

MECHANICAL ENGINEERING EDUCATION AT THE UNIVERSITY OF MINHO

Paulo Flores, Eurico Seabra

*University of Minho, Mechanical Engineering Department
Campus de Azurém, 4800-058 Guimarães, Portugal
pflores@dem.uminho.pt, eseabra@dem.uminho.pt*

Abstract

This paper draws upon research aiming at investigating teaching and learning at higher education within the so-called Bologna Process. It discusses the ways in which students learn at Engineering Education and it analyses their implications for redesigning initial training and rethinking teachers' role. Data were gathered through interviews and questionnaires. A questionnaire was designed including both closed and open-ended questions. Four levels of information were included: biographic data (gender, age, initial training, current job position, etc), academic education (reasons for choosing Mechanical Engineering, reasons for selecting University of Minho, expectations about Mechanical Engineering course, etc), transition from University to labor market (difficulties faced, scope and nature of the work, etc) and graduate and post-graduate interests (areas, type and organization for high level courses, specific courses, Masters' and PhD courses). Background characteristics, such as years of experience, academic years of experience at the current job were also included. Overall, findings suggest a positive evaluation of initial training, namely the ways students adapted to university, relationship between students, and length of their practicum. They also highlight a number of issues to be improved: a more hands-on approach, a better pedagogical intervention from lecturers, a more adequate articulation between content knowledge at secondary school and university education.

Keywords: Mechanical Engineering Education, Bologna Declaration.

1. Introduction

Understanding the ways in which students at higher education live and assess their learning experiences is a key issue in improving the education and development opportunities provided to them, especially in times of change and challenge. Engineering programs are under restructuring according to the so-called Bologna Process in Europe (Hedberg 2003, Heitmann 2005, Teixeira et al. 2006). Issues related to new modules, new curriculum structure, active learning, and student independent work, cooperative learning (as is the case of Project-led education) became key features in this process. Along with this is the discussion of what should be done in terms of teaching and learning, assessment, development of competencies/skills (technical and soft) within the view of lifelong learning in the context of higher education. Thus, an educational paradigm shift is under debate. Traditional teaching and learning at higher education is mostly an outcome-led process, in which key technical competencies are to be acquired and assessed, usually through final exams. The need to think about teaching and learning at higher education from a different perspective is recognized. This implies a different role for both the student and the teacher.

The reasons behind the shift from traditional to more student-centred education in higher education may be associated with various reasons, namely focus on learning rather than on teaching, articulation with professional practice, enhancing critical thinking, better understanding of the subject matter, development of cross-disciplinary competencies, team work, research and communication skills, conflict management, project management and autonomous and creative work, etc. (Schachterle and Vinter 1996, Helle et al. 2006). The idea of self-regulated learning also becomes a key issue in a more student-centred process which is "an active, constructive process whereby learners set goals for their learning and then attempt to monitor, regulate, and control their cognition, motivation, and behaviour, guided and constrained by their goals and the contextual features in the environment" (Pintrich 2000). Learning is then seen as a multidimensional process which

embodies personal aspects (both cognitive and emotional), and behavioural and contextual ones (Zimmerman 1998). Therefore, learning is a dynamic and open process which requires students to engage in a wide array of tasks and activities which imply, in turn, careful planning, decision-making and self-reflection.

These are some of the thoughts and ideas that have inspired the authors to undertake the present study in order to explore Mechanical Engineering students' views on their training course at the University of Minho in the context of a deep and complex process of restructuring under the so-called Bologna Declaration (Teixeira et al. 2006). One of the main objectives of the Portuguese law document (Decree-Law n° 74/2006, 24/3) is "to assure the qualification of the Portuguese people, applying the Bologna Process, a unique opportunity to enhance people with higher education, to improve quality and relevance of education offer, to promote the mobility of our students and graduates and the internationalization of our education offer". This requires the need to reform Portuguese Higher Education System according to the new learning-teaching paradigm, in order to comply with one of the aims of Bologna Process which is the construction of a European Area of Higher Education.

