The Flow of Knowledge and Level of Satisfaction in Engineering Courses Based on Students' Perceptions

Celina P. Leão, Filomena Soares, Anabela Guedes, M. Teresa Sena Esteves, Gustavo R. Alves, Isabel M. Brás Pereira, Romeu Hausmann and Clovis António Petry

Abstract In this chapter, the results of a questionnaire are analyzed to assess engineering students' satisfaction toward their courses, working conditions, and academic environment, as well as the flow of knowledge perception along the first

---

This work has been supported by research centre CIETI (Centro de inovação em engenharia e tecnologia industrial) in the scope of UID/EQU/00305/2013 and FCT (Fundação para a ciência e tecnologia) in the scope of the projects COMPETE: POCI-01-0145-FEDER-007043 and UID/CEC/00319/2013

C. P. Leão · F. Soares
Centro ALGORITMI, School of Engineering, University of Minho, Campus de Azurém, 4800-058 Guimarães, Portugal
e-mail: cpl@dps.uminho.pt

F. Soares
e-mail: fsoares@dei.uminho.pt

A. Guedes · M. T. Sena Esteves · G. R. Alves · I. M. Brás Pereira (✉)
Centro de Inovação em Engenharia e Tecnologia Industrial, Instituto Superior de Engenharia do Porto (ISEP), 4200-072 Porto, Portugal
e-mail: imp@isep.ipp.pt

A. Guedes
e-mail: afg@isep.ipp.pt

M. T. Sena Esteves
e-mail: mte@isep.ipp.pt

G. R. Alves
e-mail: gca@isep.ipp.pt

R. Hausmann
Department of Electrical and Telecommunication Engineering, University of Blumenau, Blumenau, Brazil
e-mail: romeuh@furb.br

C. A. Petry
Federal Institute of Santa Catarina, Florianópolis, Brazil
e-mail: petry@ifsc.edu.br

M. M. Nascimento et al. (eds.), *Contributions to Higher Engineering Education*,
https://doi.org/10.1007/978-981-10-8917-6_3

three curricular years. With a sample of 654 students from four higher education institutions and two countries, the study focused in eleven items, concerning teachers' involvement perception, student–teacher interaction, course organization, and functioning, and overall satisfaction. Several research hypotheses were considered, and significant correlations were investigated. Results show that students, in average, are satisfied with the course and with student–teacher interaction, but perceive that teachers do not contextualize the contents in a professional perspective. The flow of knowledge is neither clearly understood. Two positive significant correlations exist between: students' overall satisfaction and their expectations; the way students assess their interaction with teachers and the way they assess teachers' involvement. No significant differences were found between the two countries.

Keywords Students' perceptions · Satisfaction questionnaire · Engineering courses · Higher education

1 Introduction

Students' satisfaction and perceptions regarding their university courses are important measures for higher education institutions. Several studies can be found in the literature with different focuses but where the common issue is to analyze students' feedback [1–12].

In particular, in Sinclaire's work [1], it is referred that often, in the literature, students' satisfaction is related to institutional concern for the quality of courses and programs and the need to understand student perceptions. This author [1] presented a study in a business course of a public university in the southeast region of the USA with 560 students by using a questionnaire delivered via the Internet (a 5-point Likert-type scale was used, where 1 meant unimportant, and 5 represented very important). The items under evaluation were institutional factors, specifically "How important are college facilities and services to student satisfaction with a college course?"; learning environment, in detail class size, time, frequency, methods of instruction, instructor characteristics and behavior, learning technology, methods of grading, and course content; and considering all the above factors, "How important is each item to your overall satisfaction with a college course?". The results pointed out that factors relating to instructor characteristics (the teacher is always available, has a working knowledge of the subject, is interested in student learning, and he/she is passionate about the subject), methods of instruction and methods of grading were considered important or very important for student satisfaction with a college course. Additionally, 86% of students rated student-oriented course factors (student interest in subject, perception that course subject applies to work or profession, course in student major) as important or very important.

Tasirin et al. [2] present a study about students' satisfaction in master engineering programs (Universiti Kebangsaan Malaysia). By means of a survey that uses the service–product concept and analyzes expectations and perceptions, students' satisfaction is evaluated in different groups of factors: non-academic aspects, academic aspects, program issues, design, delivery and assessment, reputation, and access. The overall satisfaction is then related to each of the referred issues in order to identify the aspects that may be improved in terms of service quality. Results show that the overall satisfaction relies mostly in university reputation and that the worst assessment is given to non-academic aspects (such as administrative services). Results also show that students recognize the effect of the courses in developing certain employability skills. The study also allows identifying specific topics in the learning methodologies that might need some modifications in order to improve students' competencies in professional domains and science and engineering knowledge.

Cronje and Coll [3] presented a study developed in New Zealand university and polytechnic sectors in science and engineering courses. Students' beliefs of their higher education experiences were addressed as well as how they see the learning process and if it serves their careers' aims. One of the conclusions of the study was that polytechnic students were more positive regarding their learning, where its practical component may lead to enhance career prospects.

Borges et al. [4] focused their study on business courses (management, accounting, and tourism business) in two Brazilian universities, one public and one private. A quantitative and descriptive study was performed based on 513 students' responses. The results pointed out that students have more confidence in private universities than in public institutions. Nevertheless, the authors concluded that students' trust decreases with time. Also, it was verified that female students rely more on their universities than their male mates.

Some attempts have been made in order to study cultural and social factors that may influence students' degree of satisfaction. Demographics characteristics, ethnicity, and gender were analyzed by Lord et al. [5]. This study considered a large and diverse dataset with 90,000 first-time-in-college and 26,000 transfer students who attended engineering institutions at the USA, including students who started in first-year engineering programs, those changing majors, and those transferring from other institutions.

The study presented by Vaz et al. [6] aimed to analyze the applicability of a model of student satisfaction within higher education in two different countries: Portugal and Uruguay. The index of higher education student satisfaction developed by Alves and Raposo [7] was taken as a basis and compared with Uruguay. The results showed different performances in the two countries.

