The academic culture among bridge programme students and the performance on mathematics exams

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Conference Key Areas: Diversity in engineering education, Mathematics and engineering education, Engineering education research

Keywords: bridge programme, mathematics, academic culture

INTRODUCTION

In Belgium two different types of engineering degrees coexist: Master of Science in Engineering (also: Master of Engineering Science) and Master of Industrial Sciences. The first degree requires the completion of a 5 year programme and focuses strongly on abstract thinking and applied scientific research, the latter requires the completion of a 4 year programme and has a less abstract and more hands on approach to engineering. Both types of engineer are highly valued in all

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sectors of industry. In academia, holders of each degree qualify to start a PhD programme although in practice only a small number of Masters of Industrial Sciences choose this career path.

To obtain a Master in Industrial Sciences one must complete a Bachelor in Industrial Sciences (3 years) followed by a one year Master programme. There is however an alternative program for technicians with a Professional Bachelor degree. This degree requires a 3 year study program that is strongly practice oriented, in Belgium it is the highest level degree in a technological field below a university engineering degree. Technicians with a Professional Bachelor degree can enrol in a one year bridge programme of intensive courses in mathematics, natural sciences and basic engineering. Upon successful completion of this programme they can obtain a Master of Industrial Sciences in one extra year [1]. This alternative study trajectory has become increasingly popular over the last decade (Fig.1), to such an extent that at our university college almost 1 out of 3 fresh engineering students are students in the bridge programme. This is something teachers and managers should take into account in deciding educational policy because these engineering students, like non-traditional students in general, have a different set of interests and professional goals compared to regular students [2,3,4].

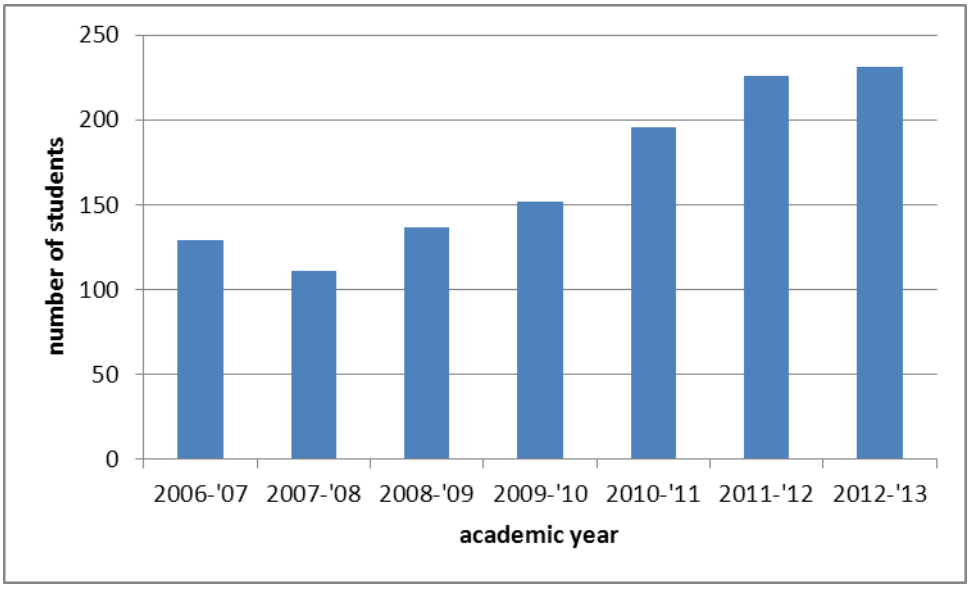

Fig.1 Number of students enrolled in the bridge programme at Catholic University College Ghent in the last seven academic years. These numbers are the total number of daytime students, including students who take more than one year to complete the bridge programme and students who quit the programme without taking exams. Students taking distance learning courses are not included.

