS format.

3. Research findings

In order to build the analysis model for the evaluation performed by teachers to students with a view to identifying the subjects which produced significant differences in the results obtained in exams, the grades of 441 students were used, among which: 62 students in International Business, 39 in Business Administration in English, 51 in Finance and Banking, 26 Business Information Systems, 65 in Marketing, 57 in Management, 51 in the Economics of Trade, Tourism and Services, 74 in Accounting and Management Information Systems.

Table 1 shows the means of the grades obtained by the students grouped in clusters by means of the k-Means technique.

Programmes of study	Subjects	Means		
		Cluster 1	Cluster 2	Total
AI	Introduction to Business Information Systems	8.71	6.30	7.29
	Business Law	9.10	7.43	8.12
	World Economics	8.24	6.00	6.92
	Mathematics applied in Economics	7.33	4.77	5.82
	Microeconomics	5.57	4.23	4.78
	Valid N/Missing:14	21	30	51
BA	Business Law	8.36	6.92	7.85
	Economics of the Firm	8.50	6.58	7.82
	World Economics	8.55	6.08	7.68
	Business Information Systems Mathematics applied	8.14	6.83	7.68
	in Economics	8.27	3.08	6.44
	Microeconomics	9.00	8.08	8.68
	Valid N/Missing:11	22	12	34
CIG	Introduction to Business Information Systems	8.56	5.97	7.26
	History of the European Construction	8.69	8.28	8.49
	Management	8.39	6.33	7.36
	Mathematics applied in Economics	8.03	4.61	6.32
	Microeconomics	5.78	5.00	5.39
	Valid N/Missing:6	36	36	72
FB	Introduction to Business Information Systems	8.36	6.00	7.20
	History of the European Construction	9.32	8.50	8.92
	Management	8.12	5.29	6.73
	Mathematics applied in Economics	7.28	3.71	5.53
	Microeconomics	5.84	4.75	5.31
	Valid N/Missing:5	25	24	49
ECTS	Introduction to Business Information Systems	7.23	5.28	6.24
	Economics of the Firm	9.29	7.72	8.49
	European Economics	7.71	5.22	6.44
	Introduction to the Science of Commodities	6.00	5.34	5.67
	Mathematics applied in Economics	5.90	3.72	4.79
	Microeconomics	9.29	6.53	7.89
	Valid N/Missing:8	31	32	63
MK	Introduction to Business Information Systems	8.06	5.46	6.90
	Economics of the Firm	9.46	8.50	9.03
	European Economics	7.37	5.18	6.40
	Introduction to the Science of Commodities	6.26	5.11	5.75
	Mathematics applied in Economics	7.37	4.71	6.19
	Microeconomics	9.03	6.43	7.87
	Valid N/Missing:7	35	28	63

Programmes of study	Subjects	Means		
		Cluster 1	Cluster 2	Total
IE	Algebra and Probability	9.60	7.00	8.04
	Mathematical Analysis	8.50	4.20	5.92
	Introduction to Business Information Systems	9.20	8.13	8.56
	Business Law	10.00	9.60	9.76
	Microeconomics	7.10	6.13	6.52
	Valid N/Missing:4	10	15	25
MN	Introduction to Business Information Systems	6.61	4.42	5.45
	Commercial Law	9.65	8.77	9.18
	Economics of the Firm	9.09	8.08	8.55
	Management general	8.57	6.35	7.39
	Mathematics applied in Economics	6.04	3.12	4.49
	Microeconomics	5.83	4.73	5.24
	Valid N/Missing:19	23	26	49

Table 1. *Cluster analysis*

For each programme of study, the discriminant analysis was applied in order to identify the subjects that produced significant differences between the means of the 2 clusters. The findings are presented in Table 2.

Programmes of study	Canonical Discriminant Function Coefficients	Chi-square	Wilks' Lambda	df	Sig.
AI	Y = -9,267+0,506X1+0.403X2+0.397X3 X1 Introduction to Business Information Systems X2 Business Law X3 Mathematics applied in Economics	54.228	.319	3	.000
BA	Y = -5,725+0.490X1+0,334X2 X1 Mathematics applied in Economics X2 World Economics	40.995	.266	2	.000
CIG	Y = -7,213+0,424X1+0,371X2+0,250X3 X1 Mathematics applied in Economics X2 Introduction to Business Information Systems X3 Management	79.525	.313	3	.000
FB	Y = -6,126+0,642X1+0,382X2 X1 Mathematics applied in Economics X2 Management	63.385	.252	2	.000
ECTS	Y = -9,782+0,586X1+0,372X2+0,325X3 X1 Microeconomics X2 European Economics X3 Economics of the Firm	72.954	.293	3	.000