It is within this context that this study was carried out. This work deals with initial training, more specifically with initial training of Mechanical Engineers, within times of change of educational paradigm within the context of the so-called Bologna Process. It is a study of the conceptions and experiences of Mechanical Engineers in regard to their initial training, the transition to the labour market and their perspectives on further training and professional development opportunities. It is a descriptive study following mainly a quantitative methodology, although at the beginning a qualitative approach was used. 162 Mechanical Engineers were involved in the study which included, in the first phase, an exploratory interview which constituted the basis for the construction of the questionnaire used in the second phase of data collection. The process of qualitative data analysis is carried out according to a comparative and horizontal analysis. The quantitative data was analyzed statistically with the use of SPSS 11.5®. This and other issues will be discussed further in the paper.

2. Bologna Declaration in Short

Over the last few years, a number of works have been dedicated to the issue of Bologna Declaration, namely, Hedberg 2003, Augusti 2005, Heitmann 2005, Teixeira et al. 2006, Grünwald et al. 2006 just to mention a few. In 1999, the ministers of education of 29 countries and university leaders from the whole of Europe met to discuss the future development of higher education in Europe. The post-summit declaration issued by the ministers – the Bologna Declaration, as it is known – expressed the goal of developing a European Higher Education Area by 2010. This development process is known as the Bologna Process (Bologna Declaration 1999). Two years after the Bologna Conference, the ministers met in Prague, and then again in Berlin in 2003, and more recently in Bergen in 2005. The number of member countries increased to 40. In fact, the ministers have decided to meet every two years to reconfirm the Bologna Declaration goals, to analyze the results and to set guidelines for the next period.

The Bologna Process defines 10 action lines or objectives on the road towards the achievement of a European Higher Education Area. These goals overlap, or are inter-dependent, but each goal is important itself. The objectives defined in the Bologna Process include the adoption of a comparable degree system with two main cycles, aimed at facilitating movement between countries. This in turn is a condition for achieving the goal of increased mobility for students and academic and administrative staff in higher education. The promotion of quality assurance and increased inter-institutional cooperation is also an objective. The 10 action lines defined on the conferences of ministers responsible for Higher Education at Bologna, Prague and Berlin are:

1. Adoption of a system of easily readable and comparable degrees;
2. Adoption of a system essentially based on two main cycles;
3. Establishment of a system of credits, favourably the European Credit Transfer System (ECTS);
4. Promotion mobility for students and academic and administrative staff;
5. Promotion of European cooperation in quality assurance;
6. Promotion of the European dimension in higher education;
7. Lifelong learning;
8. Higher education institutions and students;
9. Promoting the attractiveness of the European Higher Education Area;
10. Doctoral studies and the synergy between the European Higher Education Area and the European Research Area.

The first 6 action lines were defined in the Bologna Declaration, action lines 7 to 9 were established in the Prague Communiqué, and finally, the action line 10 was defined in the Berlin Communiqué. It should be highlighted that the social dimension of higher education may be seen as an overarching or transversal action line. Further information and details on this issue can be found at www.bologna-bergen2005.no.

In short, the main objectives of the Bologna Declaration are to increase the mobility and employability of the European higher education graduates, and thus ensuring competitiveness of European higher education on the world scale. Achieving these goals will also require identification and solution of a number of social issues. This paper draws upon a broader piece of research aiming at investigating issues of teaching and learning at higher education within the so-called Bologna Process.

3. Research Methodology

The goals of the study reported in this paper were twofold: to analyze the perceptions of Mechanical Engineers in relation to their training at University and to discuss the implications of these for improving teaching/learning process, in particular the teacher and student's role. Three main research questions were behind this study, namely (Flores 2006):

1. How do Mechanical Engineers graduated at the University of Minho evaluate their initial training (curricular organization, practicum, theoretical vs practical components of the program, activities undertaken ...)?
2. How did they adapt to their workplace?
3. What are the key areas for further training and professional development opportunities?

In order to capture their views on their initial training, on their transition to the labor market and on further training and professional development opportunities, a combination of methods was used. Exploratory semi-structured interviews were conducted with 8 Mechanical Engineers (former students at the University of Minho) in order to examine the ways in which they looked back on their initial training at University. Diversity in terms of age, years of experience and date of conclusion of their degree was taken into account to select the interviewees. The interviews lasted about an hour and were used to explore and identify key dimensions and categories to be transformed into questions to be used during the main phase of data collection. A questionnaire was then designed which included both closed and open-ended questions.

