FRESHMEN AND SENIORS IN ENGINEERING: HOW DO THEY PERCEIVE THE ABILITIES AND COMPETENCES, WHICH ARE IMPORTANT FOR THIS PROFESSION?

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Abstract. *The objective of this paper is to investigate whether (or not) freshmen and senior university students have the same views about the abilities and competences that they consider most important for exercising this profession. This survey was conducted with students of 11 engineering courses of Barretos, Campinas, São Carlos e São Paulo. The data were collected through the use of a Likert scale and analyzed according to the statistical method of discriminant analysis. Such analysis makes it possible to check not only if the viewpoints are different, but also pinpoint in which abilities and competences the groups differ. This analysis showed that the enrollment year in the engineering course does not matter, all the groups show the same opinion about the most important abilities and competences for the profession, since there were no significant differences between the answers given by each group for each of the assertions analyzed.*

***Keywords**: Abilities, competences, Discriminat Analysis*

1. Introduction

When speaking about teaching engineering, what we can observe in the international scenario is the need for a new educational background, that is, a restructuring of the courses in order to meet the new expectations of society and, therefore of the work market (Querino e Borges, 2002; Silva *et al,* 2002; Bucciarelli *et al,* 2000; Rompelman, 2000, Bazzo, 1998; ForGrad, 1999; McKee, 1999; Moraes, 1999; Peschges e Reindel, 1999; Raghy, 1999; Silva, 1999).

Both society and the market demand new abilities and competences (non-technical) of the engineer practicing this profession.

However, a first analysis of the structure of most of the graduation courses in engineering and, consequently, of the pedagogical practice of classrooms, suggests that such abilities and competences are not being fully developed in the courses for future engineers (Simon et al, 2002; Bazzo, 1998).

Thus, we could ask: do freshmen and veterans share (or not) the same views about the abilities and competences which they consider to be the most important to practice this profession?

In this paper, we will present the results of a survey conducted with students of 11 Engineering courses. It is an attempt to structure a broader investigation aimed at identifying the shortcomings of engineering courses in relation to the development of new abilities and competences.

2. Methodology and instruments used

This investigation is quantitative. The advantage of such a method is to collect a large quantity of information with a certain degree of statistical reliability. The data were obtained through a survey, with a Likert attitude scale, and were analyzed according to multivariate statistical methods.

In order to do that, we used a questionnaire elaborated by Simon (2004), that includes a set of abilities and competences, which was answered trough a Likert scale. This scale was conceived by Rensis Likert in 1932 and is comprised of a set of assertions in which the respondents are required give grades from 1 (not important) to 5 (extremely important). It aims at listing attitudes towards a set of assertions. In this specific case, the assertions were about abilities and competences.

So, it was asked that the respondents agreed or disagreed with the statements proposed, in a hierarchical manner, which allows giving opinions that range from strong agreement to strong disagreement towards the statement. For each of the choices points ranging from 1 to 5 are awarded, so that the sample can be treated quantitatively according to a statistical method known as Discriminant Analysis (Hair *et al*, 1998). With this method we are able to check if there are statistically significant differences between the average profiles, for each assertion, for previously defined groups.

3. Sample

The data were gathered from a sample of 402 students in 11 majors of graduation courses in engineering in the regions of Barretos, Campinas, São Carlos and São Paulo.

In order to conduct the analyses, the subjects were divided in 6 Groups, with 67 respondents each[1].

a) Group 1 – Subjects enrolled in the course up to 1999
b) Group 2 – Subjects enrolled in 2000
c) Group 3– Subjects enrolled in 2001
d) Group 4– Subjects enrolled in 2002
e) Group 5– Subjects enrolled in 2003
f) Group 6– Subjects enrolled in 2004

4. Results

Table 1 below, shows that the variable means do not significant vary individually among groups.

1This survey was conducted in the first term of 2004.

Table 1 – Means and Standard Deviation of groups for each of the variables[2]