Several other studies are available in the scientific community. In the present work, it is not the authors' goal to present an extensive review on students' perceptions regarding engineering courses. However, there is still scope for identifying and exploiting many other different approaches. Following this trend, this paper is focused on evaluating the students' perception in the first three years of six engineering courses in electrical/electronics area in universities and polytechnic institutions in two countries, Portugal and Brazil. By doing this, it would be possible to follow how this perception and students' satisfaction evolve over the three years of the programmes. Also, it may allow to perceive if students understand that as the years pass, the state of knowledge increases and somewhat concurrently. This is what the flow of knowledge stands for in the present work.

This chapter is organized in five sections besides the Introduction. Section two, Frame of Study, presents the main objectives of the study, and the higher education institutions and courses analyzed. Section three, Materials and Methods, details the research instrument (questionnaire used), the methodology followed as well as the sample characterization. Section four describes the research hypotheses, and the results are presented and analyzed in section five. Conclusions are drawn in the last section of the paper.

2 Frame of Study

2.1 Main Objectives

The general objective of this full-scale study is to analyze and determine the level of satisfaction of electrical/electronic engineering students toward their courses, working conditions and academic environment, as well as to assess the way students perceive the flow of knowledge along the first three curricular years and in four different higher education institutions (HEIs), from two different countries.

2.2 Higher Education Institutions and Courses Analyzed

This study considers four HEI: two from Portugal (Instituto Superior de Engenharia do Porto, ISEP, and Escola de Engenharia da Universidade do Minho, EEUM) and two from Brazil (Instituto Federal de Santa Catarina, IFSC, and Universidade Regional de Blumenau, FURB).

Six different studies' programmes were chosen: two from ISEP (electrical and computer engineering, ECE-ISEP, and electrical engineering—power systems, EE-PS-ISEP), two from IFSC (electrical engineering, EE-FSC and electronics engineering, EiE-IFSC), one from FURB (electrical engineering, EE-FURB) and one from EEUM (industrial electronics engineering and computers, IEEC-UM) [13].

For each of the six engineering degrees in electrical/electronic, the first three years will be analyzed, corresponding to the first cycle of higher education.

3 Materials and Methods

This section presents briefly the instrument used for the data collection, the methodology followed as well as the sample characterization.

3.1 Description of the Research Instrument (Questionnaire)

A questionnaire was used as the research instrument in order to fulfill the objective and validate the set of hypotheses (defined in Sect. 4). In summary, the questionnaire includes two main parts: (1) student's characterization (age, gender, higher education institution, curricular year, semester, regime, number of registrations in the course, and regular/working student), (2) a list of forty-four items, divided in six groups [teachers' involvement perception (TIP), student interest (SI), student–teacher interaction (STI), course organization and functioning (COF), infrastructures (IS), and overall satisfaction (OS)], classified in a 5-point agreement Likert scale, 1 (Strongly Disagree) to 5 (Strongly Agree), with the neutral point (3) being neither disagree nor agree. The questionnaire reliability and validity had been previously assessed [13, 14]. Other details about the questionnaire and its previous validation may be found elsewhere [13, 14]. To fulfill the purpose of this study, eleven items from four of the six groups mentioned above were analyzed. Since the questionnaire was originally written in Portuguese (mother language in both countries), the translation of the items into English will be presented in the paper expressing the same meaning as in the original language.

The eleven items under analysis in the present study are included in groups: teachers involvement perception (TIP), student–teacher interaction (STI), course organization and functioning (COF), and overall satisfaction (OS), as follows:

TIP_4: *In general, teachers aim to contextualize the contents in a professional perspective*;
TIP_6: *In general, teachers present challenges to be solved outside the classroom*;
TIP_7: *In general, students assess positively teachers' performance*;
STI_6: *In general, the student–teacher interaction is positive*;
COF_8: *Teachers try to relate the syllabus with other courses*;
COF_9: *The syllabuses of the courses are well articulated with previously acquired knowledge*;
COF_10: *In general, the courses meet my expectations*;
COF_11: *The engineering course is well organized*;
OS_1: *I'm satisfied with the school environment and working conditions*;
OS_2: *I'm satisfied with the academic environment (cultural, sporting, and recreational activities)*;
OS_3: *In general, I'm satisfied with the course*.

3.2 Methodology

The questionnaires were approved by the courses' directors and then distributed according to the availability of teachers and students timetable. This procedure was chosen not to interfere with the proper functioning of the classes, in the second semester of 2014/15 and in order to ensure a larger sample, were also distributed in the first semester of 2015/16 (to different students). A curricular unit of each curricular year was chosen to hand out the questionnaire. After an explanation of the questionnaire aim, students answered it on a voluntary basis. Filling out the questionnaire took no more than 15 min.

3.3 Sample Characterization

Out of 661 questionnaires received, 654 answered completely all items and considered valid for analysis, with 18.9% from EEUM, 26.0% from FURB, 32.6% from IFSC, and 22.5% from ISEP. Based on the purpose of the present study, this sample size was considered acceptable and adequate [15]. With a confidence level of 95% and ±3% precision, considering a correction for finite population ($N \approx 950$ students), it would be necessary a sample size of 503 students (lower than the received valid 654 questionnaires). Also, the dimensions of the four subgroups (from the four HEIs) are considered acceptable.

The mean age is 21.7 years (SD = 4.9, range 17–55 years), and most of the students (67.2%) are aged 21 years or less. In all HEI, the majority of students (86.8%) are male (EEUM 91.2%, FURB 93.0%, IFSC 74.8%, ISEP 93.3%). Regarding classes' regime, FURB and ISEP are the two HEIs that have both day and after work classes. FURB has 87.1% and ISEP has 19.3% of students in after work classes. However, all of the HEI have students with student worker status (EEUM 7.2%, FURB 85.4%, IFSC 29.4%, ISEP 18.2%).

Table 1 summarizes the descriptive statistics regarding these variables.