Several levels of information were included: initial training; practicum; first years at the workplace and further training and professional development opportunities. Background characteristics, such as gender, age, years of experience, academic qualifications and years of experience at current job were also included. Data were collected in January to March 2006. The process of qualitative data analysis was undertaken according to two phases: a vertical analysis (Miles and Huberman 1994) according to which each of the respondents' interviews was analyzed separately. A second phase was then carried out according to a comparative or horizontal analysis (cross-case analysis). In this phase, the method of 'constant comparative analysis' (Glaser and Strauss 1967) was used to look for common patterns as well as differences. Quantitative data were analyzed statistically with the use of SPSS 11.5®. Overall, 162 Mechanical Engineers responded to the questionnaire: 91.4% are male and 8.6% female; 51.9% are 30 years old or younger; 47.5% are between 31 and 39; and 94.4% are employed at the moment. Figures 1 through 3 show the results obtained from the Mechanical Engineers relative to the gender, age and employability, respectively.

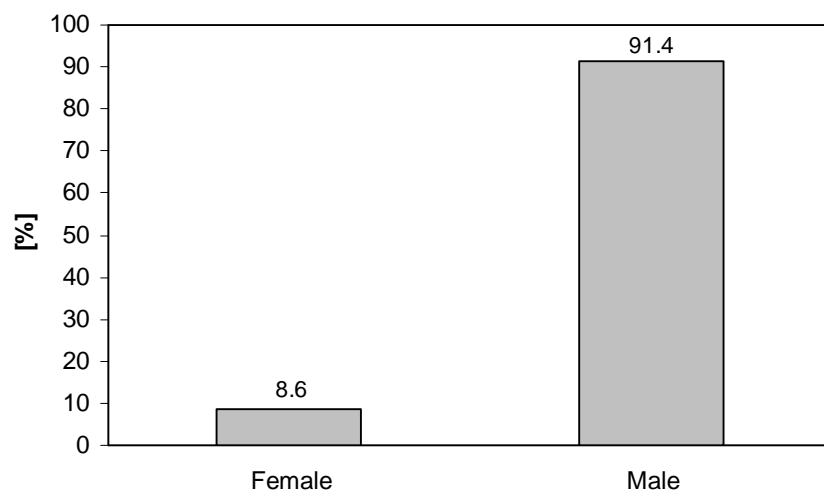


Figure.1: Gender of the Mechanical Engineers that responded to the questionnaire.

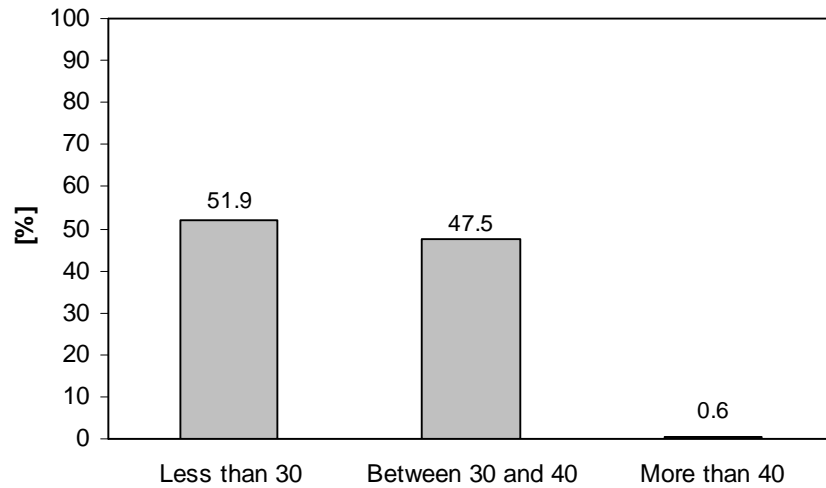


Figure.2: Age of the Mechanical Engineers that responded to the questionnaire.

