
AC 2012-3916: THE BACKGROUND AND MOTIVATION OF FIRST-YEAR ENGINEERING STUDENTS IN RELATION TO GENDER

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The background and motivation of first year engineering students in relation to gender

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Each year over 400 students enter the first year of the Engineering Bachelor's Program at KU Leuven, a catholic university in the Dutch speaking part of Belgium. Amongst them, there are only about 14 % female students. The female students do not differ from the male students in background. However, significant differences are noticed in their overall grades in high school, their motivation profiles, self-esteem and total study time. Due to all these observations, it is expected that the average female student would be the better performer in her first year at university. This however, was not observed. Overall there is no significant difference in the average score for all first year courses between female and male students.

This paper first describes the materials and methods used to characterize the background and motivation profiles of first year engineering students. Then the results are discussed for the academic years 2009-2010 and 2010-2011.

1. Introduction

This paper describes the background and motivation of first year engineering students at the Engineering Faculty of KU Leuven.

KU Leuven is a Catholic University situated in the Dutch speaking part of Belgium. The university organizes approximately 60 Bachelor's programs and more than 125 Master's programs in three main fields: Humanities and Social Sciences; Science, Engineering and Technology and Biomedical Sciences. In 2010 approximately 37000 students were enrolled at KU Leuven. The Engineering Faculty is part of the Science, Engineering and Technology group. The engineering curriculum consists of a three year Bachelor's program that prepares the students for a subsequent Master's program of two years. The Faculty organizes Master's programs in several disciplines, like Architecture, Electrical Engineering, Mechanical Engineering, Chemical Engineering, Materials Engineering, Civil Engineering, Biomedical Technology, Computer Science, Energy Engineering, Nuclear Engineering, Industrial Management, Nano science and Nanotechnology, Mathematical Engineering, Bioinformatics, Statistics, ...

The Engineering Bachelor's program is divided in two subsequent phases. The first phase of the Bachelor lasts three semesters and is common for all engineering disciplines with the exception of the study leading to the degree in architecture.

For the subsequent three semesters, this is the second phase of the Bachelor's program, the students choose a Major and Minor discipline, that prepare the students for the subsequent

Master's program. That way the Faculty of Engineering combines teaching a broad base of scientific knowledge with educating very specialized technological knowledge and skills.

The performed study took place in the first year of the Engineering Bachelor's program, which is common for all engineering students. The courses are subdivided into three groups: mathematics, energy and material science, information and communication science. Parallel to the regular coursework, all engineering students take the project based course Problem Solving and Engineering Design (acronym P&O in Dutch) that introduces them from the first semester onwards into real engineering practice and teamwork.¹

Each year around 450 students enter the first year of the Bachelor's program, which is common for all engineering disciplines. Amongst them, there are only about 14% female students. This is reflected within the staff of the Engineering Faculty: about 10 % of the professors are female.

Within this study the differences in background and motivation of the first year engineering students were measured in relation to gender. Furthermore, because it was hypothesized that both aforementioned characteristics have an influence on the academic achievement^{2,3}, the students' study time and grades were compared with the gathered data.

2. Materials and methods

Subjects

For this study, data was gathered during two subsequent academic years: 2009 – 2010 and 2010 – 2011. All participants were first year engineering students. Table 1 gives an overview of the number of students that participated and their gender distribution.

Table 1: Overview of the number of participants and their gender.

Academic year	Total number of participants	Number of female participants	Percentage of female participants
2009-2010	421	61	14.5 %
2010-2011	430	57	13.3 %
Total:	851	118	13.9 %

All participants filled out a written questionnaire in the beginning of the academic year and provided informed consent for the study. The students filled out the questionnaire during class time within the presence of didactic staff.

Background

To characterize their background, in the first part of the written questionnaire, all participating students were asked to indicate the level of their prior mathematical education (number of hours mathematics per week) and their overall score in high school. The overall score in high school in Flanders is a common achievement-indicator and is calculated as a weighted average of the grades a student gets on all courses in the final year at high school.

