International Journal of Engineering Education Vol. 35, No. 1(A), pp. 156–167, 2019
Printed in Great Britain
0949-149X/91 $3.00+0.00

Factors Affecting Engineering Students Dropout: A Case Study*

LORENZO SALAS-MORERA, M.ª ANTONIA CEJAS-MOLINA, JOSÉ L. OLIVARES-OLMEDILLA, LAURA GARCÍA-HERNÁNDEZ and JUAN M. PALOMO-ROMERO
Escuela Politécnica Superior de la Universidad de Córdoba, Campus Universitario de Rabanales. Edificio Leonardo da Vinci, 14071, Córdoba, Spain. E-mail: lsalas@uco.es, ma1cemom@uco.es, el1ololj@uco.es, ir1gahel@uco.es, juanmaria@uco.es

Engineering professions have a high demand in the global labor market but, in spite of this, there are high dropout rates and low graduation rates specially in engineering and STEM in general all over the world. A research has been conducted in the Polytechnic School of Córdoba University (Spain) to determinate the reasons for engineering degree dropouts using data from a quantitative and qualitative survey (n = 315) and analyzing the behavior of students during a period of one year. A set of causes of dropout and attrition has been identified, including students' lack of motivation, bad planning of the course by the students, high level of the course's starting point, syllabus too long, too many targeted activities, exams too difficult, inadequate class timetables, and inadequate examinations calendars, as a consequence a set of measures to improve the situation has been proposed.

Keywords: engineering dropout; students retention; students motivation; outreach; tutoring

1. Introduction

1.1 The problem of high dropout and low graduation rates in engineering degrees all over the world

Even though employment in the field of STEM (Science, Technology, Engineering and Mathematics) are expected to grow more than 9 million only in the United States, between 2012 and 2014 [1], 48% of bachelor degree students and 69% of associate's degree students who entered STEM fields between 2003 and 2009 had left these fields by spring 2009 [2, 3]. In the same way, more than 76 million people were employed in science and technology in 2015 in the EU-28 (31.5% of the total labor force and increasing 1.6% from 2011 to 2015) [4], but there is a key concern in Europe related to the high rates of student dropout before obtaining a higher education degree [5]. These numbers are no different in Spain, where the global student dropout in university degrees rose 21% among those who entered in 2012–2013 (20% in social sciences, 23.2% in engineering and architecture, 27.5% in arts and humanities, 15.7% in health sciences, and 23.3% in sciences). Moreover, the graduation rate in Spain is much lower in engineering and architecture than in other fields of knowledge (50.7% in social sciences, 26.2% in engineering and architecture, 44.6% in arts and humanities, 69.4% in health sciences, and 41.4% in sciences) [6].

In this academic and social context in which engineers of the XXI century are expected to be very solvent technically and with very well seated skills of leadership, group work, and global ethical compromise; having a well designed academic curriculum is not enough to ensure success. Thus, academic and social authorities all over the world are concerned with the analysis and are searching for solutions for the high dropout rates and the low rates of graduation specially in engineering and STEM in general [7]. In this way, some authors have proposed the main causes of attrition in university degrees. Several authors proposed that a high number of credits enrolled by each student could be a possible cause of failure [8] and that the lack of social and organizational adaptation during the first year is probably the first cause of attrition, pointing out the necessity of a proactive role of the universities in preventing this effect [9]. According to this study some authors pointed out that the exact type of approach is less important than providing a culture of belonging through supportive peer relations in order to obtain student's retention and success, and proposed that any action should be: included in the mainstream and be directed to all the students; proactive in the line of search for the less successful students; relevant and meaningful for the student current interests and future aspirations; well timed in order to fill the student necessities of advising and information at any time; collaborative with fellow students and faculty staff; and, finally, monitored. Moreover, they insist in the necessity of programming pre-entry interventions in order to provide information and develop realistic expectations in pre-university students [10]. Similarly, it has been found that adult learners taking on-line courses are more likely to dropout when they do not get organizational support as well as when they

* Accepted 15 September 2018.

do not find the course relevant to their professional careers [11].

In the search for the reasons of student attrition and low graduation rates, some authors have proposed a set of possible causes, even though many of them pointed out that there is no unique reason, but a combination of them. In general, social reasons are seen as an important factor to student dropout and attrition, and the students able to establish peer networks, generating good classroom climate and opportunities to learn collaboratively, are more likely to remain in the degree than those that are not able to do it [12], so propitiating student-student interaction in special academic programs is supposed to promote the increase of student retention, even though there are students more outgoing than others. In the same way, academic and social reasons have been identified as causes for students to leave engineering. On the one hand, poor teaching and advising as well as the difficulty of the engineering curriculum are identified as academic reasons for attrition [13]; on the other hand, a lack of sense of belonging, mainly in under-represented students, and a poor understanding of engineering, are identified as social causes [14]. The authors argued that social causes are more complex and important than academic ones even though a more extensive study should be done in this respect. Similarly, a set of academic and social reasons have been found [15–17]. In the first group, they mentioned poor high school preparation, poor teaching and advising and that students feel overwhelmed due to program difficulty; in the second one, they identified failure to integrate and feeling unwelcome in the engineering culture. Even more, the authors pointed to another group of reasons, such as projected age of graduation, marital status or financial pressures, among others. Moreover, they found a deep level of emotion in the students when describing their experience on leaving engineering, and they concluded that the outreach from departments to students during first and second years could have a positive effect upon retention.

Other possible factors affecting student attrition are gender and race. Although female gender is clearly under-represented in STEM degrees, and academic support and services are better for men than for women, women's graduation rates are better than men's. In the same way, there are clear racial differences in graduation rates in favour of whites [18]. Racial and gender reasons have been identified as motivating students attrition among other four (classroom and academic climate, grades and conceptual understanding, self-efficacy and self-confidence, high school preparation, interest and career goals), but the main responsibility is put on the academic authorities in terms of lack of showing engineering human factors, showing the importance of scientific and mathematical skills needed for engineering, and providing a welcoming atmosphere to students [19].