Var	Mean Until 1999	SD Until 1999	Mean 2000	SD 2000	Mean 2001	SD 2001	Mean 2002	SD 2002	Mean 2003	SD 2003	Mean 2004	SD 2004
01	4,33	,82	4,19	,87	3,94	1,00	4,15	,84	4,00	,82	3,99	,86
02	4,07	,93	4,04	,88	4,09	,92	4,00	,97	4,22	,98	4,04	,75
03	3,63	,74	3,78	,90	3,67	1,08	3,45	1,03	3,58	,92	4,03	,89
04	4,34	,69	4,27	,73	4,22	,85	4,40	,82	4,42	,68	4,16	,90
05	3,88	,91	4,13	,80	4,03	,87	4,16	,83	4,28	,75	4,24	,84
06	4,27	,73	4,34	,79	4,21	,86	4,18	,78	4,06	,85	4,13	,90
07	3,61	,85	3,82	,97	3,67	,81	3,58	,87	3,70	,90	4,12	,84
08	4,36	,73	4,55	,58	4,39	,72	4,42	,74	4,57	,66	4,52	,61
09	4,61	,55	4,57	,76	4,52	,70	4,60	,58	4,67	,64	4,43	,76
10	4,22	,76	4,25	,80	4,19	,82	4,42	,84	4,33	,75	4,22	,78
11	4,27	,73	4,18	,83	4,06	1,06	4,34	,81	4,09	,81	4,07	,82
12	4,22	,65	4,31	,76	4,04	,96	4,28	,85	3,99	,88	4,31	,74
13	3,76	,84	3,67	,88	3,78	,93	3,88	1,02	3,64	1,08	4,16	,83
14	4,27	,71	4,31	,72	4,27	,77	4,22	,88	4,27	,86	4,37	,74
15	3,97	,97	4,10	,97	3,96	,89	3,91	1,01	4,01	,93	4,09	,93
16	4,04	,86	4,13	1,01	3,90	,89	3,97	1,00	4,15	,86	4,27	,69
17	3,90	,80	3,94	,89	3,81	,94	4,01	,84	4,00	,83	4,19	,78
18	3,84	,79	4,06	,87	4,12	,81	4,07	,86	4,15	,76	4,13	,72
19	3,88	,86	3,87	,92	3,69	,89	3,87	,85	3,76	,87	4,13	,80
20	4,19	,72	4,15	,91	4,10	,78	4,10	,91	4,07	,64	4,15	,78
21	3,91	,75	4,22	,85	4,12	,86	4,18	,87	4,09	,71	4,24	,74
22	3,85	,82	3,91	,88	3,82	,69	3,87	,90	3,84	,79	4,12	,81
23	3,93	,89	4,18	,85	3,99	,95	4,18	,92	4,31	,82	4,37	,69
24	4,15	,80	4,06	,90	3,82	,90	4,18	,82	4,16	,83	4,10	,76
25	3,93	,88	4,06	,89	4,03	,89	4,03	,90	4,12	,90	4,27	,77
26	4,31	,78	4,30	,76	4,25	,77	4,33	,91	4,46	,75	4,36	,73
27	4,03	,95	4,04	,93	3,99	1,04	4,10	,94	4,15	,84	4,45	,63

To start the discriminant analysis, a Box´s M test was conducted in order to check whether or not the different dispersions observed among groups were statistically significant. Once the test revealed a significance level of 0,083 (higher than 0,05) we were able to find that there was equanimity of dispersion among groups and proceed with the analysis.

After that, the value for Wilks' lambda was calculated for each individual variable, in order to evaluate the significance of the differences among the average of independent variables for all 6 groups. Table 2 shows the values for each variable.

2) See in annex the variables studied.

Table 2 – Wilks' lambda for each variable

Variable	Wilks' Lambda	Sig.
01	,976	,081
02	,994	,788
03	,963	,010
04	,986	,343
05	,974	,066
06	,988	,424
07	,958	,005
08	,955	,011
09	,987	,413
10	,990	,578
11	,984	,283
12	,972	,045
13	,966	,018
14	,996	,921
15	,994	,821
16	,981	,180
17	,970	,009
18	,983	,222
19	,975	,069
20	,998	,964
21	,981	,180
22	,985	,289
23	,966	,016
24	,969	,042
25	,985	,324
26	,993	,738
27	,981	,129

Table 2 shows that variables 3, 7, 8, 12, 13, 17, 23 e 24 have low significance levels (under 0,05), which demonstrates significant differences among the 6 groups. The other variables did not display significantly differences for the groups studied.

Now, we will analyze the structure matrix (Table 3) in order to assess the correlation between each variable and the discriminant functions.