Motivation profile

The self-determination theory distinguishes the quantity of motivation from the quality or type of motivation.^{4,5} Autonomous motivation, which leads among others to greater use of adaptive meta-cognitive strategies, better cognitive processing and higher grades, consists of two subcomponents: intrinsic motivation ('I am motivated to study because I like studying') and well-internalized extrinsic motivation ('I am motivated to study because I think it is worthwhile'). Controlled motivation, which predicts undesirable outcomes like less engagement in adaptive meta-cognitive strategies, superficial cognitive processing and lower achievement, also consists of two subcomponents: external regulation ('I am studying because I am supposed to do so') and introjected regulation ('I am studying because I would be ashamed if I wouldn't study'). Vansteenkiste et al. used a cluster analysis to categorize individuals in four groups with similar motivational profiles.⁵ Table 2 describes the four distinguished motivational profiles. Not only the quantity of the motivation is important regarding students' learning and performance, but also the quality matters. Students with a good quality motivation profile are most likely to achieve good educational outcomes relative to all other profiles.

Table 2: Overview of the different types of motivation profiles.³

Motivation profile	Autonomous motivation (intrinsic motivation + well-internalized extrinsic motivation)	Controlled motivation (external regulation + introjected regulation)
1. Good quality	High	Low
2. High quantity	High	High
3. Poor quality	Low	High
4. Low quantity	Low	Low

In both academic years, the motivation profile of the participants was measured by including a series of Likert-type statements in the written questionnaire (on a scale from 1 = not at all true to 5 = very true).⁵

Self-esteem

For measuring the students' self-esteem two additional statements were added to the questionnaire in both 2009-2010 and 2010-2011. The students answered on a Likert-type scale from 1 (not at all true) to 5 (very true) whether they agreed with the statements: 'I find myself able to pass the exams' and 'This study is too difficult for me'.

Study time

At the end of the first semester in the academic year 2010-2011, after the exams, self-reported study time measurements were performed. Table 3 summarizes the different courses in the first year of the Engineering Bachelor's Program.

Academic achievement

The students' grades on the examinations were gathered in both academic years for all three examinations periods (January, June and September).

Table 3: Summary of the courses in the first year of the Engineering Bachelor's Program.

Course	Semester	ECTS
Calculus - 1	1	6
Calculus - 2	2	5
Algebra	1	5
Technical chemistry	1	7
Applied mechanics	1	5
General physics	2	7
Thermodynamics	2	3
Informatics	2	6
P&O - 1	1	4
P&O - 2	2	3
Philosophy	1	3
Material science	2	3
Electrical circuits	2	3

3. Results

Background

The female students do not differ from the male students in their prior mathematical education. However, significant differences are noticed in the overall percentage in high school.

Around 90 % of the incoming students studied at a general secondary school Science – Mathematics or Latin/Greek – Mathematics as their main subjects. This means that most of these students followed 6 to 8 hours of mathematics per week in high school (figure 1).

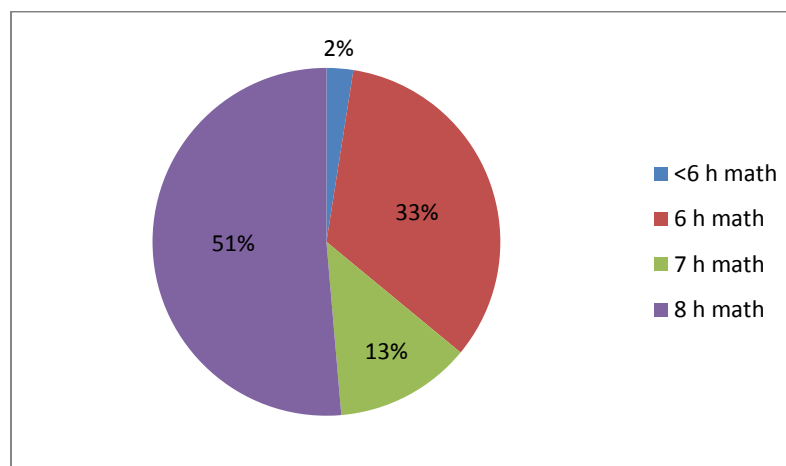


Figure 1: Distribution of background of the incoming students: prior hours of mathematics courses in high school. This distribution is similar for men and women.

The overall score in high school is calculated as a weighted average of all the grades a student gets on all courses in the final year at high school. The overall high school score of the starting female students is significantly higher compared to the male starting students: 78%, $\sigma = 6$ versus 75%, $\sigma = 7$ ($p < 0.001$). Figure 2 shows a histogram of the overall percentage of the incoming students in their final year at high school.