In another way, some authors have searched for relationships between academic performance in certain subjects and engineering degree dropout rates [20] and found a clear relationship between high school mathematics performance and engineering dropouts, so they pointed out that this subject is a good early indicator of dropout rates without forgetting other causes such as resilience, motivation, teamwork competency, and dedication. So, it is possible to identify the students at risk of dropout as soon as possible using data mining to predict the academic results before the middle of the course [21]. Similarly, other authors used data mining techniques to identify the more likely factors affecting students dropout and concluded that low scores in English, physics, and mathematics could be good predictors [22]. In the same way it has been found that students who failed mathematics related subjects represent an important fraction of the cohort that has to retake the classes or choose to leave engineering for an alternate major [23]. Nevertheless, an integrated approach considering the whole set of factors affecting students motivation to remain or dropout in engineering degrees is needed. In this sense, interactions of multiple motivational characteristics including individual goals and orientations, perception of course contents, beliefs about the profession, and class climate, were analysed [24], finding that beyond a set of complex relationships between the variables tested, learned skills and malleable motivational characteristics, both of them being influenced by teaching style, motivate more to students' success than innate abilities or preparation.

1.2 The search for solutions

Other authors have centered their work more on the search for solutions than on the investigation of causes. In this sense, making access to higher education more restrictive has been proposed as a possible way for the solution after recognizing the importance of student attrition and analyzing the ways how it is measured and explained, how it might be addressed and what it costs [25]. In a similar way, the retention of undergraduate engineering students could be influenced by admission requirements, program completion requirements, and curriculum design as well as the difficulty of contents, so first-year students require more attention from teachers and faculty staff [26]. Far away from this approach, other authors have proposed a set of solutions to students' attrition problems, for example, the use of peer instruction by means of a course at the beginning of the year. The benefits of this approach are multiple: students have opportunities to know and help each other in a way of collaborative learning, and the teachers have the opportunity to participate, providing better faculty-students interaction [27]. The results showed an increase in student retention as well as better scores and the development of critical skills. In the same way, the contents of introductory courses have been modified in order to include industry mentors with the aim of retaining students who would have failed under other conditions. Moreover, a high engagement of faculty, administrators and staff is recognized as necessary to get good results of students retaining [28]. Additionally, it has been identified that the majority of the students who drop out did it during the first semester of the first year. Thus, giving adequate information to freshmen to allow them to know their real possibilities to enrol before choosing an engineering program is proposed [29]. In another way, combined strategies to retain freshmen have been put into practice consisting of: (1) two courses of "Introduction to Engineering Practice"; (2) development of a faculty mentoring program; (3) development of a peer mentoring program; and (4) development of an industrial mentoring program, with the result of an increasing retention ratio. Moreover, asking the population of retained students for the reasons why they would leave their degrees (inverting the normal point of view) is concluded that none of the possible strategies for student retention would have a 100% success, even though the combined strategy has proved to be useful [30]. Other authors have developed a double program with the aim of creating a sense of community among students, peers, and faculty by forcing students to participate. So, the students were required to work in groups along the semester which improves academic success and retention, but faculty involvement is critically important to create a real state of community among the students [31].

The above-mentioned references seem to suggest that motivation and engagement are even more important than knowledge for students retention [32]. In this sense, an analysis of students' emotions in their work by means of saliva cortisol levels has been made, concluding that incorporating future thinking into engineering educational programs helps to improve students' motivation to continue their studies [33]. In a similar way, the effect of motivation and emotions on students' retention has been examined, finding that promoting students' autonomy helps to obtain better results in male students development. On their part, goals of self-efficacy and achievement were more important for women. In general, students' affective experiences suggest that efforts to make instructional activities enjoyable and relevant and creating a classroom environment emotionally adaptative would help retention of STEM students [34]. In line with the necessity of promoting the acquisition of students' transversal skills, such as collaborative learning, working in groups, and ability to communicate effectively, among others; has been tried to connect the acquisition of these abilities with students' engagement and retention, concluding that a holistic approach should be explored more intensively in the 21st century in order to correctly understand the causes that motivate students to remain or to leave their studies [35]. In the same line of integrated approaches, the combination of feelings related to program belonging, as acceptance, respect, and inclusion, has been highlighted as reinforcing of the probability of the students' retention [36]. So, teachers should demonstrate the usefulness of the contents, and insist on the idea that the personal effort leads to success in order to motivate the students' retention. Finally, the authors remarked that the two most influencing factors on student retention are the students' motivation and curriculum design.

2. Research design

The purpose of this work is to analyse the reasons why students decide to dropout from their studies in the first two courses of the degrees of Mechanical Engineering, Electrical Engineering, Industrial Electronics Engineering and Software Engineering in Córdoba University (Spain). This project is included in the general strategy of Córdoba University to improve teaching quality and promote innovative teaching methods. The program aims to improve the academic results of students, increase retention rates, and any other in the line of quality assurance of university degrees [37]. As a starting point, the central services of Córdoba University analyzed, in collaboration with the Students Council, the indicators of success of all the degrees of the University. As a matter of fact, a high rate of dropouts was found in the degrees of the Polytechnic School, which worried the academic authorities about the development of the degrees. The research team was integrated by teachers of basic subjects of the engineering degrees of the School as well as others of specific subjects making a total of five teachers led by the teachers of Projects Engineering, which is a subject of the last year, and with the permission of the School directive team. In general, there is a sense that these degrees are difficult and dense, with too many targeted activities, not very well organized along the semester, and without coordination between and inter-subjects.

Table 1. Survey about quantitative and qualitative reasons for subjects' abandonment

Number of different courses in which you are enrolled in the present academic year					
Number of subjects in which you are enrolled in the first semester					
Number of subjects in which you are enrolled in the second semester					
Number of subjects you abandoned during the first semester					
Number of subjects you have decided to abandon in the second semester					
Mark your degree of agreement with the following statements for the subjects you have decided to abandon	**1**	**2**	**3**	**4**	**5**
I haven't had enough time along the semester to prepare all the subjects					
I started to study too late					
Too many targeted academic activities, which require a lot of preparation time					
The level of the subject is too high for my previous knowledge and I don't understand it					
The examinations that are carried out in some subjects during the semester prevent me from studying the others					
I have given priority to the subjects of the first year (only for students enrolled in subjects of 2nd year or higher)					
Indicate reasons other than those indicated in the previous questions why you abandoned a subject					
Free text					

The research was organized in three phases:

1. Quantitative and qualitative survey: a survey containing quantitative and qualitative questions about the number of subjects the students had abandoned during the first semester and those that had already decided to abandon during the first half of the second semester (Table 1).
2. Analysis of the whole data of objective behavior of the first and second year students in comparison with surveys.
3. Proposal of a plan of improvement.