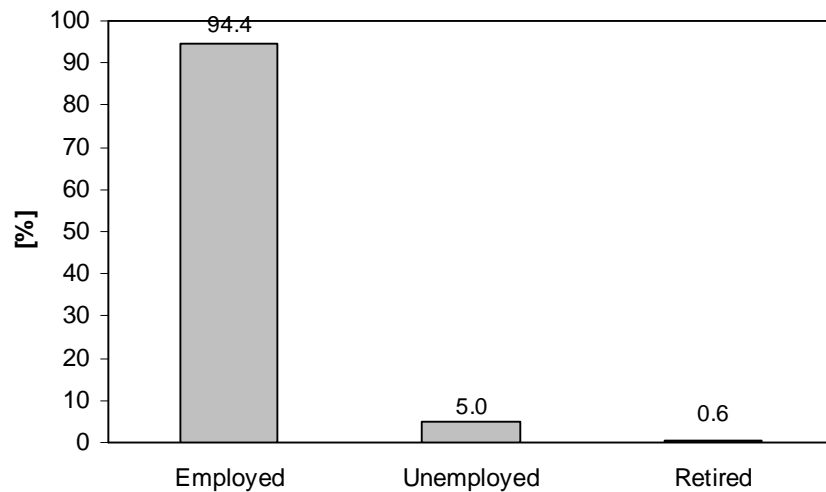


Figure.3: Employability of the Mechanical Engineers that responded to the questionnaire.

4. Results and Discussion

In this section some of the main results and opinions from Mechanical Engineers relative to the topics included in the questionnaire are presented and discussed. From the data, it is possible to know that 63.3% of the respondents changed job over the last three years, see figure 4. The main reasons put forward were better working conditions; better professional career; end of contract; geographical proximity.

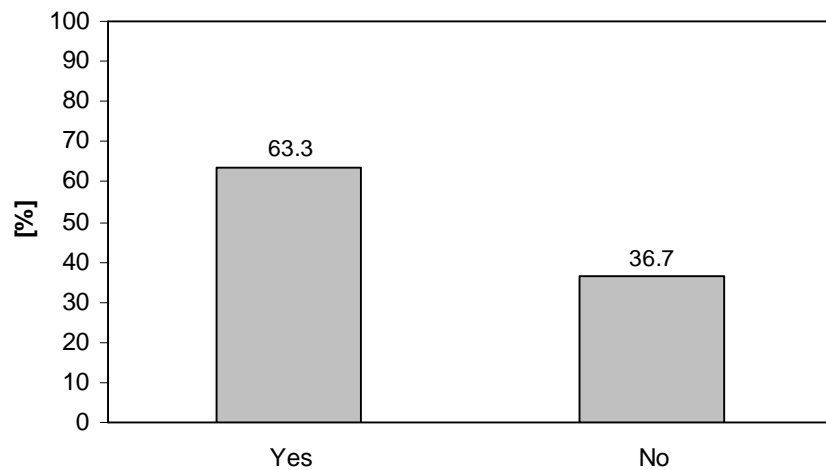


Figure.4: Did the Mechanical Engineers change their job over the last three years?

When asked about the main motives for entering a Mechanical Engineering Course at the University they pointed out several situations: vocation/calling – 31.5% (1st choice); enjoying working with machines – 19.1%; enjoying working with cars – 18.5% and employment opportunities – 16.7%.

Also of interest is the fact that for the large majority of the respondents (78.9%) Mechanical Engineering was the first choice in terms of career when applying at a post at University, see figure 5. This is also the case of the University of Minho, which was the first choice for 65.2% of the respondents, as it illustrated in figure 6.