Table 1 Summary of the descriptive statistics of the students' characteristics (see Sect. 2.2 for acronyms)

HEI	EEUM	FURB	IFSC	ISEP	Total
Characteristics	Percentage (%)				
Questionnaires	18.9	26.0	32.6	22.5	100
Gender					
Male	91.2	93.0	74.8	93.3	86.8
Female	8.8	7.0	25.2	6.7	13.2
Age					
≤18	17.6	25.1	32.1	1.3	20.6
19 < > 21	62.4	33.9	43.3	52.7	46.6
22 < > 24	11.2	18.1	12.6	21.4	15.7
≥25	8.8	22.9	12.0	24.6	16.7
Regime of class					
Day	100	12.9	100	80.7	73.0
After work	0.0	87.1	0.0	19.3	27.0
Students with student worker status	7.2	85.4	29.4	18.2	37.2
Characteristics	Mean ± S.D.				
Age	20.9 ± 4.2	22.2 ± 5.2	20.6 ± 3.9	23.3 ± 5.7	21.7 ± 4.9

4 Research Hypotheses

In order to achieve the proposed main objective of this study more easily, sixteen hypotheses were formulated to investigate students' perceptions in the four HEIs and their evolution along the first three curricular years. These hypotheses were stated on the basis of expected students' answers to the questionnaire distributed. They are as follows:

Hypothesis 1. Students perceived positively teachers' interest in contextualizing the contents in a professional perspective.
Hypothesis 2. Students' perception about whether teachers contextualize the contents in a professional perspective is independent of the curricular year and shows a similar behavior regardless of institution.

These two hypotheses allow understanding if and how students recognize the concern of the teacher in contextualizing the contents in a professional perspective. It is known that the first year usually consists of introductory courses, in the second year some of the subjects may be more theoretical than practical, and the third year has a different character from that of the earlier years with more specific and more practical subjects. Also, it will be possible to understand if this awareness changes over the years and if it is different or similar in the four institutions.

To do this analysis, the students' answers to the item "*In general, the teachers aim to contextualize the contents in a professional perspective*" (from TIP group, TIP_4) will be considered.

Hypothesis 3. Students perceived positively teachers' interest to present challenges to be solved outside the classroom.
Hypothesis 4. Students' perception about whether teachers present challenges to be solved outside the classroom is independent of the curricular year and shows a similar behavior regardless of institution.

In a way, these two hypotheses follow the idea of the previous ones: "students perceive that teachers' challenges together with the demonstration of the syllabus applicability to real problems promote students' interaction, satisfaction, and motivation."

To do this analysis, the students' answers to the item "*In general, the teachers present challenges to be solved outside the classroom*" (from TIP group, TIP_6) will be considered.

Hypothesis 5. Students assess positively teachers' performance.
Hypothesis 6. Students' assessment on teachers' performance is independent of the curricular year and shows a similar behavior regardless of institution.

To do this analysis, the students' answers to the item "*In general, students assess positively teachers' performance*" (from TIP group, TIP_7) will be considered.

Hypothesis 7. Students assess positively student–teacher interaction.
Hypothesis 8. Students' assessment on student–teacher interaction is independent of the curricular year and shows a similar behavior regardless of institution.

If students demonstrate a positive assessment regarding this issue, this could result in a more proactive attitude toward learning.

To do this analysis, the students' answers to the item "*In general, the student–teacher interaction is positive*" (from STI group, STI_6) will be considered.

Hypothesis 9. Students are able to realize the connection between the different courses (or curricular units, CU) and contents articulation.
Hypothesis 10. Students' perception on the connection between the different courses and contents articulation is independent of the curricular year and shows a similar behavior regardless of institution.

Any engineering degree incorporates a wide range of topics/subjects (from mathematics, statistics, and management to specific electronics subjects), so it is essential to create links between topics that apparently have no connection, in a well-structured manner. One way of doing this is to include these topics in integrating projects. So, it is important to understand if students are aware of this course structure.

To do this analysis, the students' answers to the two items "*Teachers seek to relate the contents with other CUs*" and "*The CU syllabus is well articulated with prior knowledge acquired*" (from COF group, COF_8 and COF_9, respectively) will be considered.

Hypothesis 11. Students positively assess course organization and this meets the students' best expectations.
Hypothesis 12. Students' assessment on course organization and students' best expectations fulfillment are independent of the curricular year and show a similar behavior regardless of institution.

To do this analysis, the students' answers to the two items "*In general, the courses meet my expectations*" and "*The course is well organized*" (from COF group, COF_10 and COF_11) students' answers will be considered.

Hypothesis 13. Students are satisfied with the school and academic environment.
Hypothesis 14. Students' satisfaction with the school and academic environment is independent of the curricular year and shows a similar behavior regardless of institution.

Satisfied students create a good work environment, and so they can stay longer at school not only for academic work but also for sports and cultural activities.

To do this analysis, the students' answers to the three items "*I'm satisfied with the school environment and working conditions*", "*I'm satisfied with the academic environment (cultural, sporting, and recreational activities),*" and "*Overall, I'm satisfied with the course*" (from OS group, OS_1, OS_2, and OS_3, respectively) will be considered.

Besides analyzing the referred answers, some correlations were tested aiming to identify tendencies among students' perceptions, and those correlations are described by hypotheses 15 and 16.

Hypothesis 15. The student–teacher interaction assessment is positively and significantly related to how students assess teachers' performance.

If students assess their interaction with teachers positively, it would be interesting to observe if and how this is related with their teachers' performance assessment. To do this analysis, the students' answers given to items STI_6 and TIP_7 will be considered.

Hypothesis 16. There is a significant and positive relationship between the students' overall satisfaction and the students' expectations regarding the course.

To do this analysis, students' answers to items OS_3 and COF_10 will be considered.

5 Results Analysis and Discussion

The results analysis of the students' awareness of the flow of knowledge and level of satisfaction throughout the first three years of the engineering course are presented and discussed below. The SPSS statistical tool was used for the data analysis [16].

As the data collected from the students do not follow the normality (normality was checked with the Shapiro–Wilk test), nonparametric tests were considered on the analysis in accordance with the various hypotheses to test (Kruskal-Wallis (H), for the comparison of more than two independent samples as alternative to the *t*-test, Friedman (F), alternative to the *t*-test for dependent samples, and Spearman's correlation coefficient (r_S) to study the relationship between two items). A significance level of 5% was considered.

5.1 Global Results

In Table 2, the results of the eleven items are summarized in terms of mean value, standard deviation (s.d.), and median, for the three curricular years and for the four

HEI. Regarding the different courses, they were not considered separately as they come from a similar area of knowledge: electrical/electronic engineering.