3. Results and data analysis

3.1 Quantitative survey

The survey was taken by a total of 315 students belonging to the four engineering degrees of the School: Mechanical Engineering, 86 (43 of the first year and 43 of the second); Electrical Engineering, 44 (12–32); Industrial Electronics Engineering, 71 (37–34); and Software Engineering, 114 (60–54). The distribution of the number of subjects that each one of the surveyed students who has dropped out in the first semester or who has already decided to drop out in the second semester is shown in Fig. 1. The figure shows that almost 50% of the students have dropped out or have decided to drop out of at least one of the subjects enrolled, so the concern of the academic authorities is completely justified.

The first question to be addressed is whether there is a relationship between the number of courses the student enrol in and the number of dropouts. The hypothesis that supports this idea could be that the students fail in a number of subjects in the previous year and choose subjects belonging to various courses in the general curriculum in the following

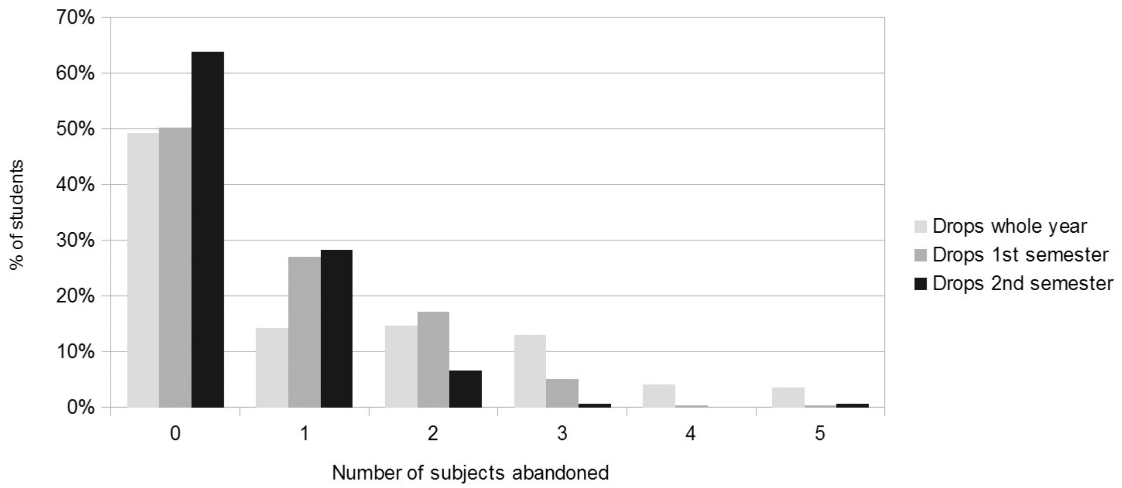

Fig. 1. Percentage of students that abandoned 0...5 subjects during first, second semester and the whole year according to survey data.

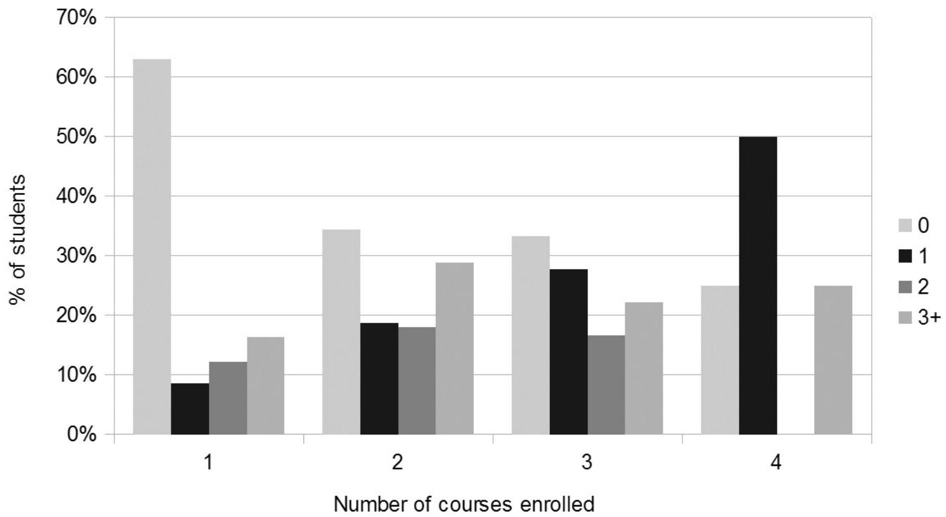

Fig. 2. Percentage of students that abandoned 0, 1, 2, and 3 or more than 3 subjects by number of courses enrolled.

Table 2. Contingency matrix for the number of students that abandoned a number of subjects by number of courses enrolled

		Courses enrolled				
		1	2	3	4	Total
Number of subjects abandoned	0	104	44	6	1	155
	1	14	24	5	2	45
	2	20	23	3	0	46
	3+	27	37	4	1	69
	Total	165	128	18	4	315
	χ^2 = 32.59	d.f. = 9	p = 1.58e-04			

year. So, there is a lack of organization in timetables and a loss of the sense of belonging to a group. Figure 2 shows the percentage of students that abandoned 0, 1, 2, and 3 or more subjects among those enrolled in subjects of 1, 2, 3, and up to 4 courses. The figure seems to suggest that there is a real relationship between the two concepts. To analyze this question a χ^2 test has been performed.

Table 2 shows the contingency matrix of the number of students who abandoned a number of subjects classified by the number of courses enrolled by the students. The χ^2 value obtained was 32.59; with 9 degrees of freedom and a resultant significance of p-value = 1.58e-04. Under such conditions, it is correct to reject the hypothesis of independence between variables, so it can be said that there is a real dependence between the number of subjects abandoned by the students and the number of courses in which they are enrolled.

