SEFI 2006

34th Annual Conference

Engineering Education and Active Students

ISBN 13: 978-91-631-8387-4

SEFI
European Society for Engineering
Europäische Gesellschaft für Ingenieur Ausbildung
Société Européenne pour la Formation des Ingénieurs

June 28 - July 1. Uppsala. Sweden.

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Tracking Student Success in Engineering Education

Duncan Fraser, Department of Chemical Engineering, University of Cape Town, Rondebosch, 7701 South Africa (dmf@chemeng.uct.ac.za)

This paper considers ways in which one could track the overall performance of students in an engineering programme by examining student throughput data.

In South Africa, the National Plan for Higher Education has proposed that the ratio of enrolments (students registered) to graduates in any calendar year be used as a measure of the success of the academic process. I will call this a headcount analysis. In this paper I will demonstrate the differences between the results generated by a headcount analysis and those that come out of a cohort analysis, which follows a group of students who enter engineering study in a certain year, and records how many years each student spends in the system until they leave, either without a qualification or with one.

I will first present a model system to demonstrate the results you would obtain, and then the real data. The data used in this paper is for university engineering students undertaking a four-year degree programme. In presenting the data I will also explain how they are derived. I have chosen a full decade of results for both analyses: the period 1991 – 2000 has been chosen for the headcount analysis, because it is roughly equivalent to the graduation times of the intake years 1988 – 1997 used in the cohort analysis.

This small study demonstrates that a headcount analysis, which leads to values of Enrolment/Graduates, yields results that are meaningless when the student intakes are changing, both overall, and especially with respect to students from different educational backgrounds.

On the other hand, a cohort analysis leads to meaningful results that show the performance of students in different categories. I would therefore contend that it is necessary to invest in the processes needed to generate such an analysis for students in different engineering disciplines.

It should be noted that neither of these analyses take any account of many of the reasons behind students not succeeding in their studies, which may have nothing to do with their academic abilities or the quality of the education they are receiving. These include personal and family factors, as well as financial considerations.

I will also demonstrate how this sort of data can be used to measure changes in performance due to curriculum and other changes.

In conclusion, this paper will demonstrate that it is possible to obtain meaningful measures of student success by doing cohort analysis, although extraneous factors lead to considerable variation in the results, and one can only observe tends by examining data over extended periods of time.

Keywords: Student success rates, engineering

An academic profile of first-year engineering students

Rosa Vasconcelos, Conselho de Cursos de Engenharia, Universidade do Minho, Guimarães, 4800-058, Portugal

Leandro Almeida, Instituto de Educação e Psicologia, Universidade do Minho, Braga, 4710-057, Portugal

Sílvia Monteiro, Conselho de Cursos de Engenharia, Universidade do Minho, Guimarães, 4800-058, Portugal [silvia@cce.uminho.pt]

Social and cultural diversification increases the students' heterogeneity in Higher Education in Portugal. This article will analyse some variables that characterise first-year university students of engineering courses at the University of Minho. Aspects like learning habits and approach, entrance grade, as well as vocational choice will be analysed. Some differences considering gender have been found, namely better daily study activities organization and time management in female students.

Keywords: higher education, first year engineering student, learning variables, vocational variable

An academic profile of first-year engineering students

R. M. Vasconcelos[1], L. S. Almeida[2], S. C. Monteiro[1]

[1]Council of Engineering Courses of the University of Minho, Guimarães, 4800-058, Portugal (rosa@det.uminho.pt)
[2]Institute of Education and Psychology, University of Minho, Braga, 4710-057, Portugal

Abstract
Social and cultural diversification increases the students´ heterogeneity in Higher Education in Portugal. This article will analyse some variables that characterise first-year university students of engineering courses at the University of Minho. Aspects like learning habits and approach, entrance grade, as well as vocational choice will be analysed. Some differences considering gender have been found, namely better daily study activities organization and time management in female students.