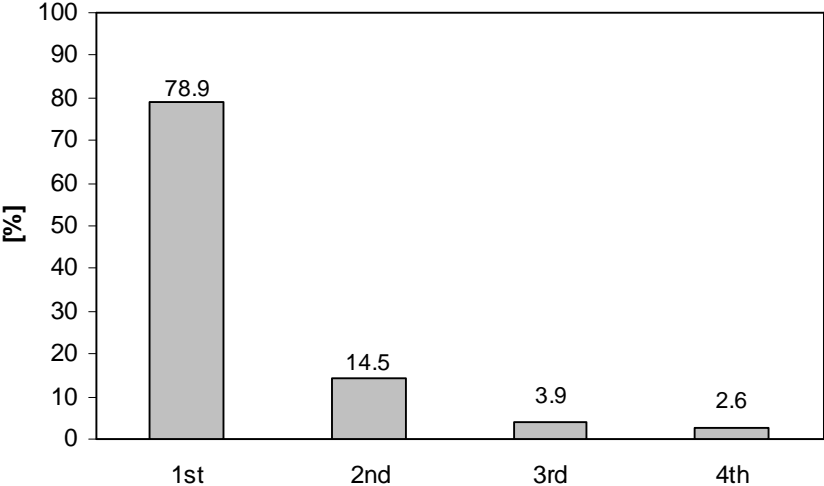


Figure.5: Option for choosing Mechanical Engineering course when entering at the university for the first time.

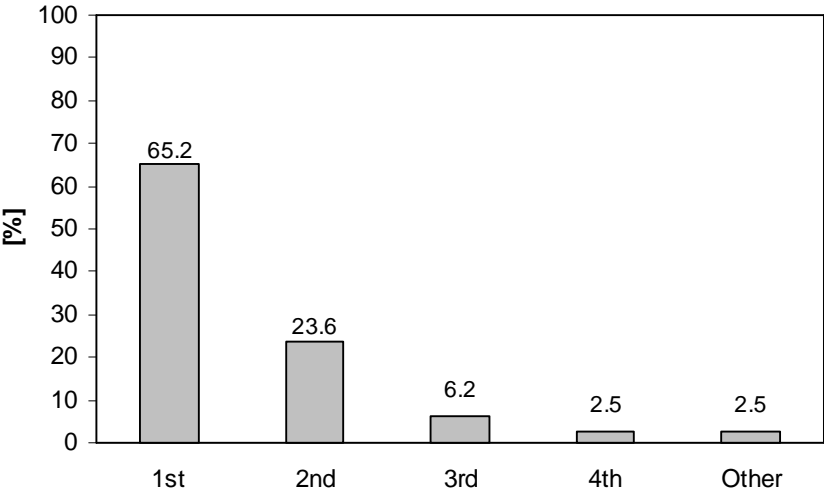


Figure.6: Option for choosing the University of Minho.

When asked about the overall evaluation of the quality of Mechanical Engineering course obtained from Mechanical Engineers at the University of Minho, the opinion from the respondents is, in general, good, as it can be observed in figure 7. Several reasons were identified for this positive evaluation, namely the broad overview of the course, professional opportunities, good technical knowledge-base for future work and adequate curricular organization of the course. Following are some opinions of the respondents:

“The course has provided me with a good basis of technical knowledge. It has provided me with a good preparation for the labour market.”

“It is a very broad course at all levels in the mechanical world. Thus it opens many doors in terms of future job.”

“I’ve learned how to identify problems and looking for solutions.”

“I think the course was useful because I developed technical and scientific knowledge which is relevant to my work and because I’ve always had several job opportunities.”

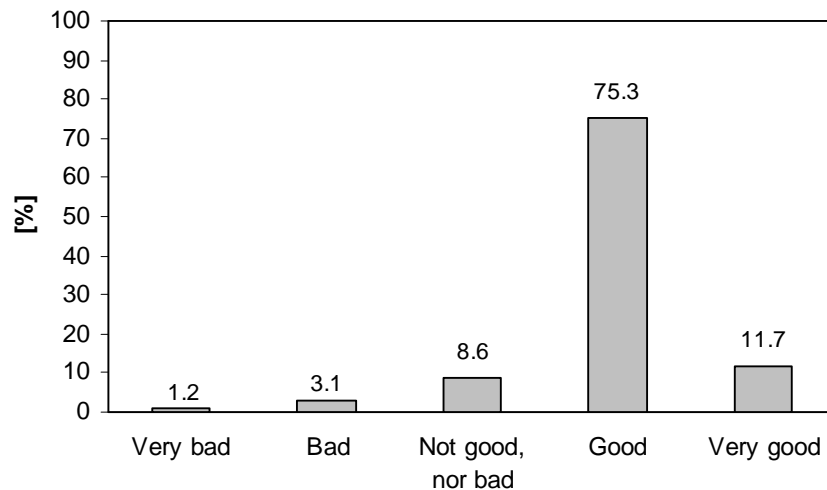


Figure.7: Overall evaluation of the quality of Mechanical Engineering course.