The second question to be analyzed is if there is a relationship between the number of subjects each student is enrolled in and the number of dropouts. There is a possible hypothesis that the greater the number of enrolled subjects the higher the number of dropouts. This idea could be supported in the appreciation that if there was a failure in the previous year, the student could have the temptation of ignoring it and enrolling in a greater number of subjects with the hope of reversing this situation. Figure 3 shows the percentage of students that abandoned 0, 1–2, and 3 or more than 3 subjects

Table 3. Contingency matrix for the number of students that abandoned a number of subjects by number of subjects enrolled

		Subjects enrolled						Total
		7–	8	9	10	11	12+	
Number of subjects abandoned	0	10	15	5	111	12	3	156
	1–2	5	6	2	62	9	7	91
	3+	1	4	6	41	12	4	68
	Total	16	25	13	214	33	14	315
	χ^2 = 18.27	d.f. = 10	p = 0.05					

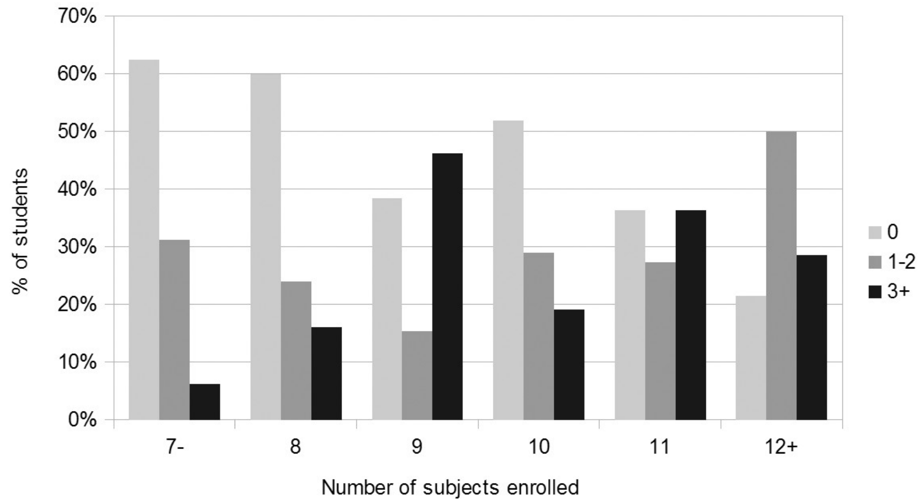

Fig. 3. Percentage of students that abandoned 0, 1–2, and 3 or more than 3 subjects by number of subjects enrolled.

among those enrolled in 7 or fewer, 8..11, and 12 or more subjects. As well as in the previous analysis, a χ^2 test was performed. Table 3 shows the contingency matrix of the number of students who abandoned a number of subjects classified by the number of subjects enrolled by the students. The χ^2 value obtained was 18.27; with 10 degrees of freedom and a resultant significance of p-value = 0.05. With these results, it can be said that there is a real dependence between the number of subjects abandoned by the students and the number of subjects in which they were enrolled, even though that relationship was not as strong as the one obtained before.

The third question to take into account is if the number of subjects abandoned by the students is greater in the first semester than in the second one. This hypothesis could be based on the idea that the starting of the academic year, especially for freshmen and sophomores, is difficult and has adaptation problems. Figure 1 suggests that the number of subjects abandoned during the first semester was significantly greater than the number of subjects abandoned in the second semester. Prior to corroborating this, a test of normality must be performed in order to know whether a t-test is feasible or not (Table 4). As Table 4 shows, neither of the variables fit the normal distribution, so the t-test is not suitable here. Instead, a Wilcoxon signed-rank test has been performed (Table 5) which concluded that the number of subjects abandoned during the first semester was significantly greater than the correspondent in the second semester.

Table 4. Normality Kolmogorov-Smirnov test for the number of subjects abandoned by the students each semester

		Subjects abandoned first semester	Subjects abandoned second semester
N		315	315
Mean		0.79	0.47
Std. deviation		0.96	0.74
Extreme differences	**Absolute**	0.30	0.37
	Positive	0.30	0.37
	Negative	–0.20	–0.26
K-S statistic		5.29	6.63
p-value		<0.001	<0.001

3.2 *Qualitative survey*

The qualitative survey was asked only to the students who had abandoned at least one subject (203) and oriented to the questions traditionally pointed out as weak in the organization of the School. The results are shown in Table 6. The percentages that appear in the table have been calculated with respect to the total number of students surveyed (203),

Table 5. Wilcoxon test results for the number of subjects abandoned by the students each semester

		N	Mean ranks	Sum of ranks
First semester – second semester	Negative ranks	4	74.5	298
	Positive ranks	101	52.15	5267
	Ties	201		
	Total	315		
			Z = –8.82	p-value <0.001

Table 6. Results of the qualitative survey

Mark your degree of agreement with the following statements for the subjects you have decided to abandon	1	2	3	4	5	DK/DA	mean	s.d.
I haven't had enough time along the semester to prepare all the subjects	16 7.88%	38 18.72%	**63** **31.03%**	**49** **24.14%**	30 14.78%	7 3.45%	3.20	1.16
I started to study too late	32 15.76%	**55** **27.09%**	**51** **25.12%**	44 21.67%	16 7.88%	5 2.46%	2.78	1.19
Too many targeted academic activities, which require a lot of preparation time	10 4.93%	17 8.37%	49 24.14%	**60** **29.56%**	**63** **31.03%**	4 1.97%	3.75	1.14
The level of the subject is too high for my previous knowledge and I don't understand it	11 5.42%	26 12.81%	**69** **33.99%**	**59** **29.06%**	32 15.76%	6 2.96%	3.38	1.08
The examinations that are carried out in some subjects during the semester prevent me from studying the others	**58** **28.57%**	**58** **28.57%**	32 15.76%	33 16.26%	19 9.36%	3 1.48%	2.49	1.32
I have given priority to the subjects of the first year (only for students enrolled in subjects of 1st and 2nd year or higher)	**48** **23.65%** **(37.21%)**	18 8.87% (13.95%)	17 8.37% (13.18%)	**28** **13.79%** **(21.71%)**	**18** **8.87%** **(13.95%)**	74 36.45%	2.61	1.50

except the percentages between parenthesis, which have been calculated with respect to the number of students enrolled in subjects of first and second or superior courses simultaneously (129). It is especially striking that students do not recognize the number of exams as a problem. In the same way, it seems that their own organization to prepare the exams is not seen as a problem by the students. Conversely, the two points that seem to be the most responsible for the students failures or dropouts are the great number of targeted activities and the insufficient time to prepare the exams correctly. In another way, there is no consensus with the assertion that students give priority to the subjects of the first year in detriment to others.