The descriptive analysis of the results presented in Table 2 shows that, in average, students' assessment is positive (mean value higher than 3). More than

Table 2 Summary of the descriptive statistics of the results for the eleven items (see Sects. 2.2 and 3.1 for acronyms)

Items	Year\HEI	Mean (s.d.); Median				
		EEUM	FURB	IFSC	ISEP	Total
TIP_4	First	3.8 (0.8); 4	3.3 (0.9); 3	4.1 (0.7); 4	3.4 (0.9); 3	3.6 (0.9); 4
	Second	2.9 (0.9); 3	3.5 (0.8); 3	3.3 (1.0); 3	3.6 (0.7); 4	3.3 (0.9); 3
	Third	3.0 (0.8); 3	3.3 (1.0); 3	3.6 (1.0); 4	3.2 (0.9); 3	3.2 (0.9); 3
	Total	3.2 (0.9); 3	3.3 (0.9); 3	3.8 (1.0); 4	3.4 (0.9); 3	3.4 (0.9); 3
TIP_6	First	3.6 (0.7); 4	3.8 (1.0); 4	4.1 (0.9); 4	3.7 (0.8); 4	3.8 (0.9); 4
	Second	3.3 (1.0); 3	3.8 (1.0); 4	3.7 (1.0); 4	3.5 (0.7); 3	3.6 (1.0); 4
	Third year	3.5 (0.7); 3.5	3.5 (0.9); 4	3.7 (1.0); 4	3.2 (0.9); 3	3.5 (0.9); 4
	Total	3.5 (0.8); 4	3.7 (1.0); 4	3.9 (1.0); 4	3.5 (0.8); 4	3.7 (0.9); 4
TIP_7	First	3.7 (0.7); 4	3.9 (0.8); 4	4.3 (0.7); 4	3.8 (0.8); 4	4.0 (0.8); 4
	Second	3.2 (0.8); 3	3.9 (0.5); 4	4.0 (0.8); 4	3.7 (0.5); 4	3.8 (0.7); 4
	Third	3.4 (0.7); 3	3.8 (0.6); 4	4.0 (1.0); 4	3.5 (0.8); 4	3.6 (0.8); 4
	Total	3.4 (0.7); 4	3.8 (0.7); 4	4.2 (0.7); 4	3.6 (0.8); 4	3.8 (0.8); 4
STI_6	First	3.8 (0.6); 4	3.9 (0.8); 4	4.2 (0.6); 4	3.7 (0.7); 4	4.0 (0.7); 4
	Second	3.7 (0.6); 4	3.9 (0.8); 4	4.2 (0.8); 4	3.7 (0.6); 4	3.9 (0.8); 4
	Third	3.5 (0.7); 4	3.6 (0.7); 4	4.5 (0.7); 5	3.5 (0.8); 4	3.6 (0.8); 4
	Total	3.6 (0.7); 4	3.8 (0.8); 4	4.2 (0.7); 4	3.7 (0.7); 4	3.9 (0.8); 4
COF_8	First	3.7 (0.8); 4	3.5 (0.9); 4	3.9 (0.8); 4	3.7 (0.8); 4	3.7 (0.8); 4
	Second	3.2 (0.8); 3	3.7 (1.0); 4	3.4 (1.0); 3.5	3.7 (0.6); 4	3.5 (0.9); 4
	Third	3.6 (0.7); 4	3.6 (0.9); 4	4.0 (0.9); 4	3.4 (0.7); 3	3.6 (0.8); 4
	Total	3.5 (0.7); 4	3.6 (0.9); 4	3.7 (0.9); 4	3.6 (0.7); 4	3.6 (0.9); 4
COF_9	First	3.7 (0.7); 4	3.6 (0.8); 4	3.8 (0.8); 4	3.2 (0.8); 3	3.6 (0.8); 4
	Second	3.4 (0.6); 3	3.7 (0.8); 4	3.5 (1.0); 4	3.6 (0.7); 4	3.5 (0.9); 4
	Third	3.4 (0.9); 4	3.5 (0.8); 3	3.7 (0.8); 4	3.3 (0.9); 3	3.5 (0.9); 4
	Total	3.5 (0.8); 4	3.6 (0.8); 4	3.6 (0.9); 4	3.3 (0.8); 3	3.5 (0.9); 4
COF_10	First	3.8 (0.7); 4	3.8 (0.8); 4	4.1 (0.8); 4	3.5 (0.7); 4	3.8 (0.8); 4
	Second	3.6 (0.6); 4	3.7 (0.7); 4	3.8 (0.9); 4	3.8 (0.5); 4	3.7 (0.7); 4
	Third	3.4 (0.8); 3	3.6 (0.7); 4	4.1 (0.9); 4	3.3 (0.6); 3	3.5 (0.8); 4
	Total	3.5 (0.7); 4	3.7 (0.8); 4	3.9 (0.8); 4	3.5 (0.7); 4	3.7 (0.8); 4
COF_11	First	4.0 (0.7); 4	4.0 (0.9); 4	3.9 (0.9); 4	3.4 (0.9); 4	3.8 (0.9); 4
	Second	3.2 (0.9); 3	3.7 (0.7); 4	3.2 (1.0); 3	3.6 (0.5); 4	3.4 (0.9); 4
	Third	3.0 (0.9); 3	3.5 (0.8); 4	3.8 (0.9); 4	3.1 (0.7); 3	3.3 (0.9); 3
	Total	3.3 (1.0); 3.5	3.7 (0.9); 4	3.7 (1.0); 4	3.4 (0.8); 4	3.6 (1.0); 4
OS_1	First	4.0 (0.5); 4	4.0 (0.8); 4	4.1 (0.8); 4	3.9 (0.6); 4	4.0 (0.7); 4
	Second	3.3 (0.7); 3	3.8 (0.7); 4	3.7 (1.1); 4	4.1 (0.6); 4	3.7 (0.9); 4
	Third	3.7 (0.7); 4	3.7 (0.7); 4	3.7 (0.7); 4	3.6 (0.6); 4	3.7 (0.6); 4
	Total	3.7 (0.7); 4	3.8 (0.8); 4	3.9 (0.9); 4	3.9 (0.6); 4	3.8 (0.8); 4