Keywords: higher education, first year engineering student, learning variables, vocational variable

1. INTRODUCTION

The transition from secondary education to higher education tends to be a hard process to some students. This new context of learning demands a set of skills, like independent learning competencies [1], that many students do not yet have developed. Study skills, learning strategies and a significant background in mathematics and physics, for example, can be good predictors to academic success in engineering courses. In effect, student expectations of the teaching and learning environment in higher education are influenced by their previous educational and psychosocial experiences [2], and their level of pre-university preparation [3]. Therefore, the success in higher education reflects the level of correspondence between capacities, interests and students´ values and supports that university offers to their students [4]. In Ramsden´s perspective [5], environmental variables and student's perceptions of the learning environment, will influence the strategies or approaches students adopt in learning activity. In this way, we have to examine student maturity when we analyse some aspects like success in adaptation and achievement in higher education. For that, we consider some vocational and learning process variables in our analysis.

Considering vocational variables, it is important to assume that the abilities, values, and interests become in adolescence a basis for subsequent career-related choices [6]. Some authors [7] analysed the effects of gender, socioeconomic status and early academic performance on postsecondary educational choice. Over the last three decades, the number of women choosing high-skilled fields such as engineering and business has increased [8]. Other research has also demonstrated that girls are becoming less stereotypical than boys in their occupational aspirations. However, both women and men continue to choose careers traditionally associated with their gender [9]. The characteristics of the engineering students at the University of Minho (about 70% male and 30% female) show this fact. Eccles [9] explains this gender difference with the subjective task values for various achievement-related contexts, which are developed within a socialisation context and directly affect educational and occupational plans and choices. In his opinion, female students tend to place higher value on language-related abilities, while male place higher value on mathematics and physics abilities.

Analysing adolescents' mathematics grades and course enrolment intentions, Crombie *et al* [10] verified that perceptions of the usefulness of mathematics are important to students´ choice in high school. For girls, the most important factor is competence beliefs while for boys good mathematics grades appear to be effective in encouraging them to take academic options with higher level of math exigency. In contrast to girls, boys´ prior mathematics grades have a direct relation with future enrolment intentions, for example in practical graduation courses. This idea could also explain the larger percentage of male candidates in engineering courses.

Another aspect we need to consider when analysing vocational choice in Portuguese higher education is the limited amount of vacancies for each course, as determined by the Ministry of Higher Education. The access to

Portuguese higher education is based on national exams of secondary schools for specific subjects that are required for each course at the university. Higher Education in Portugal, in public institutions, has a "numerus clausus" access system. The student indicates up to six courses he or she would like to take. Based on the overall classification, a student is allocated to a course. The student with the highest overall classification, nation-wide, has the first choice, having priority in choosing the course. Students with lower classifications may be allocated to another course than their first choice, according to their grade. Although they may have a clear preference for a certain course or field of study, they will select other courses with lower entrance requirements and normally less popular [11]. In this way, they enlarge their chances of being allocated. Enrolment intentions can thus be influenced by students´ perception of the possible enrolment to the course intended by them. This fact can have serious implications regarding to the motivation and involvement with academic life and consequently, academic achievement.

Another important variable on academic adjustment is the students learning habits and competencies. There is a large range of motivation, cognition and behavioural variables interrelated, that explain the complex process of learning in higher education. Several studies on student learning propose a basic model to conceptualise the process of learning: the deep approach, which describes active engagement with the content, leading to extensive elaboration of the learning material while seeking personal understanding; and the surface approach, which appeals to the use of routine memorisation to reproduce those aspects of the subject matter [12]. More recently, Kember, Biggs and Leung [13] present a hierarchical factor structure of the revised Learning Process Questionnaire (LPQ) presenting at the top the deep and surface approaches and at the middle level the motive and strategy elements to each approach. The deep strategy refers the intention of seeking understanding and relating ideas, which contrasts to the fragmented knowledge that commonly results from a surface approach.

Entwistle [12] argues that student approaches are affected by their prior and personal histories, which produce habitual patterns of studying. However, he also explains that the evocation of strategies is influenced by the content and context of the specific task or situation, having to be incorporated into descriptions of student learning [12] [14]. Ramsden [5] also emphasized learning outcomes as being directly influenced by their orientation to learning, which is influenced by prior educational experiences and by learning task perceptions. The approach to learning is strongly related to aspects like self-regulation, conceptions of learning and learning orientations, for example a deep approach is related to self regulation of learning, intrinsic motivation and optimistic strategies [15]. On the other hand, a surface approach appears related to problems with regulation of studying and self-handicapping (students who are afraid of potential failure and that concentrate on task-irrelevant behaviour in order to create excuses for their failure) [16].