Simultaneously, a free text box was put at the disposal of the students with the aim of having the opportunity to express their opinions about the causes of dropout. 104 of the 315 students that took the survey decided to write a personal opinion. The results were grouped into 9 categories as shown in Fig. 4. 28 (26.9%) students said that "The teacher doesn't explain well"; 21 (20.2%), that "There are too many targeted activities"; 13 (12.5%), that "The level of the subject was too high for their previous knowledge"; 10 (9.6%), that "The exams calendar is inadequate"; 9 (8.7%), that "The exams are too difficult in comparison with the level of the class" and that "The classes timetables are inadequate"; 7 (6,7%) that "The syllabus of the subjects is too long"; and the other 7 (6,7%) gave other reasons.

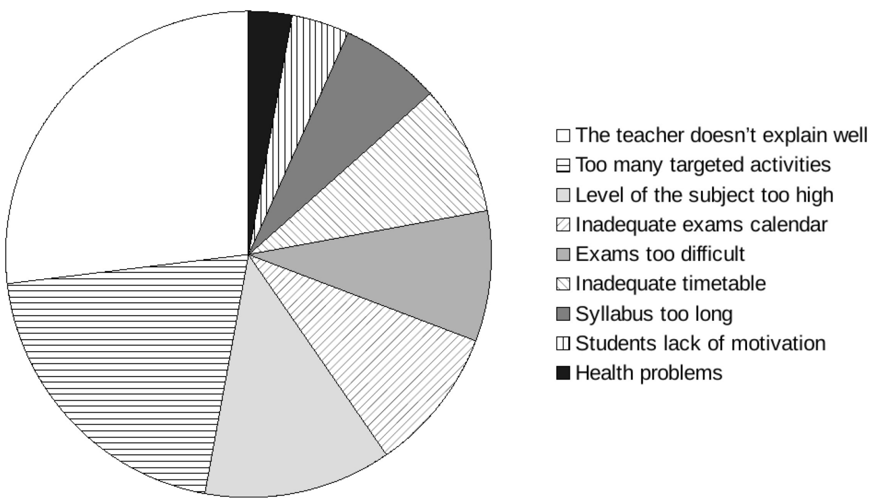

Fig. 4. Distribution of students' free opinions.

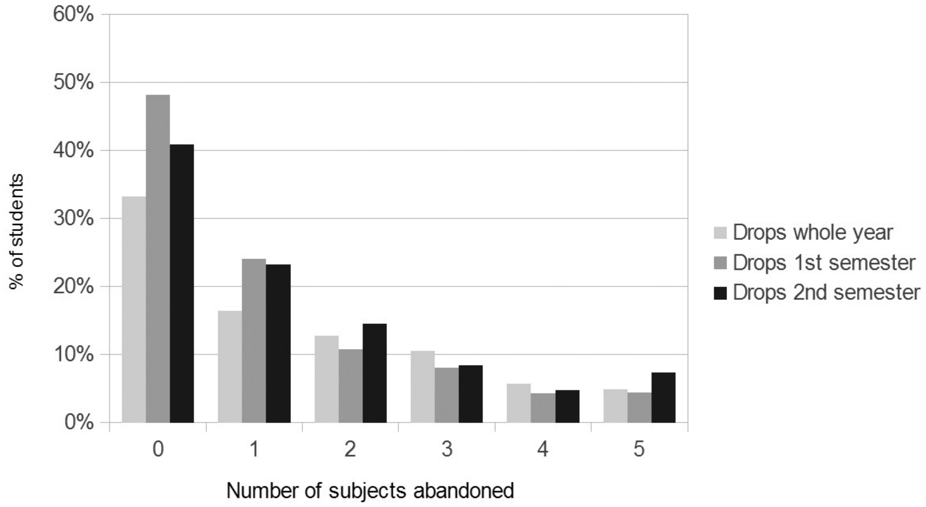

Fig. 5. Percentage of students from the whole group that abandoned 0...5 subjects during first, second semester and the whole year.

3.3 Analysis of the entire results of the academic year

Once analyzed the general results of the students enrolled in the first two courses, the first striking question is the number of students enrolled in comparison with the number of students who took the survey. According to teachers' information, the number of students who took the survey (all the attendees the day the survey was realized) is the normal number of students attending the classes. Nevertheless, the number of students who filled the survey was 315, while the number of total students enrolled in the subjects of first and second courses was 1037, so there was a general dispersion of the students among the subjects and a lack of class attendance. The second alarming point is the comparison between the number of students enrolled in subjects of first and second courses (1037) and the total number of students in the School (1532), so about the third part of the students of the School had subjects of the first two courses. In another way, the normal number of subjects to be enrolled in by the students is 10 (a course of 60 credits and 6 credits per subject), but only 41% of the students were enrolled in 10 subjects; from the other 59%, 27% chose fewer than 10 subjects, and 32% chose more than 10 subjects. Related to the distribution of dropouts in the whole universe of students (Fig. 5), the comparison between Fig. 1 and Fig. 5 seems to suggest that the students who normally attend classes compared to the whole group of students have a different behavior in respect to the number of subjects that they abandoned in the first, the second semester and the whole year. To prove this effect a triple Mann-Whitney test has been done: the first one comparing the number of dropouts in the first semester among the students who took the survey and the whole group; the second one with the dropouts of the second semester; and the third one with the dropouts of the whole year. According to Table 7, the behavior of the students that normally attend classes was the same as the whole group in the first semester. Nevertheless, in the second semester, and even in the whole year, there were significant differences between the two groups. In another way, it is possible to wonder if there is a different behavior in the whole group in respect to the number of subjects abandoned in the first or in the second semester. As the corresponding Wilcoxon test effectively shows (Table 8), there is a significant difference between the behavior of students in the first and second semester.