The large majority of the participants in the study (79.5%) revealed that the course has met their expectations (see figure 8). They emphasized the following issues for this: good preparation to face future work/profession; being broad enough in terms of knowledge and competencies; practical component and curricular organization adequate; lecturers' professionalism. However, 20.5% stated that the course did not meet their expectations and they highlighted the following issues: being too theoretical; the lack of liaison between University and industry; poor preparation to the labour market; lack of articulation and inadequate curricular organization, and lack of support, and poor pedagogical preparation from some teachers/lecturers. The following quotations are illustrative of this:

"I think the course should be more practical, especially during the first years."

"As it is, it's too theoretical, with poor effect on your real job..."

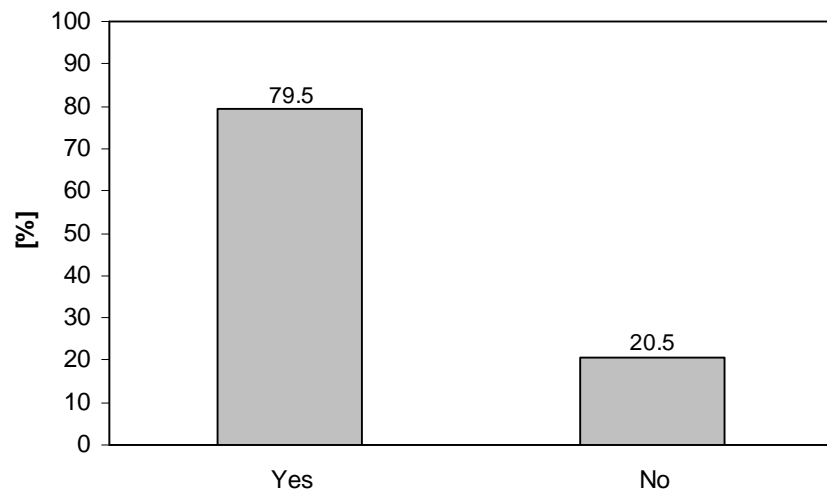


Figure.8: Does the Mechanical Engineering course correspond to the initial expectations?

In the present study, the respondents also identified a number of issues related to their course at the University of Minho in relation to which they feel more or less satisfied. Concerning with the adaptation to the University of Minho, 41.6% of the respondents are completely satisfied. In relation to the range of professional options in terms of job/career, 58.0% of the respondents are satisfied. 35.2% of the respondents are not satisfied, nor dissatisfied with the teacher/student relationship, development of social and professional skills. Concerning with the access, during the course, to laboratory work and study visits, 30.4% of the Mechanical Engineers are dissatisfied. Finally, 21.4% of the respondents are completely dissatisfied with the support from the University in finding a job. Figures 9 through 13 show these opinions.

Along with this is also a number of key issues to be improved according to the participants in this study. They refer to a more hands-on perspective from the beginning of the course; the introduction of curriculum units related to resource management; better pedagogical approach of some teachers/lecturers; more emphasis on

transversal competencies such as teamwork, communication skills, leadership, etc; better articulation between what is taught at University and at secondary education; and better articulation between university and industry. To some of them:

“I think the curricular structure of the course need improvement, namely in regard to the practicum. It will help to develop and apply knowledge if you have a more hands-on work.”

“It needs to be more in line with Portuguese industry needs...”

“We need a better articulation between University and Industry, and therefore better integration in the labour market...”

“The course should include more projects during the five years and more hands-on work especially during several periods of time in industry...”

“Even though there are teachers/lecturers with good pedagogical preparation, there are other who need training on pedagogy skills, namely in approaching the content and relating to students... Some of them are for too many years on the job without training...”

“I think teachers/lecturers should be evaluated in order to distinguish between good and not so good teachers...”