Vermunt & Vermetten [17] understand regulation strategies as being consistently associated with students' conceptions of learning and learning orientations. A conception of learning is regarded as a coherent system of knowledge and beliefs about learning and related phenomena. These authors verified that older or more experienced students show a greater ability to differentiate between various learning strategies, conceptions, and orientations than younger or less experienced students. Based on this knowledge, it is expected that first year students will develop new learning strategies, probably because of the necessity to adapt to a different context of learning with new requirements.

The relation of learning approaches with academic performance was also studied by Duff, Boyle, Dunleavy and Ferguson [18]. They found that a deep approach and a strategic approach were positively correlated with academic performance, while surface approach was negatively correlated with academic performance. The ability of self-regulation and the use of deeper strategies of learning, including an active role of the student in his process of learning, appear to be strongly related with positive academic performance and efficient study habits. Students who have developed better study skills will certainly be more prepared to face requirements of autonomy and self-regulated learning in higher education.

The present study analyses vocational and learning variables of sample of engineering first-year students at the University of Minho, exploring possible difficulties these students have to face in their process of adjustment to higher education and the role that university can play in this process.

2. METHOD

Paticipants

The participants were 398 engineering first-year students of the University of Minho (278 male and 120 female), being males overrepresented in the study. The ages ranged from 17 to 37 years old (M=18.9; SD= 2.63), as it is presented on table I.

N		Age			
		M	SD	Min.	Max.
M	278	18.73	2.28	17	37
F	120	19.23	3.29	17	37
Total	398	18.88	2.63	17	37

TABLE I. Participants by gender and age

Instruments and Procedures

The IACHE - *Inventário de Atitudes e Comportamentos Habituais de Estudo* (Tavares, Almeida, Vasconcelos & Bessa, 2004) – is a multidimensional questionnaire about study attitudes and habitual behaviours. It has five subscales: comprehension dimension; reproductive dimension; study involvement; study organisation and self-perceptions of abilities. There are 44 items organized in a *lickert* format, varying with accord level with statements presented. A questionnaire developed by Ministry of Education, analysing some socio-demographical aspects and student's educational background and another with some vocational questions was also used.

The questionnaires were given to students during the register in their courses. Data were analysed with SPSS (version 14.0 for Windows).

3. RESULTS

On table II we present the entrance grade (general mean of access to university) and the specific subject grade of access to the course (0 to 200 points scale), with regard to the gender of the participants.

	Entrance general grade				Specific subject			
	N	Min-Max	M	SD	N	Min-Max	M	SD
M	247	107-191	141.1	18.35	274	95-192	134.7	23.75
F	98	106-189	142.0	20.29	98	95-194	134.1	24.56
Total	346	106-191	141.4	18.87	346	95-194	134.6	23.93

TABLE II. Entrance and specific classifications to access to university

We can verify a large similarity of values between males and females, showing no statistically significant differences between entrance grade (t= -.414; df= 343; p= .68) and in the specific subject too (t= .220, df= 343; p= .83).

When we analyse the entrance option, we can observe that the majority of the students attend a course of their first option (71.2%), 17.3% are placed in their second option and nearly 11.5% are attending a course of their third or higher option.

Looking at the time students dedicate to study apart from lesson attendance, 39% of the students say they spend at least 10 hours per week studying, 25% dedicates about 10 hours or less to the study, and 20% of the students indicates that they dedicate time to studying every now and then on a monthly basis. The remaining students, 16% only studies in exam periods.

On table III we present data concerning the IACHE dimensions by gender and courses option.

Dimensions	Male						Female					
	1st option		2nd option		Other option		1st option		2nd option		Other option	
	M	S.D.	M	S.D.	M	S.D.	M	S.D.	M	S.D.	M	S.D.
Comprehension	38.6	6.21	38.0	5.55	40.8	7.66	40.9	6.92	39.1	5.99	40.4	7.99
Reproduction	28.9	4.56	29.9	4.93	29.7	5.20	31.6	5.79	30.7	5.47	29.8	5.63
Involvement	31.3	5.09	31.1	5.07	32.7	5.54	33.9	5.02	32.1	4.67	32.5	6.63
Organisation	32.2	7.22	32.8	7.31	33.3	6.44	35.7	6.99	37.2	6.72	36.1	6.73
Self-perceptions	26.6	6.41	25.2	5.05	27.7	6.24	26.4	5.92	23.0	6.61	26.2	5.93