Another possible question to be addressed is whether there is a relationship between the number of subjects the students were enrolled in and the number of dropouts in the whole universe of students. Fig. 6 shows the percentage of students

Table 7. Comparison of behavior among students who normally attend to classes and the whole group in respect to the number of subjects abandoned. Mann-Whitney U test

Dropouts in the first semester	
U_A = 158433.5	U_B = 168221.5
z = 0.81	P = 0.209
Dropouts in the second semester	
U_A = 111307	U_B = 215348
z = 8.57	P < 0.0001
Dropouts in the whole year	
U_A = 134137.5	U_B = 192517.5
z = 4.81	P < 0.0001
n_A = 1037	n_B = 315

Table 8.- Wilcoxon test results for the number of subjects abandoned by the students each semester

		N	Mean ranks	Sum of ranks
First semester – second semester	Negative ranks	344	264.15	90869
	Positive ranks	170	244.04	41486
	Ties	523		
	Total	1037		
			Z = –7.64	p-value <0.001

that abandoned 0, 1–2, and 3 or more than 3 subjects among those enrolled in 7 or fewer, 8..11, and 12 or more subjects. The χ^2 test was performed to analyze the possible relationship between these two variables (Table 9). The statistic χ^2 value obtained was 73.42; with 10 degrees of freedom and a resultant significance of p-value = 9.63e-12. As well as in the previous analysis, it can be said that there is a real dependence between the number of subjects abandoned by the students and the number of subjects in which they are enrolled. The comparison between the p-values obtained in the analysis of dropouts of the students who attend classes normally and the whole group shows that the relationship between the number of subjects enrolled in by the students and the number of subjects abandoned is stronger in the whole group than in the group of students who took the survey.

4. Discussion

There is a range of possible causes for engineering student attrition. When asked, students pointed out a clear lack of motivation and a high academic level of the subjects. There are some possible explanations in respect to these subjects. In a first level, the demand of university studies in Spain is much greater in Health Sciences and Social Sciences degrees than in Engineering degrees, so it is possible that students enter engineering degrees as their second or third option. In the second level, as it is

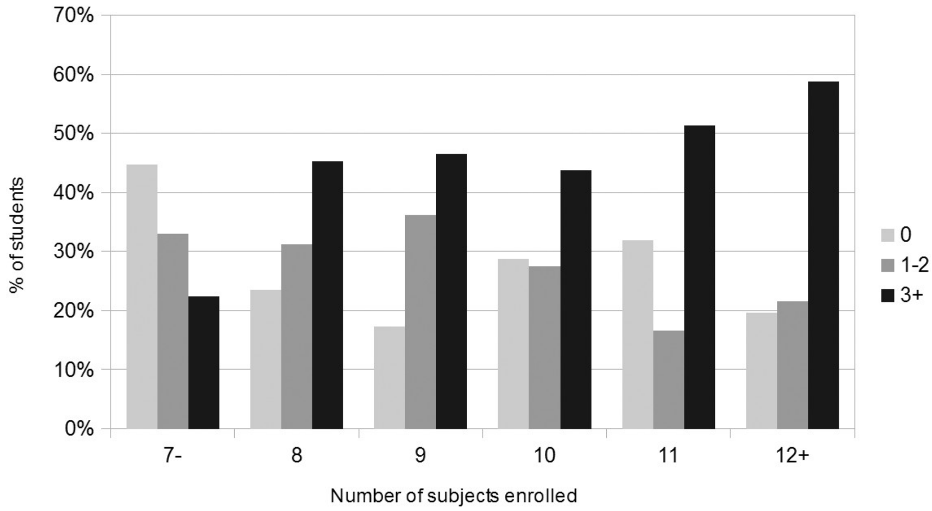

Fig. 6. Percentage of students that abandoned 0, 1-2, and 3 or more than 3 subjects by number of subjects enrolled for the whole group.

Table 9. Contingency matrix for the number of students that abandoned a number of subjects by number of subjects enrolled for the whole group

		Subjects enrolled						**Total**
		7–	**8**	**9**	**10**	**11**	**12+**	
Number of subjects abandoned	**0**	164	15	10	122	23	10	344
	1–2	121	20	21	117	12	11	302
	3+	82	29	27	186	37	30	391
	Total	367	64	58	425	72	51	1037
	χ^2 = 73.42	d.f. = 10	p = 9.63e-12					

commonly known [38], the knowledge level of the students at the end of High School is not as high as it should be. The level of the Spanish students is slightly above the average in Science and Reading and below the average in Mathematics, compared with OECD countries, so the starting point of engineering degrees seems to be too high for freshmen. In the second level, and reinforcing the previous ideas, the time needed by the students to adapt to their new situation and feel themselves as a part of a new social environment, seems to be too long as well.

In another way, students say that the workload of targeted activities is excessive for the time available, the syllabuses are too long, and the exams are too difficult for the level of the contents seen in class, which is something that university authorities should consider in the quality revision of the degree; on the contrary, the students do not see as a problem the number of partial exams existing in some subjects. Similarly, there are clear problems of organization put in evidence by the complicated timetables of class and examination calendars.

In the same line that the students' lack of motivation is the lack of attendance to classes, that can be identified as less than 50%. The reality is that, as a matter of fact, a part of the students do not abandon their studies, since they do not really start them even though they have effectively enrolled.

With respect to the students that effectively start their studies and attend classes normally, less than 50% of them took all the examinations of the first semester, and this subject has to be a central point in the future intervention of university authorities. Nevertheless, it is particularly striking that more than 60% of the same students said that they were going to take all the examinations in the second semester. It can be an excess of optimism on their behalf, an intention to improve in the second semester, or a sense of being adapted to the system, but the analysis of the real data of exams attendance showed that the correct interpretation was an excess of optimism.

Analyzing the way the students choose their subjects for the academic year it can be seen that only a small number of freshmen and sophomores take the number of subjects recommended in the syllabus (five subjects and 30 credits per semester), and they use other different criteria to make their enrollments. A possible interpretation of this effect

Table 10. Plan of improvement for the next years

Causes	Proposal	Responsible for the action
Students' lack of motivation	Outreach activities in High Schools to motivate engineering enrolment	Faculty staff University staff
	Intense tutorial action during the first year of the course	Faculty staff Teachers
	Tutorial action along the whole academic year	Teachers Peers mentors
Bad course planning	Tutorial action along the whole academic year	School teachers Peers mentors
High starting point	Support courses	Faculty staff Teachers
	Revision of syllabus	
Syllabus too large	Revision of syllabus	Faculty staff Teachers
	Coordination of contents between subjects	
Too many targeted activities	Limit the number of targeted activities and analyze the weight of each activity over the final assessment	Teachers
	Analyze the workload of every activity and the whole workload of the subject in relation with the credits assigned	
	Analyze the possibility of assessing the same activity in several subjects combining and coordinating contents and assessments	
Exams too difficult	Revision of contents and exams in relation to the activities and credits of the subjects	Teachers
Inadequate classes timetables	Revision and coordination of timetables and calendars	Faculty Staff Teachers Students council
Inadequate examinations calendars		

can be that the students feel themselves as a part of their entrance cohort and tend to enrol in all failed subjects of the previous year and the whole set of subjects of the following year, which only contribute to worsen the things. Effectively, by looking at the number of different courses of the syllabus in which the students are enrolled and their academical success, it can be clearly seen that the greater the number of courses enrolled the greater the number of subjects abandoned.