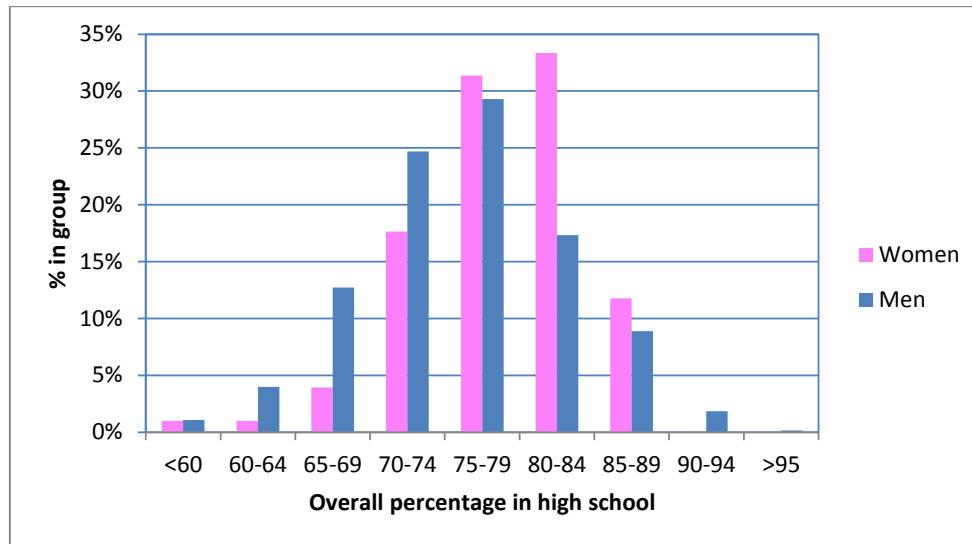


Figure 2: Histogram of the overall percentage of the incoming students in their final year in high school.

Motivation profiles

Significant differences are noticed in the motivation profiles of the female and male first year engineering students. Figure 3 shows the distribution of the participants' motivation profiles. The figure shows that relatively more female students have the most beneficial motivation profile (good quality). The motivation profile of the female students is in general of a much better quality: an average of 2.5 ($\sigma = 1.0$) on a scale from 1 (good quality, which is the best motivation profile) to 4 (low quantity, which is the worst motivation profile), whereas the average male student has a motivation profile of 2.9 ($\sigma = 1.1$), with $p < 0.01$.

Self-esteem

At the beginning of the academic year, more male students (60%) are certain, they will pass their exams with good results compared to the female students (only 40%), with $p < 0.01$. Figure 4 shows the percentage of female versus male students which agreed upon the statements (and responded with either 4 or 5 on the 5-point Likert-type scale).

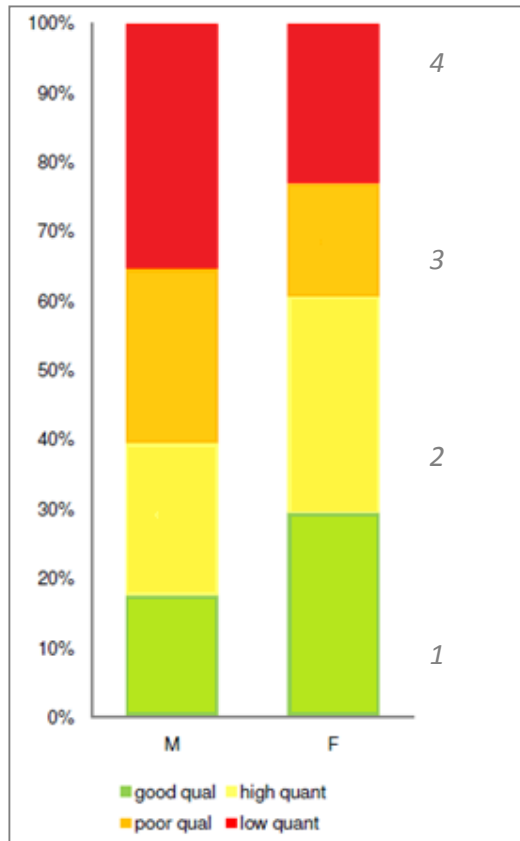


Figure 3: Distribution of the motivation profiles of the male (M) and female (F) first year engineering students. (1) good quality, (2) high quantity, (3) poor quality and (4) low quantity.