TABLE III. Dimensions of IACHE by gender and entrance option

When analysing discrepancies by Manova test of variance (2x3), we do not verify any interaction effect of both variables statistically significant. However, there is a significant effect of the entrance option in self-perceptions of competence ($F= 4.098$; $p < .05$). The same effect is observed considering gender in the daily study organisation dimension ($F= 13.108$; $p < .001$). Unexpectedly, there are students placed in third or higher option with higher self-perceptions of competence. However, we verify that 49% of these students are allocated at biological and biomedical engineering, and even they have high classifications, these are not sufficient to enter in Medicine course (probably their first option) because the "numerus clausus" system.

Looking at the motivations to attend university, 78% of student justify their decision with the intention to their preparation for a job, 18% refer to the interest in increasing their general education, 14% explains their motivation with the interest in developing social and personal abilities, and the remaining 1% argues that they enter into university to be with their friends or because of parents pressure.

On table IV we present the difficulties expected by the students at the entrance in university. Data considers male and female students separately.

Difficulties	N	Total %	Males %	Females %
Economical problems	83	20%	20%	20%
Learning/achievement	47	13%	10%	15%
Relationship with colleagues	12	3%	2%	3%
Relationship with teachers	8	2%	2%	1%
Psychological states (withdraw, anxiety, depression)	15	3%	2%	6%
Time management	183	45%	50%	36%
Relationship with family and relevant persons in campus	15	3%	3%	3%
Financial management	42	10%	9%	10%
Health (migraine, fatigue, ...)	15	3%	2%	6%
Total	399	100%	100%	100%

TABLE IV. Expected difficulties at the entrance in university

Data observed suggest higher difficulties in time management (namely for male students), as well as in the area of the economic support and financial management. Learning and achievement difficulties have not a significant frequency (namely for male students).

4. DISCUSSION AND CONCLUSIONS

We have observed that engineering courses are mainly populated with male students, in consistency with vocational aspects previously described. This can be interpreted as an influence of the social environment in students´ career choices. In this case, we should be able to observe the tendency of male students, more than female students, to be more aimed at to courses with an emphasis on mathematics and physics. However, a statistically significant difference in relation to the gender for the specific subjects it was not verified (Mathematics, in almost all courses analised). We can raise the question whether or not the perception of the usefulness of mathematics is clearer for male than for female students, having a direct relation with the enrolment intentions pointed by Crombie *et al* [10].

Entrance options express difficulties inherent to the actual system of access to Higher Education in Portugal. As observed, there is a significant number of engineering students, including students with high grades, who are not

allocated at the course they would really prefer, because of restrictions imposed by the "numerus clausus" system. Maybe this fact can explain high values of self-perception of competence found for students allocated in third or higher option. That is, students with high perceptions of competence chose courses with higher entrance requirements. These aspects should be taked into account when we try to understand aspects like adaptation into higher education, student´s achievment, academic abandonment and many other aspects related to the academic adjustment and success in higher education. These aspects can also be related to the students´ motivation to access to university. Although a large majority of students state they enrolled at their course because of labour market perspectives, it would be interesting understand deeply if this intention is just to obtain a grade or if it is related with an intrinsic motivation to the subject.

Another interesting aspect to analise is the difficulties expected by engineering students when accessing to university. They expresse more difficulties concerning daily time management and, on a second level, the money related problems. It should be emphasised that male students express more worried about time management than females. If we consider that females score higher on the daily organisation subscale (which is also compatible with other researches in this subject), we can probably establish a relation between these data. That is, the daily organisation abilities of females can help them in the adaptation into a new education context, with higher demands of autonomy, and so this aspect deserves less attention by females. Students tend to adapt themselves to the institutional learning environment in ways that suit their own habits, ideas and preferences of learning well. They prefer and act as if there is congruence between teaching and learning [19]. A student-oriented learning environment, and especially one oriented to connectedness, appears to stimulate a constructive learning. In this way, students appear to adapt their learning approaches to the characteristics and demands of the learning environment [20]. To conclude, we emphasize the importance of the closeness between university and students to promote a greater perception of students´ difficulties and to promote learning styles more oriented towards an active participation of students in their learning process.