The general problem is difficult to be addressed since there is not a unique cause for it and the plan of improvement of the degree should take into account the whole set of causes identified in the study: students' lack of motivation, bad planning of the course by the students, high level of the course's starting point, syllabus too long, too many targeted activities, exams too difficult, inadequate class timetables and inadequate examinations calendars. The set of actions of improvement proposed to try to reverse the situation are shown in Table 10. In order to put in practice all the actions programmed it is necessary the implication of all the classes of the School: Faculty staff, teachers, peer mentors and students' council, all of them well coordinated by the staff. Equally, the whole process must be yearly revised, analyzed and re-planned in order to obtain the desired results.

5. Conclusions

Even though engineering degrees have a high rate of employment all over the world and the professionals of the engineering ambit are very well considered socially, the dropout rates of the students of these degrees are extraordinarily high in comparison with other branches of knowledge, as for example health sciences or social sciences. The reasons for this abandonment are not simple and have their roots in a set of causes. Some of them depend on the students, including lack of basic knowledge from High School, or the number of students that choose engineering degrees as their second or third option. In fact, the students recognize their lack of motivation to choose engineering degrees as well as their poor entrance level in engineering studies, but they claim that the level of the exams is too high compared with the level of the classes and that the number of targeted activities is too high too. In another way, as the results of the surveys clearly pointed out, the strategy followed by the students to plan their enrollments is too optimistic, as the number of subjects chosen, and the number of different courses that the subjects belong to, are excessive. This set of reasons, added to a low rate of class attendance, make the situation specially worrying.

But not all of the responsibility must relapse on the students. There are a set of causes depending on university too: class timetables too complex, inadequate examinations calendars, many targeted activities with low weight over the final assessment, or exams too difficult for the level of classes.

The university staff has the responsibility of putting into practice the measures needed to try to reverse this situation. Some of them could be outreach activities, tutorial action, syllabus revision, subject coordination, or timetable revisions, among others. Anyway, all those actions should be included in a general improvement plan of the degree and be revised by university authorities yearly.

Acknowledgments—The authors gratefully acknowledge the University of Cordoba for the funds received in the Plan of Educative Improvement and Innovation (Modality 1, Coordinated Projects for Official Degrees). In particular, the authors acknowledge the unselfish collaboration of David Fernández Rodríguez and Alejandro Bogarín Vega in the creation of the data sheets needed for the results analysis of this project.

References

1. D. Vilorio, STEM 101: Intro to tomorrow's jobs. *Occupational Outlook Quarterly, Bureau of Labour Statistics*, Spring 2014, pp. 2–12.
2. X. Chen, STEM attrition among high-performing college students: Scope and potential causes, *Journal of Technology and Science Education*, **5**(1), 2015, pp. 41–59.
3. X. Chen and M. Soldner, *STEM Attrition: College Students' Path Into and Out of STEM Fields.* National Center for Education Statistics (NCES), Statistical analysis report, Washington-DC, 2013, pp. 1–104.
4. Eurostat. R & D personnel — Statistics Explained, http://ec.europa.eu/eurostat/statistics-explained/index.php/R_%26_D_personnel#Human_resources_in_science_and_technology, Accessed 13 September 2018.
5. E. Hovdhaugen, A. Kottmann and L. Thomas, *Drop-out and Completion in Higher Education in Europe - Annex 1, Literature review*, European Commission, Luxembourg: Publications Office of the European Union, 2015, pp. 1–60.
6. MECD. Sistema Integrado de Información Universitaria (SIIU), Ministerio de Educación Cultura y Deporte, https://www.mecd.gob.es/servicios-al-ciudadano-mecd/estadisticas/educacion/universitaria/siiu.html, Accessed 13 September 2018.
7. S. Haag and J. Collofello, Engineering undergraduate persistence and contributing factors, *Proceedings—Frontiers in Education Conference, FIE*, 2008, pp. 8–14.
8. L. Esteban, A. Gargallo, M. Marzo and A. Marín, Factores determinantes del abandono de los estudios universitarios: análisis de un caso, *Actas del XII Congreso de Innovación Educativa en las Enseñanzas Técnicas*, 2004, pp. 1–10.
9. L. Cabrera, J. T. Bethencourt, P. Álvarez-Pérez and M. González-Afonso, El problema del abandono de los estudios universitarios, *Relieve*, **12**(2), 2006, pp. 171–203.
10. L. Thomas, *Building Student Engagement And Belonging In Higher Education At A Time Of Change: final report from the What Works? Student Retention & Success programme*, Paul Hamlyn Foundation, London WC1X 9HY, 2012.
11. J. H. Park and H. J. Choi, Factors influencing adult learners' decision to drop out or persist in online learning, *Educational Technology and Society*, **12**(4), 2009, pp. 207–217.
12. L. J. Barker, C. Mcdowell and K. Kalahar, Exploring Factors that Influence Computer Science Introductory Course Students to Persist in the Major, *Association for*