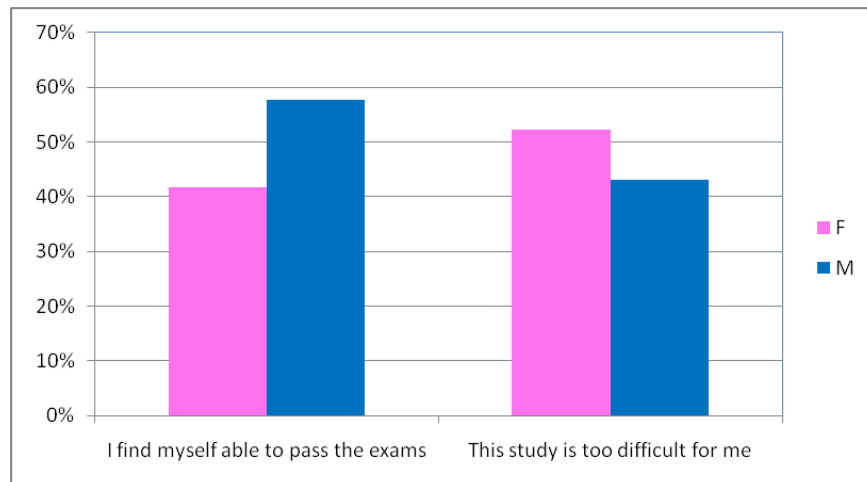


Figure 4: Percentage of students that agreed upon the statements regarding a high self-esteem. The data is gathered in both the academic years 2009-2010 and 2010-2011 and students that agreed responded with either 4 or 5 on the 5-point Likert-type scale.

Study time

Figure 5 shows the hours that the students report to spend studying at home for their courses in the first semester. To be able to compare the different subjects, the data is reported per ECTS-credit. It can be concluded that the average female student spends more time (about 8 hours) on studying each specific course of the first year compared to the average male student.

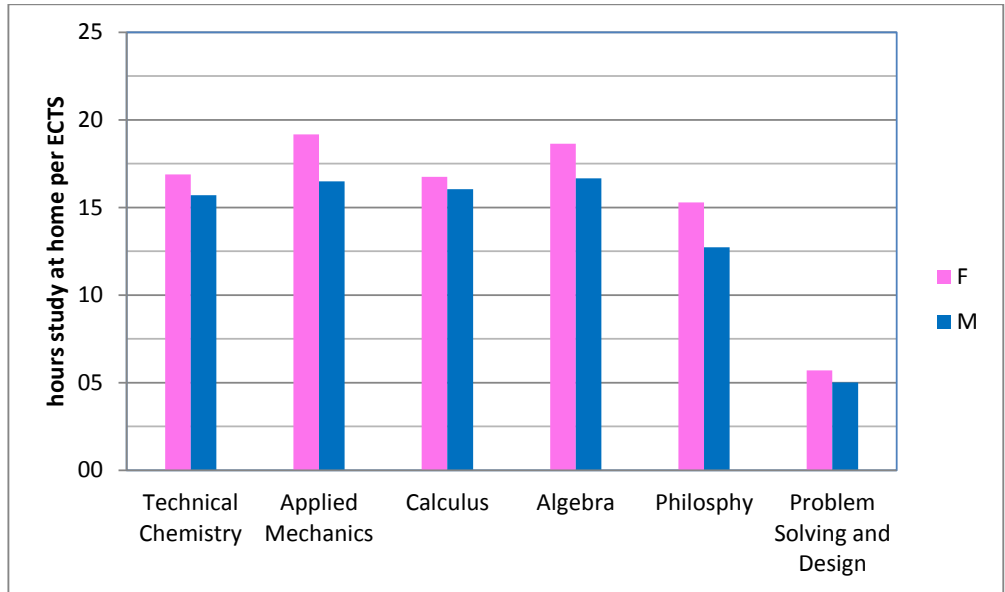


Figure 5: Overview of the self-reported hours of study time per ECTS, based upon a study time measurement at the end of the first semester in the academic year 2010-2011. The time spent in class is not taken into account in the graph.