Programmes of study	Canonical Discriminant Function Coefficients	Chi-square	Wilks' Lambda	df	Sig.
MK	Y = -7,363+0,397X1+0,351X2+0,300X3 X1 Introduction to Business Information Systems X2 Microeconomics X3 Mathematics applied in Economics	63.636	.343	3	.000
IE	Y = -4,95+0,836X1 X1 Mathematical analysis	33.193	.229	1	.000
MN	Y = -6,349+0,507X1+0,322X2+0,314X3 X1 Mathematics applied in Economics X2 Introduction to Business Information Systems X3 General Management	52.358	.316	3	.000

Table 2. *Discriminant analysis*

For all these subjects, Wilks' Lambda shows an acceptable discrimination. Table 2 shows that there are common subjects that produced significant differences for the cluster means: Mathematics, Introduction to Business Information Systems, Microeconomics.

Based on these analyses, we were further interested to study the students' opinions regarding the courses where they obtained very different grades. For building the analysis model for the teachers' evaluation by students, we developed a research study based on an online questionnaire that was applied to students before the exams. 214 completed questionnaires were received. For each program of study, we calculated the percentage of those who answered, considering the total number of registered students: 18.97% from International Business, 51.28% Business Administration (in English), 68.63% Finance and Banking, 76.92% Business Information Systems, 49.23% Marketing, 78.95% Management, 76.12% Economics of Trade, Tourism and Services.

In order to verify the representativeness of the sample, we compared the structure of the sample for each program of study with the structure of the analyzed students based on their grades (as total population) and we obtained an error of 4.34%, lower than 5%; therefore, we considered the sample as representative.

The questionnaire was structured into two components: the first part comprised 17 questions related to the evaluation of courses where significant differences appeared among student grades (Likert scale 1-5:1 – I totally disagree, 2 – I disagree, 3 – I neither agree nor disagree, 4 – I agree, 5 – I fully agree). The second part was also based on 22 questions (the majority of questions using the Likert scale) for evaluating the teachers. For further processing, we grouped the questions into categories, among which:

– Teaching and learning activities related to the logistics of the course

– Respect to the student
– Communicating expectations
– Engagement during the class – involving students in discussions related to novelty in the field
– Evaluation and feedback
– Subject cohesion and how it was taught
– Teachers' enthusiasm and interest
– Organization and clarity regarding the way the course was organized and delivered.

Each item was analysed using descriptive statistics. For each answer, we calculated the relative frequencies. A question has arisen: *How the students' answers are distributed among the following possible answers: Agreement, Total Agreement, Disagreement, Total Disagreement.*

For answering this question, we built the **NetScore** indicator using the formula:

$$SN = PTAA - PTNAA$$

where:

SN - net score (%)
PTAA - the percent of those who agreed with the item (%)
PTNAA - the percent of those who did not agree with the item (%)

If SN > 0 the course or the teacher received positive feedback from the students

If SN < 0 the course or the teacher received negative feedback from the students

Based on this *NetScore*, we created a synthesis of the answers for the discriminant subjects and programs of study (Table 3), out of which we exemplify Mathematics and Introduction to Business Information Systems as discriminant subjects to the majority of the programs of study.

	Net scores% for the Course								
	Mathematics applied in economics						Introduction to Business Information Systems		
	MN	IE	AI	MK	BA	FB	AI	MN	MK
The general atmosphere during this course favoured learning.	0	35.00	63.6	93.75	60.0	-8.57	18.18	48.89	68.75
The course used different learning types (audio/video, group activities).	8.89	5.00	36.3	65.63	30.0	-14.3	-9.09	62.22	65.63
The requirements of the course (projects, papers, exams) were clearly explained.	40	5.00	45.4	87.50	40.0	-5.71	9.09	57.78	71.88
Students were invited to share ideas and knowledge.	-11.1	-10.0	18.1	62.50	35.0	-11.4	0.00	4.44	-9.38