Computing Machinery, Special Interest Group on Computer Science Education Bulletin, **41**(2), 2009, pp. 282–286.
13. R. M. Marra, K. A. Rodgers, D. Shen and B. Bogue, B. Leaving Engineering: A Multi-Year Single Institution Study, *Journal of Engineering Education*, **101**(1), 2012, pp. 6–27.
14. D. Bennett, R. Kapoor, K. Rajinder and N. Maynard, First year engineering students: Perceptions of engineers and engineering work amongst domestic and international students, *The International Journal of the First Year in Higher Education*, **6**(1), 2015, pp. 89–105.
15. M. Meyer and S. Marx, Engineering dropouts: A qualitative examination of why undergraduates leave engineering, *Journal of Engineering Education*, **103**(4), 2014, pp. 525–548.
16. M. Meyer, *Persistence of engineering undergraduates at a public research university*, Utah State University, Logan Utah, 2015, pp. 1–125.
17. M. Meyer and N. Fang, Factors affecting persistence of undergraduate engineering students: A quantitative research study using institutional data, *International Journal of Engineering Education*, **32**(5), 2016, pp. 1879–1887.
18. D. Chen and H. Kelly, Understanding the leaky STEM pipeline by taking a close look at factors influencing retention and graduation rates, *40th Annual Conference of the North East Association for Institutional Research*, 2013, pp. 139–151.
19. B. N. Geisinger and D. R. Raman, Why They Leave: Understanding Student Attrition from Engineering Majors, *International Journal of Engineering Education*, **29**(4), 2013, pp. 914–925.
20. G. Bischof, A. Zwölfer and D. Rubeša, *Correlation between engineering students' performance in mathematics and academic success*, 2015 American Society for Engineering Education Annual Conference & Exposition, 2015, pp. 1–21.
21. C. Márquez-Vera, A. Cano, C. Romero, A. Y. M. Noaman, H. M. Fardoun and S. Ventura, Early dropout prediction using data mining: A case study with high school students, *Expert Systems*, **33**(1), 2016, pp. 107–124.
22. A. Pradeep, S. Das and J. J. Kizhekkethottam, Students dropout factor prediction using EDM techniques, *Proceedings of the Institute of Electrical and Electronics Engineers International Conference on Soft-Computing and Network Security, ICSNS*, 2015, pp. 1–7.
23. J. Tsai, D. Kotys-Schwartz and D. Knight, Introducing Actor-Network Theory Via the Engineering Sophomore Year, *American Society for Engineering Education Annual Conference & Exposition*, 2015, pp. 1–18.
24. P. L. Hardré, Z. Siddique and W. F. Smith, Modeling the Motivation of Mechanical Engineering Students: Productive Perceptions for Present and Future Success, *International Journal of Engineering Education*, **31**(2), 2015, pp. 635–647.
25. M. Hayden, Student Attrition from Higher Education Institutions, *International Encyclopedia of Education*, Elsevier, Oxford, 2010, pp. 467–472.
26. A. Imran and F. G. M. Hayati, Enhancing Student Retention in Undergraduate Engineering Programs—A Case Study, *American Society for Engineering Education Annual Conference & Exposition*, 2013, pp. 1–7.
27. B. J. Watkins and E. Mazur, Retaining Students in Science, Technology, Engineering, and Mathematics (STEM) Majors, *Journal of College Science Teaching*, **42**(5), 2013, pp. 36–41.
28. J. Bracey, K. Sadeghipour, C. Baugh and S. Fagan, Chasing the Holy Grail: Successful Academic Persistence and Retention of Highly Motivated First-Year Engineering Students, *American Society for Engineering Education Annual Conference & Exposition*, 2016, pp. 1–16.
29. J. Borzovs, L. Niedrite and D. Solodovnikova, Factors affecting attrition among first year computer science students: The case of university of Latvia, Environment. Technology, *Proceedings of the 10th International Scientific and Practical Conference*, **3**, 2015, pp. 36–42.
30. J. Johnson and A. D. Niemi, A First-Year Attrition Survey: Why Do They Say They Are Still Leaving?, *American Society for Engineering Education Annual Conference & Exposition*, 2015, pp. 1–7.
31. R. Sprang and S. A. Strom, Improving Freshman Retention in an Engineering Technology Program, *American Society for Engineering Education Annual Conference & Exposition*, 2015, pp. 1–5.
32. M. Pinxten, T. De Laet, T. C. Van Soon and G. Langie, Fighting increasing dropout rates in the STEM field: The European readySTEMgo Project, *43rd Annual European Society for Engineering Education: SEFI Conference*, 2015, pp. 1–8.
33. J. Husman, K. C. Cheng, K. Puruhito and E. J. Fishman, Understanding engineering students stress and emotions during an introductory engineering course, *American Society for Engineering Education Annual Conference and Exposition*, 2015, pp. 1–14.
34. R. A. Simon, M. W. Aulls, H. Dedic, K. Hubbard and N. C. Hall, Exploring student persistence in STEM programs: A motivational model, *Canadian Journal of Education*, **38**(1), 2015, pp. 1–27.
35. D. Laux, A. Jackson and N. Mentzer, Impact of Collaborative Learning on Student Persistence in First Year Design Course, *American Society for Engineering Education Annual Conference & Exposition*, 2016, pp. 1–17.
36. B. D. Jones, J. W. Osborne, M. C. Paretti and H. M. Matusovich, Relationships among students' perceptions of a first-year engineering design course and their engineering identification, motivational beliefs, course effort, and academic outcomes, *International Journal of Engineering Education*, **30**(6), 2014, pp. 1340–1356.
37. L. Salas-Morera, M. A. Cejas-Molina, J. L. Olivares-Olmedilla, M. S. Climent-Bellido, J. A. Leva-Ramírez and P. Martínez-Jiménez, Improving engineering skills in high school students: A partnership between university and K-12 teachers, *International Journal of Technology and Design Education*, **23**(4), 2013, pp. 903–920.
38. OECD. *PISA 2015 Results in Focus*, OECD, 2018, pp. 1–31.

Lorenzo Salas-Morera is a faculty member in the Area of Projects Engineering at Córdoba University. His primary areas of research include engineering education, educational technology, collaborative learning and interactive intelligent design. He received the University of Córdoba Social Council award of Educational Innovation in 2008.

María A. Cejas-Molina is a faculty member in the Area of Applied Mathematics at Córdoba University. Her primary areas of research are engineering education and educational technology.

José L. Olivares-Olmedilla is a faculty member in the Area of Electrical Engineering at Córdoba University. His primary areas of research are engineering education and educational technology.

Laura García-Hernández is a faculty member in the Area of Projects Engineering at Córdoba University. Her primary areas of research include engineering education, educational technology and interactive intelligent design.

Juan M. Palomo Romero is a Software Engineer and doctoral student in the Area of Projects Engineering at Córdoba University. His primary areas of research include engineering education, educational technology and interactive intelligent design.