Academic achievement

Table 4 gives an overview of the overall scores in the three examination periods. The overall score is calculated as a weighted average of the students' grades on all courses. Table 5 summarizes the average grades that the students obtained for their subsequent exams in January or June. The results of the examinations in September are not taken into account.

Table 4: Overview of the overall score for the examination periods in January, June and September of female (F) and male (M) first year engineering students. Significant differences ($p \leq 0.05$) are indicated in color.

	2009-2010					2010-2011				
	F		M		p (t-test)	F		M		p (t-test)
Overall score	mean	st. dev.	mean	st. dev.		mean	st. dev.	mean	st. dev.	
January	46.5%	13.55%	46.8%	15.6%	0.43	51.9%	10.7%	47.5%	16.3%	0.03
June	47.7%	14.9%	48.5%	16.8%	0.36	50.1%	12.8%	46.1%	17.9%	0.06
September	51.9%	15.2%	52.5%	16.7%	0.40	54.8%	12.5%	51.2%	17.9%	0.07

Table 5: Summary of the students' grades in January and June for female (F) and male (M) students. Significant differences ($p \leq 0.05$) are indicated in color.

Course	2009-2010					2010-2011				
	F		M		p (t-test)	F		M		p (t-test)
	mean	st. dev.	mean	st. dev.		mean	st. dev.	mean	st. dev.	
Calculus - 1	9.52	3.38	9.10	3.85	0.22	10.30	3.02	9.07	4.19	0.02
Calculus - 2	9.49	3.80	9.00	4.56	0.24	10.14	3.99	9.69	4.68	0.26
Algebra	9.47	3.17	9.28	3.73	0.36	9.64	2.46	8.29	3.64	0.00
Technical chemistry	8.56	3.34	8.90	4.10	0.28	10.32	3.36	9.87	4.40	0.23
Applied mechanics	8.74	2.34	9.43	3.01	0.05	8.46	3.34	8.66	3.79	0.36
General physics	11.39	4.61	11.20	4.70	0.40	8.61	4.05	8.77	4.65	0.41
Thermodynamics	9.84	3.34	10.37	4.13	0.20	10.35	4.18	10.59	4.23	0.35
Informatics	9.00	3.06	9.84	3.27	0.04	10.47	2.88	10.53	3.27	0.45
P&O - 1	12.83	1.66	13.24	1.75	0.05	13.20	1.24	12.84	1.44	0.04
P&O - 2	12.29	1.36	12.76	2.20	0.06	12.16	1.36	12.33	1.71	0.24
Philosophy	10.28	3.71	9.35	3.60	0.04	11.30	3.09	9.81	3.78	0.00
Material science	10.94	3.38	10.82	3.90	0.41	10.94	3.71	10.78	4.19	0.40
Electrical circuits	12.05	4.20	12.67	4.49	0.17	9.72	4.31	10.36	4.65	0.17

In general there is no significant difference in the overall score (in September) between the male and female students. When examining the scores on the different courses, a difference can be noticed between the mean scores of female and male students for general (scientific) courses on the one hand and typical technical engineering courses on the other hand. Female students tend to obtain better scores on more general (scientific) courses (calculus, philosophy). For more typical engineering courses, the male students tend to score slightly better.

4. Discussion and future perspectives

Most of the measured characteristics show a difference between the male and female first year engineering students. The overall high school score of the female students is significantly higher compared to the males, female students have in general a better motivation profile and they spent more time studying for their courses. Due to all these observations, it is expected that the average female student would be the significant better performer in her first year at university. But it was observed, that the group of female students did not score better in their first year. For the more general courses like Calculus, and Philosophy the female students score indeed significantly better; on the other hand, for more typical engineering courses such as Applied Mechanics and Informatics, the male students score slightly better. This confirms the results of Felder et al.⁶

The female students have less self-confidence, which confirms the results of Besterfield-Sacre et al.⁷ This lower self-confidence could explain their lower results compared to the male students. However, some course specific features of the technical courses of the Bachelor's program might appeal more to male students. An effort could be made to come up with more society-related technological examples to motivate the female students.^{8,9} Furthermore female students should benefit from having more female faculty and student role models.⁶

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