(continued)

Table 2 (continued)

Items	Year\HEI	Mean (s.d.); Median				
		EEUM	FURB	IFSC	ISEP	Total
OS_2	First	4.1 (0.6); 4	3.7 (1.0); 4	3.8 (0.9); 4	3.7 (0.7); 4	3.8 (0.9); 4
	Second	3.8 (0.8); 4	3.6 (0.9); 4	3.3 (1.2); 3	4.0 (0.6); 4	3.5 (1.0); 4
	Third	3.6 (0.9); 4	3.3 (0.9); 3	3.6 (1.4); 4	3.6 (0.9); 4	3.5 (0.9); 4
	Total	3.8 (0.8); 4	3.6 (0.9); 4	3.6 (1.0); 4	3.8 (0.6); 4	3.7 (0.9); 4
OS_3	First	4.3 (0.7); 4	4.1 (1.0); 4	4.3 (0.7); 4	3.9 (0.6); 4	4.1 (0.8); 0
	Second	3.8 (0.6); 4	4.0 (0.9); 4	4.0 (0.9); 4	4.2 (0.5); 4	4.0 (0.8); 4
	Third	3.7 (0.7); 4	3.8 (0.7); 4	4.1 (0.9); 4	3.8 (0.6); 4	3.8 (0.7); 4
	Total	3.9 (0.7); 4	4.0 (0.8); 4	4.2 (0.8); 4	3.9 (0.6); 4	4.0 (0.8); 4

50% of the students "agree" with the statements proposed (median equal to 4). However, in TPI_4 (*In general, teachers aim to contextualize the contents in a professional perspective*) for practically all curricular years and HEI, in COF_11 (*The engineering course is well organized*) for the third year, and in OS_1 (*I'm satisfied with the school environment and working conditions*), and OS_3 (*In general I'm satisfied with the course*) in a few cases, a median of 3 was obtained indicating a neutral position for more than 50% of the students.

In Table 2, it can also be seen that the two items with the highest score, in average, were OS_3 (*In general, I'm satisfied with the course*) and STI_6 (*In general, the student–teacher interaction is positive*), and by opposition TIP_4 (*In general, teachers aim to contextualize the contents in a professional perspective*) which presents the lowest score.

Figure 1 illustrates the distribution of students' assessment regarding the eleven items under analysis with the corresponding 95% confidence intervals strengthening the item with the highest mean score (OS_3) and the one with the lowest (TIP_4).

In a certain sense the previous results follow the achievements obtained by other authors, namely [1], stressing the importance of teacher and student interaction in the engineering program student's satisfaction, and [3], where students assume that a more practical component helps them to be better prepared for their future career.

These observed differences in average reveal that there was a statistically significant difference in assessment depending on which item is being considered ($F(10) = 406.7$, $p < 0.001$).

In order to understand the differences observed, data were further analyzed by HEI and curricular year.

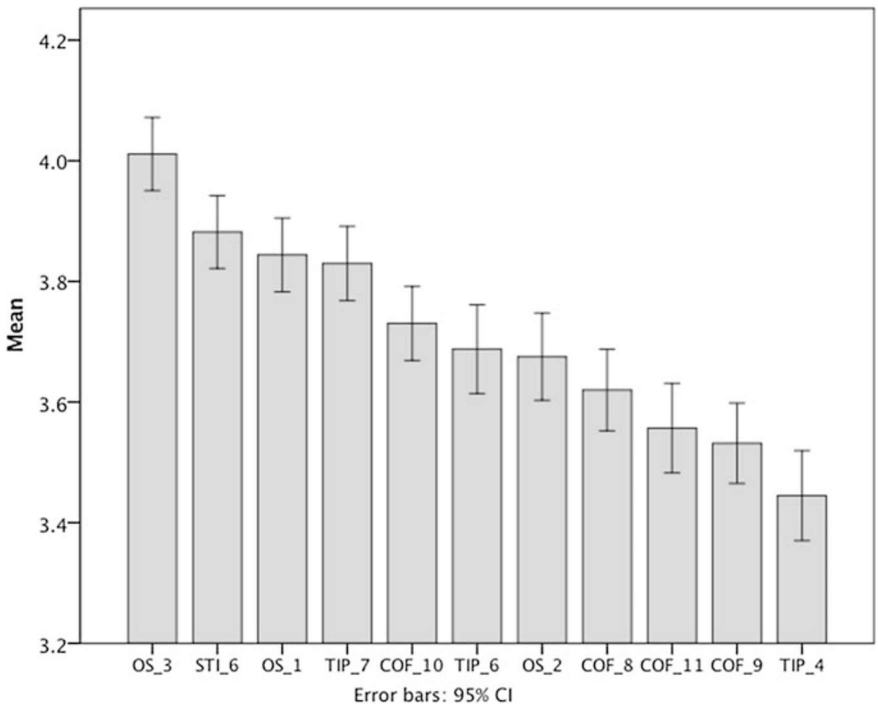

Fig. 1 Distribution of students' answers mean and 95% confidence intervals (CI) for the eleven items (see Sects. 2.2 and 3.1 for acronyms)

5.2 Results by HEI and Curricular Year

For the four HEI, the distribution of students' assessment in the eleven items is shown in Fig. 2.

Some outliers, values considered with an extreme behavior, were observed, namely the ones corresponding to the lower classification 1 "Strongly Disagree" (dots and stars in Fig. 2), in the majority of the eleven items in analysis. Nevertheless, these values were considered for the present study for their importance. In fact, these outliers do not correspond to the same student reflecting a random behavior.

The differences observed, for all the items, among the four HEIs are statistically significant ($p < 0.001$ in all items). So a different behavior is observed according to the item in study. For example, for TIP_4 item, EEUM shows an assessment score lower than the other three HEIs while IFSC has the highest. As another example, in COF_9, item ISEP shows a lower assessment in comparison to EEUM, FURB, and ISFC.