The two compulsory mathematics courses in the bridge programme are the same for every student in the programme, regardless of the selected engineering field. Mathematics Module 1 is a pre-calculus course where a selection of algebra subjects is discussed (e.g.: vector algebra, trigonometry, complex numbers, matrices, systems of equations, etc…). Since students in the bridge programme have a wide variety of educational histories the aim of this course is to provide a common ground. Mathematics Module 2 is a more advanced engineering mathematics course which

covers single- and multivariate calculus, ordinary differential equations and vector calculus. In Belgium during an academic year students are allowed two (and only two) attempts to pass an exam for a particular course. It is the authors experience that even relatively good bridge programme students need at least two attempts to pass Module 2.

As teachers and student counsellors the authors have the impression that the attitude towards abstract thinking, scientific reasoning and even the willingness to work hard on more theoretical subjects differs strongly according to the engineering field students want to graduate in. This seems to be reflected in a very different success rate on mathematics exams according to the chosen field of study. In this paper it is investigated if there is indeed a relation between the chosen field of study in the bridge programme, the success rate on exams and the educational history of the students.

1 METHODOLOGY

1.1 Selection of the students

Because students are allowed a lot of flexibility in completing their study programme it is not uncommon that students take two or more years to complete the bridge programme. To avoid complications in the data analysis it was decided to limit the investigation to students who were fresh in the bridge program in the academic year 2011-2012 and to exclude distance learning students who almost always have been active professionally for several years and thus are not typical students.

1.2 Data processing

The average and median scores on the exams of both mathematics courses are compared for students in each field of study that is offered in the bridge programme at our university college. Also the success rate on the exams are cross tabulated with the field of study and the field of study is cross tabulated with the type of secondary school education of the students. In order to qualitatively probe the prevailing culture in the respective Professional Bachelor programmes a questionnaire is presented to the respective head of departments.

2 RESULTS AND DISCUSSION

2.1 Mean and median scores

In Table 1 the mean and median scores on the exams of Module 1 and Module 2 are listed for each field of study (construction engineering, engineering chemistry, engineering biochemistry, electronics engineering, electromechanical engineering, energy technology and computer (software) engineering). The mean and median scores are calculated from the final scores after a maximum two attempts. N represents the number of students who have taken the exam. Students who did not participate in the exams are excluded from the calculation.

From Table 1 three problematic situations become apparent: the very low scores for students in the fields of electromechanical engineering and energy technology, and the fact that 40% of the students in construction engineering did not take the Module 2 exams. Also, as a positive, notice the high scores for students in the fields of chemistry and biochemistry.

Table 1 Final mean and median scores on the Mathematics Module 1 and Mathematics Module 2 exams for each field of study offered in the bridge programme. N represents the number of students who have taken the exam.

field of study		Math Module 1	Math Module 2
biochemistry	N	14	11
	Mean	13,50	14,73
	Median	15,50	15,00
	Std. Deviation	4,146	1,954
chemistry	N	20	18
	Mean	14,30	13,72
	Median	15,00	15,00
	Std. Deviation	4,105	2,967
construction	N	20	12
	Mean	11,10	12,25
	Median	11,50	13,50
	Std. Deviation	3,110	6,225
electromechanics	N	37	32
	Mean	9,95	6,06
	Median	12,00	6,00
	Std. Deviation	5,212	6,609
electronics-ICT	N	21	22
	Mean	10,48	10,73
	Median	11,00	10,50
	Std. Deviation	4,057	5,758
electronics/computer	N	15	13
	Mean	12,73	10,77
	Median	12,00	11,00
	Std. Deviation	2,939	4,086
energy	N	15	13
	Mean	10,93	8,69
	Median	11,00	9,00
	Std. Deviation	5,663	6,486
Total	N	142	121
	Mean	11,55	10,24
	Median	12,00	11,00
	Std. Deviation	4,581	6,094

2.2 Pass-fail frequencies

In Table 2 and Table 3 the number of students in each engineering discipline succeeding and failing for Module 1 (pre-calculus) after one and two tries is shown. Many students in almost all disciplines have difficulties on the first attempt at passing this exam (only 56% pass) but after the second attempt a large majority of students succeed (75% pass). In our opinion this can, to a large degree, be explained by the fact that this is the first university level exam these students are facing in their student career, they need some time to adjust to the academic standards. However, even after two attempts 37% of students in electro-mechanics and 40% of students in

energy technology do not succeed for this exam covering relatively elementary mathematics.