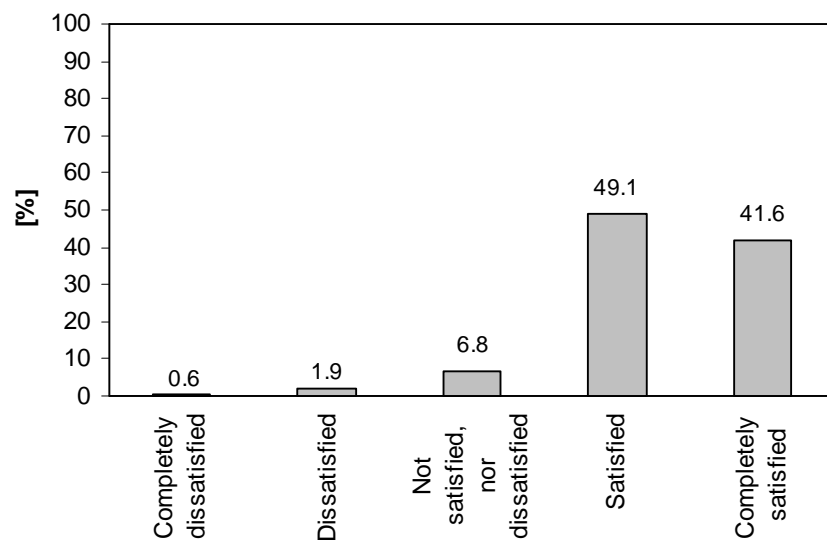


Figure.9: Degree of satisfaction relative to the adaptation to the University of Minho.

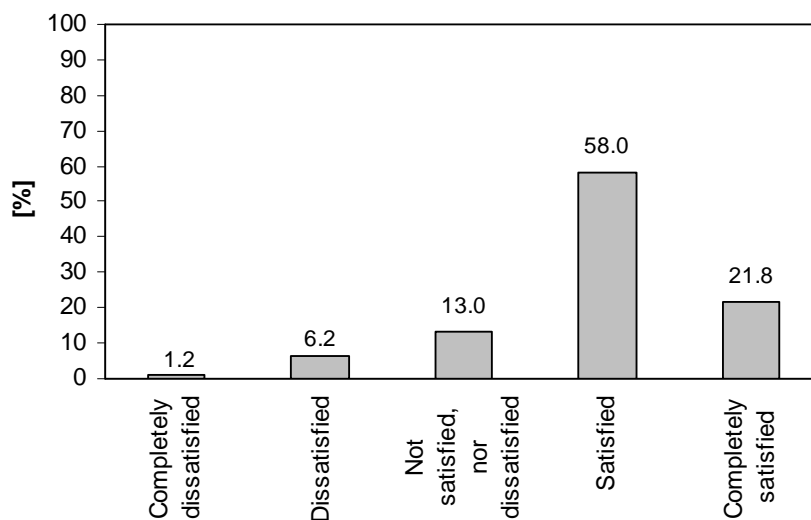


Figure.10: Degree of satisfaction in relation to the range of professional options in terms of job/career.

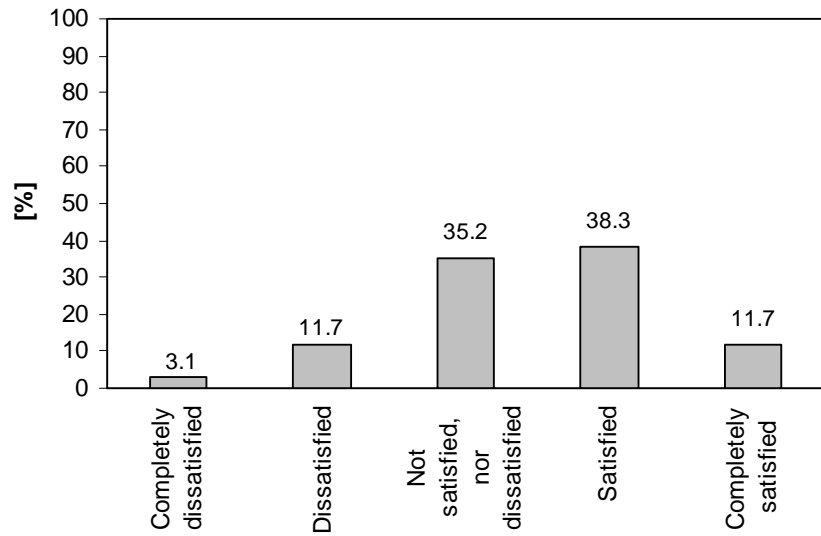


Figure.11: Degree of satisfaction in terms of the teacher/student relationship.