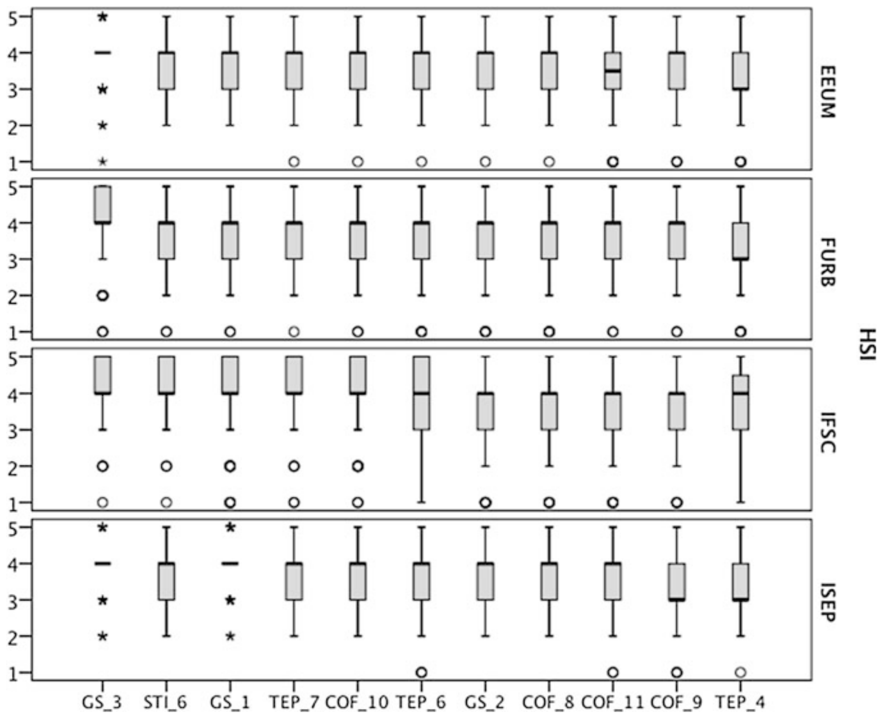

Fig. 2 Distribution of students' answers for the eleven items in analysis by HEI (see Sects. 2.2 and 3.1 for acronyms)

When analyzing the distribution of the scores throughout the three curricular years (Fig. 3), different patterns were observed. Generally, the first year represents the more positive, followed by the second and the third with the lowest score. These differences were statistically significant, except for item COF_9 (*The syllabuses of the courses are well articulated with previously acquired knowledge*) ($H(2) = 2.38$, $p = 0.304$).

Although on different areas of knowledge, other studies also ascertained that students' trust decreases with time [4, 17]. This could justify a higher awareness by teachers of the need and adoption of different and new teaching methodologies reducing student resistance to class activities.

5.3 Relevant Correlations

The student–teacher interaction assessment (STI_6) is positively and significantly related to how students assess positively teachers' performance (TIP_7) ($r_S = 0.60$, $p < 0.001$, Table 3). This result, somehow, might represent that the more students

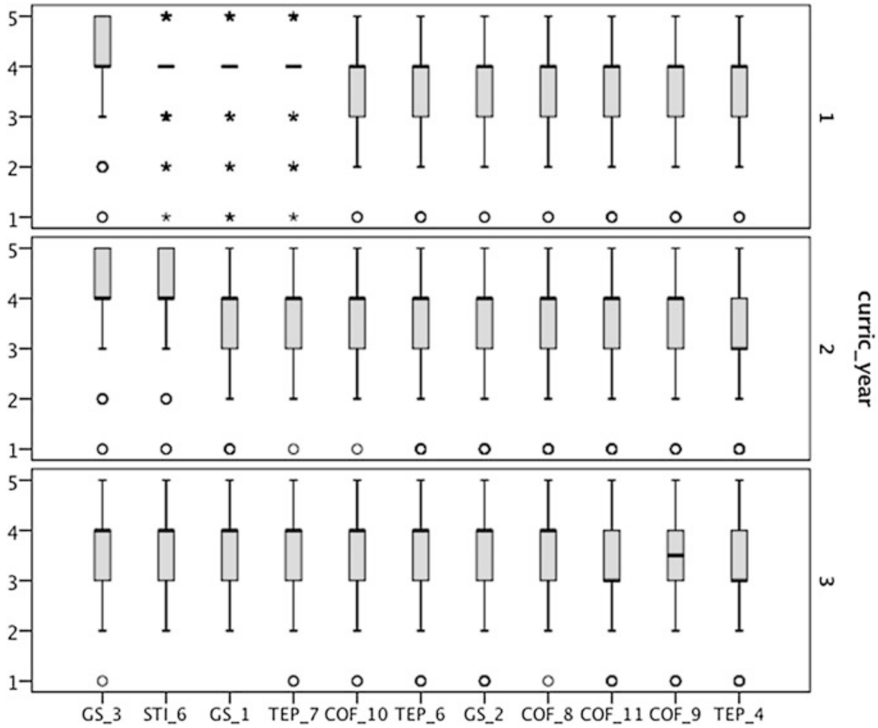

Fig. 3 Distribution of students' answers for the eleven items in analysis by academic year (see Sects. 2.2 and 3.1 for acronyms)

Table 3 Spearman's coefficients, r_s, for the correlations between the items (see Sect. 3.1 for acronyms)

		TIP_7	STI_6	COF_10	OS_1	OS_2
Spearman's coefficient, r_S	TIP_7	1				
	STI_6	0.60*	1			
	COF_10	0.48*	0.46*	1		
	OS_1	0.40*	0.43*	0.43*	1	
	OS_2	0.25*	0.24*	0.31*	0.48*	1
	OS_3	0.50**	0.44*	0.59*	0.60*	0.46*

*Correlation is significant at the 0.01 level (1-tailed)

interact with teachers in class the more positively they assess teachers' performance. This, in some sense, underscores the importance of communication between students and teachers helping the understanding of the students' feedback on teaching [9, 18].

There was a significant positive relationship between the students' overall satisfaction (OS_3) and the students' expectations regarding their course (COF_10) ($r_S = 0.59$, $p < 0.001$, Table 3). This correlation represents a positive result showing that in average students are satisfied with the course and their initial expectations have been met.

5.4 Hypotheses Validation

Table 4 summarizes the results for all hypotheses identifying its veracity.