Table 2 Pass/fail/did-not-participate frequencies for the first attempt at passing Mathematics Module 1 (pre-calculus) cross tabulated with engineering discipline

Engineering discipline	Fail	Pass	Did not participate	Total
Biochemistry	4	10	0	14
Construction	8	12	0	20
Chemistry	3	17	0	20
Electromechanics	21	16	1	38
Electronics	10	11	1	22
Energy	11	4	0	15
Computer Eng.	4	11	0	15
Total	61	81	2	144

Table 3 Pass/fail/did-not-participate frequencies for both attempts at passing Mathematics Module 1 (pre-calculus) cross tabulated with engineering discipline

Engineering discipline	Fail	Pass	Did not participate	Total
Biochemistry	3	11	0	14
Construction	5	15	0	20
Chemistry	1	19	0	20
Electromechanics	13	24	1	38
Electronics	6	16	0	22
Energy	6	9	0	15
Computer Eng.	1	14	0	15
Total	35	108	1	144

In Table 4 and Table 5 the pass/fail frequencies for Module 2 (calculus) exams are cross tabulated with engineering field of study of students in the bridge programme. Table 4 shows the results after one attempt, Table 5 shows the combined results after two attempts. It is clear that for most students this is a much harder nut to crack, only 35% pass at the first attempt, after two attempts 55% pass. Also a high number of students does not take the exam. While students in most fields seem able to cope well with mathematics the situation in electro-mechanics engineering, energy

technology and construction engineering is problematic: respectively only 27%, 40% and 45% of the students in those fields pass, in construction engineering 40% never shows up at the exam. In the authors experience these results, with the exception of the one for construction engineering, correspond to a trend that has been going on for several years. The success rate of students in construction engineering varies widely one academic year to another.

Table 4 Pass/fail/did-not-participate frequencies for the first attempt at passing Mathematics Module 2 (calculus for engineers) cross tabulated with engineering discipline

Engineering discipline	Fail	Pass	Did not participate	Total
Biochemistry	8	3	3	14
Construction	4	5	11	20
Chemistry	8	10	2	20
Electromechanics	25	6	6	38
Electronics	6	14	2	22
Energy	5	5	5	15
Computer Eng.	5	7	2	14
Total	61	50	31	142

Table 5 Pass/fail/did-not-participate frequencies for both attempts at passing Mathematics Module 2 (calculus for engineers) cross tabulated with engineering discipline

Engineering discipline	Fail	Pass	Did not participate	Total
Biochemistry	0	11	3	14
Construction	3	9	8	20
Chemistry	3	15	2	20
Electromechanics	22	10	5	37
Electronics	5	17	0	22
Energy	7	6	2	15
Computer Eng.	3	10	1	14
Total	43	78	21	142

2.3 Engineering field of choice versus secondary school education

At present in Belgium there are three types of secondary school educations:

- general secondary school (ASO) which is more scientifically oriented and prepares for higher education at the university level
- technical secondary school (TSO) which is more technology oriented and which covers a wide variety of technical educations, some of which prepare for higher education at the university level and some do not
- Vocational education (BSO) which does not prepare for higher education.

This distinction is relevant here because the number of BSO students that enrol in the bridge program is extremely small (1 or 2 in an academic year) and the average score on mathematics exams of students with an ASO education is significantly higher than that of TSO students, indiscriminate of the engineering field. The mean score on Module 2 exams for ASO students is 12.4/20 while the mean score for TSO students is 9.2/20.