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5. Curricula

Rosa M. Vasconcelos received her degree in textile engineering in 1984 at Minho University, Portugal. In 1993 she obtained her PhD in Engineering-Textile Technology and Chemistry in the speciality of textile technology, at Minho University. Since 1993 she has been working as an associate professor, in the Textile Engineering Department of Minho University. Her fields of interest are textile processes and industrial automation. Futhermore, she is President of the Council Of Engineering Courses and works on a university-wide approach to quality of teaching and learning. She is envolved in various projects on staff development, evaluation of teaching and learning, integration of first-year students and assessment of student learning.

Leandro S. Almeida - PhD in Educational Psychology from Porto University (1988). He is involved in teachers and psychologist education at basic and post-graduation levels. Main research topics are cognition and cognitive development, teaching and learning processes, and access, adjustment and academic success in higher education.

Sílvia C. Monteiro received her degree in Psychology, in 2004 at Minho University, Portugal. She works at the Council of Engineering Courses of the University of Minho and is envolved in projects of assessment of student learning and integration of first-year students.

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Initiatives for quality improvement in Portuguese Engineering Education

Natascha van Hattum-Janssen, Council of Engineering Courses, University of Minho, 4800-058 Guimarães, Portugal

Rosa Maria Vasconcelos, Council of Engineering Courses, University of Minho, 4800-058 Guimarães, Portugal {natascha@eng.uminho.pt}

This article aims to illustrate a range of different experiences, all aimed at innovation in engineering education, and in spite of their divergent nature, all related to an increased involvement of students. The different projects, coordinated by the Council of Engineering Courses, will be described to illustrate the variety in quality initiatives taken at different levels of engineering education at the University of Minho. All of the projects described are based on a perceived need for structural change towards more involvement of students in their own learning process.

The first project is a Project Led Education experience at the Industrial Management and Engineering course. The second project is aimed at assessment methods that increase involvement and responsibility of students in their own assessment process, whereas the last project, takes place at the Business Informatics course of the University of Minho. This project is aimed at supporting the collaborative learning projects of students.

The article will point at the importance of a coordinated approach to innovation, leaving enough freedom of own initiative and interpretation to (groups of) teachers and providing adequate pedagogical support to facilitate educational change.

Keywords: curriculum design, assessment, project led education, quality

Systematic Co-operation with Stakeholders Gains More Importance – Stakeholder Map of the Finnish Enginnering Education

Kati Korhonen-Yrjänheikki, The Finnish Association of Graduate Engineers TEK, Helsinki 00520 Finland (katiky@tek.fi)

The importance of universities' stakeholder co-operation in future will further increase and there will be more co-operation partners (Korhonen-Yrjänheikki 2004, 2005a; Van Vught 2004). However, stakeholder relationships are dynamic and not all stakeholders are supportive. Universities have to systematically monitor, analyze and develop strategies for efficient stakeholder co-operation. There are two critical assessments that should be carried out concerning stakeholders: what is their potential - in other words capacity, opportunity and willingness - to threaten and to co-operate (Savage et al. 1991). Based on these two factors, stakeholders can be classified to four groups: supportive, mixed blessing, non-supportive and marginal.

The tight competition in the global higher education market forces universities to collaborative competition. Currently, the fellow institutions are too often seen simply as competitors, because own focus is obscure. The closer stakeholder co-operation is also a necessity for a well-functioning anticipation, follow-up and feedback as well as quality assurance systems. Moreover, intensive co-operation with stakeholders is important for higher education funding, which must be gathered from several sources because of limited public resources.

Students are important stakeholders for universities. In most cases, their potential for co-operation is high. Active student participation in developing the education is typical of the Finnish engineering education. Engineering students are appreciated partners and well represented in university administration.

The co-operation between universities and industry in Finland resulting in well-functioning knowledge-transfer is estimated to be the best in the world (IMD 2004). Among different disciplines, engineering is considered to be an example of very good R&D co-operation with industry that for example business schools are trying to learn from (Keso et al. 2003). Finnish universities need to build further on that strength. The excellence in networking needs to be extended to developing further co-operation between higher education institutions and also research organizations. The asset of good co-operation with engineering students must be developed to active alumni co-operation.

Keywords: engineering education, stakeholders, stakeholder map, networking, collaborative competition

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