The students, in average, assessed positively all the items TIP_4, TIP_6, TIP_7, STI_6, COF_8, COF_9, COF_10, COF_11, OS_1, OS_2, and OS_3, allowing to confirm hypotheses 1, 3, 5, 7, 9, 11, and 13 (differences are not significant, see "No" in Table 4). However, this perception changes along the years and between the HEI (differences are significant for hypotheses 2, 4, 6, 8, 10, 12, and 14, see "Yes" in Table 4).

These results show that students' awareness regarding the flow of knowledge changes somewhat over the years and by HEI. At some point, students throughout their course get lost and become unable to interconnect the contents learned.

There is a significant and positive relationship between the students' overall satisfaction and the students' expectations regarding the course. Also, there is a positive relationship between the way students assess their interaction with teacher and how they assess teachers' involvement (differences are significant for hypotheses 15 and 16, see "Yes" in Table 4).

Table 4 Summary of the results regarding the sixteen hypotheses (see Sect. 3.1 for acronyms)

Hypothesis	Item	Significant differences	Hypothesis	Item	Significant differences
1	TIP_4	No	9	COF_8; 9	No
2	TIP_4	Yes	10	COF_8; 9	Yes
3	TIP_6	No	11	COF_10; 11	No
4	TIP_6	Yes	12	COF_10; 11	Yes
5	TIP_7	No	13	OS_1; 2; 3	No
6	TIP_7	Yes	14	OS_1; 2; 3	Yes
7	STI_6	No	15	STI_6; TIP_7	Yes
8	STI_6	Yes	16	OS_3; COF_10	Yes

6 Conclusions

This study presents and discusses some results on students' perceptions in electrical/electronic engineering courses from four higher education institutions: two Portuguese (Instituto Superior de Engenharia do Porto, ISEP, and Escola de Engenharia da Universidade do Minho, EEUM) and two Brazilian (Instituto Federal de Santa Catarina, IFSC, and Universidade Regional de Blumenau, FURB). Six different courses were chosen: two from ISEP, two from IFSC, one from FURB, and one from EEUM. For each of the six electrical/electronic engineering degrees, the first three curricular years were analyzed, corresponding to the first cycle of higher education, with a total of 654 questionnaires considered valid for analysis.

In general students' assessment of all the eleven items considering teachers' involvement perception (TIP), student–teacher interaction (STI), course organization and functioning (COF), and overall satisfaction (OS) is positive (mean higher than 3, in a 5-point Likert scale).

When the results are analyzed by HEI and by curricular year, there are statistically significant differences between the four HEIs and the three years.

Regarding the four HEI, in many items, the best scores are obtained in IFSC. One of the factors that might justify these results is the novelty of the degree (started in 2013), although a more detailed analysis of other possible reasons would be important and necessary.

Along the three years, the students' awareness of their course, in average, becomes more critical, i.e., from one year to the next, the students' assessment, in general decreases slightly. The analysis performed also shows that in general students do not understand the articulation of contents and the flow of knowledge along the curricular years and between curricular units. This might confirm that it is important to include integrating projects in all curricular years, and not only in last years, as it is more usual. This will have an impact on students' teaching/learning process as a first contact with real engineering problems and as a collaborative learning [19–21]. These latter aspects can be an indication that students do not understand the flow of knowledge in the first three years, which strengthens the idea of a further research to be undertaken considering the second cycle of studies (fourth and fifth year).

The students' assessment depends on which item is being analyzed: in general, students are satisfied with the course and with student–teacher interaction (highest score), and by opposition, students perceive that teachers do not contextualize the contents in a professional perspective (lowest score).

The students' overall satisfaction and the students' expectations regarding the course are positively related. Also, there is a positive relationship between the way students assess their interaction with teacher and how they assess teachers' involvement.

The results analyzed in the present work point out that there are no significant differences when considering the two countries, revealing that two countries do not necessarily imply two realities, but instead work with the same objective: to create a space to disseminate, share, and generate knowledge.

Future work will include the analysis of students' feedback in the second cycle of studies in the four institutions. Also, authors are considering the possibility of extending the study to higher education institutions in other countries.

Acknowledgements The authors would like to express their acknowledgments to the higher education institutions and to all the students who accepted, on a voluntary basis, to collaborate in this study.

References

1. Sinclaire JK (2014) An empirical investigation of student satisfaction with college courses. Res High Educ J 22
2. Tasirin SM, Omar MZ, Esa F, Zulkifli MN, Amil Z (2015) Measuring student satisfaction towards engineering postgraduate programme in UKM. J Eng Sci Technol 10:100–109 (Special Issue on UKM Teaching and Learning Congress 2013)
3. Cronje T, Coll RK (2008) Student perceptions of higher education science and engineering learning communities. Res Sci Technol Educ 26(3):295–309. https://doi.org/10.1080/02635140802276587
4. Borges GR, Carvalho MJ, Domingues S, Cordeiro RCS (2016) Student's trust in the university: analysing differences between public and private higher education institutions in Brazil. Int Rev Public Nonprofit Mark 13:119–135. https://doi.org/10.1007/s12208-016-0156-9
5. Lord SM, Layton RA, Ohland MW (2015) Multi-institution study of student demographics and outcomes in electrical and computer engineering in the USA. IEEE Trans Educ 58 (3):141–150. https://doi.org/10.1109/TE.2014.2344622
6. Vaz RÁ, Freira D, Vernazza E, Alves H (2016) Can students' satisfaction indexes be applied the same way in different countries? Int Rev Public Nonprofit Mark 13:101–118. https://doi.org/10.1007/s12208-016-0155-x
7. Alves H, Raposo M (2007) Student satisfaction index in Portuguese public higher education. High Educ Serv Ind J 27(6):795–808
8. Bell JS, Mitchell R (2000) Competency-based versus traditional cohort-based technical education: a comparison of students' perception. J Career Tech Educ 17(1):5–22. https://doi.org/10.21061/jcte.v17i1.589
9. Bagchi U (2010) Delivering student satisfaction in higher education: a QFD approach. In: 7th international conference on service systems and service management (ICSSSM), Tokyo, Japan, 28–30 June 2010
10. Xu H (2011) Students' perception of university education—USA vs. China. Res High Educ J 10. https://doi.org/10.1037/spq0000002
11. Rjaibi N, Rabai LBA, Limam M (2012) Modeling the prediction of student's satisfaction in face to face learning: an empirical investigation. In: International conference on education and e-learning innovations, Tunisia, 1–3 July 2012
12. Carvalho M, Batra B (2015) Pharmacy student's survey: perceptions and expectations of pharmaceutical compounding. Int J Pharm Compd 19(1):18–27
13. Leão CP, Soares F, Guedes A, Sena-Esteves MT, Alves G, Brás-Pereira IM, Hausmann R, Petry CA (2015) Freshman's perceptions in electrical/electronic engineering courses: early findings. In: Proceedings of the 3rd international conference on technological ecosystems for enhancing multiculturality (TEEM 2015), Porto, Portugal, 7–9 October 2015. ACM, pp 361–367. https://doi.org/10.1145/2808580.2808634
14. Leão CP, Soares F, Guedes A, Sena-Esteves MT, Alves G, Brás-Pereira IM, Hausmann R, Petry CA (2016) Sou caloiro de engenharia!: estudo multicaso em engenharia eléctrica/eletrónica/electrotécnica. In: COBENGE 2016, Brasil, 27–30 Sept (in Portuguese)