The feedback for the homework contributed to the acquisition of knowledge.	8.89	-15.0	36.3	56.25	35.0	20.00	9.09	22.22	25.00
Learning activities were well integrated in the course.	24.44	20.00	45.4	93.75	35.0	17.14	-18.18	40	46.88
In the case of this course, I was motivated to learn.	-2.22	0.00	54.5	84.38	40.0	0.00	-36.36	20	25.00
Course materials were presented in an organized manner.	51.11	50.00	72.7	96.88	60.0	0.00	45.45	71.11	71.88
Course objectives were clearly explained.	26.67	25.00	63.6	100.0	25.0	-5.71	54.55	62.22	87.50
	Net scores% for the Teacher								
	Mathematics applied in economics						Introduction to Business Information Systems		
	MN	IE	AI	MK	BA	FB	AI	MN	MK
He/ she follows the course outline presented at the beginning of the semester.	64.44	35.00	81.8	93.75	40.0	37.14	36.36	71.11	81.25
He/ she explains clearly, speaks in a manner which is easily understood.	0	0.00	90.9	96.88	45.0	-14.3	9.09	48.89	81.25
He/ she respects students.	33.33	20.00	54.5	81.25	40.0	28.57	27.27	42.22	34.38
He/ she is preoccupied with the quality of the teaching process.	-13.3	0.00	54.5	87.50	45.0	-45.7	-9.09	28.89	-6.25
He/ she encourages discussions during the class.	-35.5	-25.0	0.00	31.25	40.0	-62.8	0.00	15.56	6.25
He/ she sets evaluation and exam topics which are reasonable from the point of view of their length and degree of difficulty.	-8.89	10.00	36.3	46.88	55.0	-11.4	18.18	11.11	12.50
He/ she is available for students outside classes.	-20	0.00	54.5	53.13	40.0	-31.4	27.27	17.78	18.75
He/ she uses efficient additional materials.	-13.3	5.00	63.6	3.13	40.0	-34.2	36.36	57.78	12.50
Please rate which the general focus of the course was, on memorization or on problematization.	64.44	45.00	81.8	15.63	70.0	48.57	-90.91	-2.22	-65.63
Please rate the amount of study for the subject taught, the workload and the difficulty of each subject as compared to the other subjects taught (smaller or greater)	77.78	75.00	0.00	25.00	55.0	62.86	54.55	40	75.00
The workload for doing the homework as compared to the other subjects taught (smaller or greater)	46.67	65.00	36.3	15.63	45.0	62.86	18.18	-8.89	-34.38
The difficulty of the subject (low or high)	88.89	75.00	27.2	37.50	35.0	77.14	36.36	60	43.75

Table 3. *Net scores%*

These net scores allowed us to draw some conclusions. Thus, for **Mathematics**, for all the programs of study, students consider the subject as difficult, with an emphasis on problems, high amount of study and high workload. According to the net negative scores for some categories, we believe that greater attention from the teachers is required in order to encourage discussions during the classes, the use multiple resources for better understanding the subject and for involving students in the teaching and thoroughgoing study by means of homework.

For the subject **Introduction to Business Information Systems**, we may conclude that students consider it as a difficult subject with an emphasis on memorization (although it is a computer science subject), with low workload for homework and high workload for study. According to the net negative scores for some categories, we believe that greater attention from the teachers is required as regards the quality of teaching, so as to encourage students to share their ideas and knowledge during the classes and to involve them in the teaching and thoroughgoing study by setting homework.

4. Conclusions

This paper aimed at developing a combined evaluation model: starting from the results of the students' evaluation by teachers, by means of the cluster analysis and the discriminant analysis, we identified the subjects that have produced significant differences between the student's grades. Thus, the interest in knowing the students' opinions for some aspects regarding the workload and the difficulty of the subject has appeared, and also the way the teacher conveys the information and involves in the relationship with the students.

The results of these analyses emphasise that there are subjects with a high degree of perceived difficulty, which are oriented towards problems and which require a high workload, but also there are less difficult subjects that are oriented towards memorization. Also, we found out that higher attention from the teacher is required to encourage discussions during the classes. Students should also be invited to use multiple resources for better understanding the subject and should get involved in the teaching process, by doing the homework set.

After analysing the content of the evaluation questionnaires, the students' expectations regarding the course content can be detected: the course should be organized, systematic and coherent; the teacher should apply active, participatory methods (student-centred) and use modern tools (video projector, computer etc.); the course should be clear and concise; the course should achieve its objectives; the students should be involved in dialogue, constructive criticism and be permitted to have personal solutions; the assessment should be done correctly.

Evaluating the teachers and the courses is very useful for students, for teachers themselves and for the decision-making factors.

As a result of the study, we propose several improvement measures: teachers and students have different perceptions regarding the evaluation tools, which requires research among teachers to find out their perceptions on the way they are evaluated by the students; while designing the questionnaires, greater attention is required, as this should take into account the students' evaluation competences and the areas that could be evaluated by the students; specialists from the didactic and pedagogy fields should be involved in multi-disciplinary teams for building a guide for evaluating the teachers' transversal competences; the students should become more aware of the role and status they have in higher education

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