In Table 6 the number of students in each engineering discipline is split according to the type of secondary school education the student was in. More than 50% of the students in chemistry, biochemistry and computer engineering had an ASO education and further analysis reveals that those in these groups that had a TSO education almost always had one that prepares for university level higher education. A large majority of students of electro-mechanics, electronics and energy technology had a TSO secondary school education. However, when the data are studied more closely it becomes clear that students of electronics were in secondary school classes that paid a lot of attention to mathematics and logic thinking, while students of energy technology and electro-mechanics were usually in classes that were very practice oriented and where less attention was given to mathematics and a theoretical approach to science and technology. Again, construction engineering is the exception, about 75% of these students had an ASO education but only 45% manages to pass the more advanced course. Because of the relatively high number of students that does not show up for the exams (40%) the authors suspect that other factors, not apparent from the data, are at play here.

Table 6 Cross tabulation of the engineering discipline and the type of secondary school education.

Engineering discipline	ASO	BSO	TSO	Total
Biochemistry	11	0	5	16
Construction	15	0	6	21
Chemistry	12	0	10	22
Electromechanics	6	0	31	37
Electronics	1	0	21	22
Energy	1	1	14	16
Computer Eng.	9	0	7	16
Total	55	1	94	150

2.4 The questionnaire

To probe the academic culture of the Professional Bachelor programmes the students were in before enrolling in the bridge programme a questionnaire was presented to the heads of department. Here, a qualitative interpretation of the questionnaire answers is discussed. The Professional Bachelor in chemistry, biochemistry and electronics have a strong scientific culture: they offer several courses in mathematics and physics, all teachers have master or PhD degrees and the students have an ASO or strong TSO educational history. The bachelor in computer technology has a more hands on approach: they offer just one basic course in mathematics and no extra science courses, many teachers hold bachelor degrees and about 75% of their students have a TSO history. However, the computer technology students that enrol in the bridge programme are just as successful as the chemistry students. Because the majority of computer engineering students in the bridge programme has a ASO history it is suspected that a kind of natural selection is at play here. The other bachelor degrees have an academic culture in between these two extremes. However, the bachelor in energy technology and the bachelor in electro-mechanics recruit mainly among secondary school students with a more practice oriented TSO education.

3 CONCLUSIONS

The academic culture and success rate at mathematics exams among bridge programme students does depend on the engineering discipline. However, the choice of engineering discipline and the success rate on mathematics exams appears to be more determined by the secondary school education than by the academic culture in the Professional Bachelor programmes.

4 ACKNOWLEDGMENTS

The authors would like to thank the administrative staff of the ‘Student Administration’ at the HUB-KAHO university college in Gent and Brussels for extracting the raw data from a very uncooperative administrative computer system.

REFERENCES

[1] Higher education in the Flemish Community of Belgium, the French Community of Belgium, Luxembourg and the Netherlands, ISBN/EAN: 978-90-9024093-0, http://www.ond.vlaanderen.be/hogeronderwijs/bologna/conference/documents/BENELUX_HE.pdf

[2] Langie, G., Valkeneers G., De Samblanx G., Mees E., De Nil I., Boukhlal S., Moons G.J., van Tilburg C., Gastmans M. (2012), Study track dependent values and exam results for master students in Engineering Technology, Proceedings of the 40th annual SEFI Conference, Thessaloniki, Greece, pp. 192-193.

[3] Bamber, J., Tett, L. (2000), Transforming the Learning Experience of Non-traditional Students: a perspective from higher education, Studies in Continuing Education, Vol. 22, No. 1, pp. 57-75

[4] Van Os, W. (2007), Selection to the Master’s Phase at the Binary Divide, a Dutch Case Study, Tertiary Education and Management, Vol. 13, No. 2, pp. 127-140