15. Israel GD (1992) Determining sample size. University of Florida Cooperative Extension Service, Institute of Food and Agriculture Sciences, EDIS, Gainesville
16. Field A (2009) Discovering statistics using SPSS. SAGE, Publications Ltd., London
17. Nguyen KA, Husman J, Borrego M, Shekhar P, Prince M, Demonbrun M, Finelli C, Henderson C, Waters C (2017) Students' expectations, types of instruction, and instructor strategies predicting student response to active learning. Int J Eng Educ 33(1A):2–18
18. Weurlander M, Cronhjort M, Filipsson L (2016) Engineering students' experiences of interactive teaching in calculus. High Educ Res Develop, 1–14. https://doi.org/10.1080/07294360.2016.1238880
19. Alves AC, Moreira F, Lima RM, Sousa RM, Dinis-Carvalho J, Mesquita D, Fernandes S, van Hattum-Janssen N (2012) Project based learning in first year, first semester of industrial engineering and management: some results. In: Proceedings of the ASME 2012 international mechanical engineering congress & exposition (IMECE2012), Houston, Texas, USA, 9–15 Nov
20. de los Ríos I, Cazorlaa A, Díaz-Puentea JM, Yagüe JL (2010) Project–based learning in engineering higher education: two decades of teaching competences in real environments. Procedia—Socd Behav Sci 2(2):1368–1378
21. Stappenbelt B, Rowles C (2009) Project based learning in the 1st year engineering curriculum. In: Proceedings of the 20th Australasian Association for Engineering Education Conference (AAEE 2009), Adelaide, University of Adelaide, Australia, pp 411–416

Celina P. Leão is a Researcher at Centro Algoritmi and has been an Assistant Professor at the School of Engineering of University of Minho since 2003, in Guimarães, Portugal, where she teaches numerical methods and applied statistics. Her main interests are in modeling and simulation of processes and in the application of new methodologies in the learning process of numerical methods and statistics in engineering. Her interests also include engineering gender studies and in mixing qualitative and quantitative approaches.

Filomena Soares received her degree in Chemical Engineering in 1986 at Porto University, Portugal. In 1997, she obtained her Ph.D. in Chemical Engineering at the same University. Since 1992, she works in the Industrial Electronics Department, Minho University, and she develops her research work in R&D Algoritmi Centre. Her main scientific interests are in the areas of system modeling and control, with application to bioprocesses and in biomedical engineering science. Motor and cognitive rehabilitation has been receiving her attention, using serious games and robots to foster the communication with impaired and typically developing children. She is interested in new teaching–learning methodologies, in particular blended learning and virtual and remote laboratories. She supervised several M.Sc. and Ph.D. thesis and was co-author of several scientific articles in international conferences and journals.

Anabela Guedes is a Researcher at CIETI—Instituto Superior de Engenharia do Porto (ISEP), Portugal, and has been a teacher in the Chemical Engineering Department at ISEP since 1995. Her main interests are chemical reaction, process control, and energy optimization. Her interests also include new teaching–learning methodologies.

M. Teresa Sena-Esteves is a Researcher at CIETI and has been a Professor at the Polytechnic of Porto—School of Engineering, since 1993, in Porto, Portugal, where she teaches fluid mechanics and process integration. Her main interests are in chemical engineering, mass transfer, fluid dynamics, separation processes, and swimming pool water treatment.

Gustavo R. Alves graduated in 1991 and obtained an MSc and a Ph.D. in Computers and Electrical Engineering in 1995 and 1999, respectively, from the University of Porto, Portugal. He is with the Polytechnic of Porto—School of Engineering, since 1994. He was involved in several national and international R&D projects and has authored or co-authored +200 conference and journal papers with a referee process. His research interests include engineering education, remote laboratories, and design for debug and test.

Isabel M. Brás Pereira is a Researcher at CIETI—Instituto Superior de Engenharia do Porto (ISEP), Portugal, and has been a teacher in the Chemical Engineering Department at ISEP since 1993, in subjects like heat and mass transfer, instrumentation and control, gaseous emissions treatment. For the last nine years, she has been coordinating the curricular internships of first cycle chemical engineering students. Engineering education is presently one of her main research interests.

Romeu Hausmann is a researcher on Power Electronics in the Department of Electrical and Telecommunication Engineering at University of Blumenau—FURB, Santa Catarina, Brazil. He is a Full-Time Professor at FURB, where he is a lecturer in power electronics and electrical circuits, since 2001. His main interests are in DC–AC multilevel converters, renewable energy, and engineering education.

Clovis António Petry is a researcher at LPPE and has been a lecturer at the Federal Institute of Santa Catarina—Campus Florianópolis (IFSC) since 2006, in Florianópolis, State of Santa Catarina, Brazil, where he teaches power electronics and research methodology. His main research interests are related to teaching electronics and didactical issues, as well as the power electronics research field.