Table 3 – Structure Matrix

Variable	Functions				
	1	2	3	4	5
07	,384	,096	,023	,232	,000
03	,331	,182	-,143	,248	-,100
25	,219	-,088	,105	,031	,003
22	,215	,130	,117	,042	,044
09	-,177	-,129	,121	,146	-,059
05	,177	-,306	,254	,082	,186
01	-,187	,299	,132	,245	,116
18	,152	-,289	-,021	-,099	,145
20	-,002	,136	-,012	,064	-,024
24	-,041	,053	,507	,193	,027
23	,251	-,225	,366	,179	,162
17	,195	,028	,360	,033	,057
27	,282	,040	,315	-,011	-,096
19	,210	,259	,279	,069	,055
10	-,062	-,109	,256	-,090	,210
04	-,174	-,125	,239	,030	,000
26	,021	-,126	,213	,124	-,134
13	,267	,222	,191	-,386	,001
16	,178	,030	,220	,375	-,071
08	,120	-,176	,101	,353	,121
15	,094	,017	-,027	,250	,037
14	,101	,048	-,023	,105	-,026
12	,080	,340	,150	,064	,455
21	,182	-,107	-,006	-,025	,454
11	-,153	,154	,216	-,087	,252
06	-,067	,193	-,203	,156	,243
02	-,016	-,152	,004	,126	-,240

Note: the variables were sorted by absolute size of the correlation to each of the functions.
The greater absolute correlations between each variable and the discriminant function are shown in bold.

Table 3, shows that variables 7, 3, 25, 22 and 9 are strongly correlated with the first discriminant function, variables 5, 1, 18 and 20 with the second discriminant function, variables 24, 23, 17, 27, 19, 10, 4 and 26 with the third, variables 13, 16, 8, 15 and 14 with the fourth, and the remainder with the fifth. However, Table 2 shows that the differences are not statistically significant only for variables 3, 7, 8, 12, 13, 17, 23 e 24, that is, for variables, which have correlation coefficients with the discriminant function higher than 0,350.

Now, the importance of each discriminant function must be evaluated. The first function alone explains 48,5% of the inter-group variance, the second function contributes with 21,7%, the third with 13,4% for the total variance among groups, and the remainder with less than 9%. Thus, we will concentrate our analysis on the first function.

We proceeded with Wilks' lambda test in order to evaluate the significance of each discriminant function as well as its discrimination power. Table 4 shows such values.

Table 4 – Values of Wilks' lambda for each discriminant function

Test of Function(s)	Wilks' Lambda	Sig.
1 through 5	,698	,000
2 through 5	,759	,431
3 through 5	,851	,857
4 through 5	,914	,928
5	,958	,841

The first line of Table 4, tests the hypothesis that the averages of the 5 discriminant functions could be equal for all 6 groups, which is rejected, for the significance is lower than 0,0001. The following lines show that functions 2 to 5

display high levels of significance (above 0,05) and, therefore, are not important for the discrimination among groups. Because of that, only the first function will be analyzed.

Nonetheless, the value of Wilks' lambda obtained for this function is high, which reveals that the differences among groups obtained using this function are not significant.

This can also be observed through the structural matrix (Table 3), since the correlation coefficients among variables and the first discriminant function are not over 0,384.

This way, we can come to the conclusion that there are no significant differences, among all 6 groups, in relation to the opinions shown by the independent variables, since the value of Wilks' lambda for the only statistically significant discriminant function is high (0,698).

5. Conclusions

In our research, we could observe that both the students that have just enrolled in the course (in 2004) and the ones who have been in the course for more than 5 years (enrollment up to 1999) have the same views towards the abilities and competences, which are important in the profession. Statistically significant differences were not found in any of the assertions studied.

This leads to the following interpretation: the courses have not been able to alter the perceptions of students about the abilities and competences which they must develop during their graduation course in order to have a successful performance in the market.

This way, we could observe that a lot has been discussed and proposed about much needed restructuring of how we teach Engineering. Many papers have pointed out the necessity of curriculum reform, inclusion of new subjects, and a more humanistic background for engineers (Rompelman, 2000; Raju e Sankar, 1999). However, despite all this debate, little effective change has taken place in graduation courses in relation to the development of new abilities and competences.

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7. Anexx

Studied Variables

1. Ability to save resources
2. Treat people and projects with justice and impartiality
3. Facility to write /write well
4. Have a global vision of production
5. Basic as well as area-specific software user
6. Flexible /versatile
7. Have a broad general culture
8. Seek constant updating
9. Committed to quality in everything he/she does
10. Have a vision of market needs
11. Know foreign languages, especially English and Spanish
12. Ability to lead people
13. Bold / is not afraid of making mistakes
14. Have decision-making initiative
15. Concerned with the environment, the community and society
16. Value professional ethics
17. Have knowledge of costs
18. Qualified for planning, is objective in the establishment of aims
19. Generalist knowledge of engineering and vision of the contact fields
20. Able to explain ideas in an organized fashion
21. Have creative/original solutions
22. Able to assimilate simultaneous orientations
23. Know how to identify, formulate and solve engineering problems
24. Ability to live with/through change
25. Concerned with labor safety
26. Ability for teamwork
27. Ability design and conduct experiments

8. Responsibility notice

The authors are the only responsible for the printed material included in this paper.