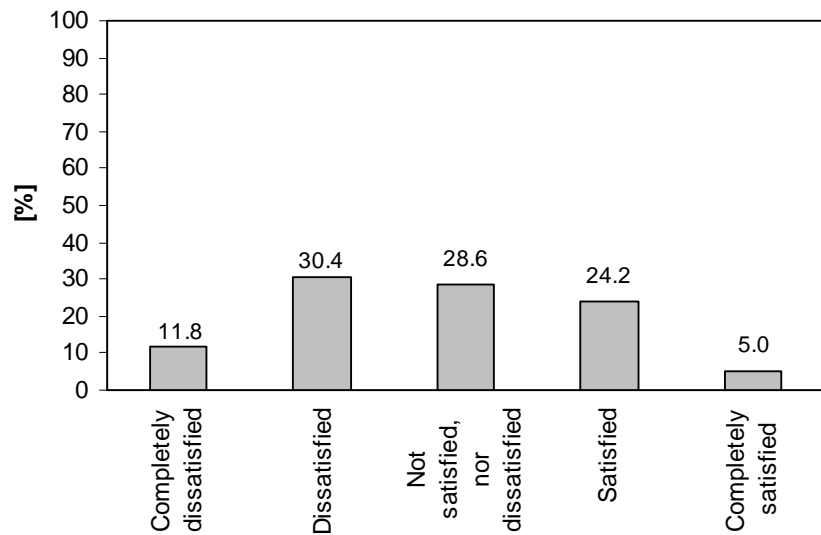


Figure.12: Degree of satisfaction in relation to the access, during the course, to laboratory work and study visits.

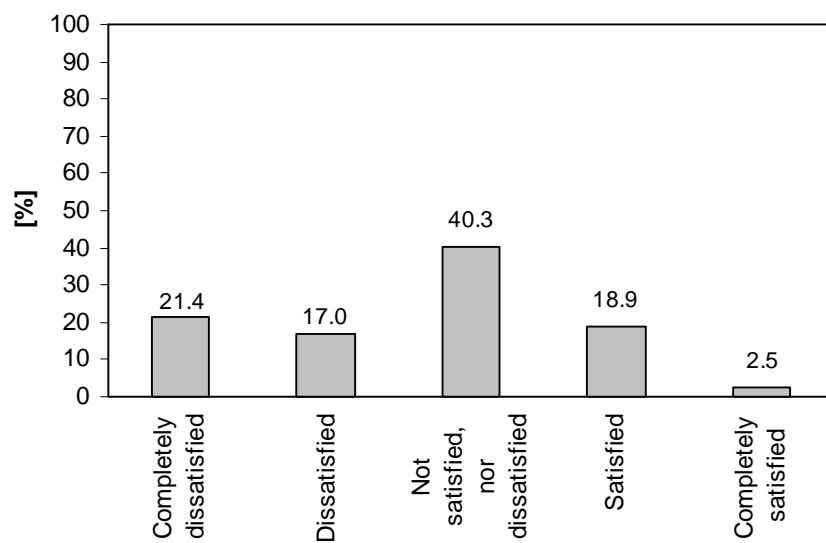


Figure.13: Degree of satisfaction in terms of the support from the University in finding a job.

Overall, findings suggest a positive evaluation of initial training, namely the ways students adapted to university, relationship between students, and length of their practicum. They also highlight a number of issues to be improved: a more hands-on approach, a better pedagogical intervention from lecturers, a more adequate articulation between content knowledge at secondary school and university education. For instance, in relation to the graduate and post-graduate interests, namely in what concerns with the first priority for thematic areas of interest, the respondents emphasize the importance of management, energetics and new technologies, as it is illustrated in figure 14.

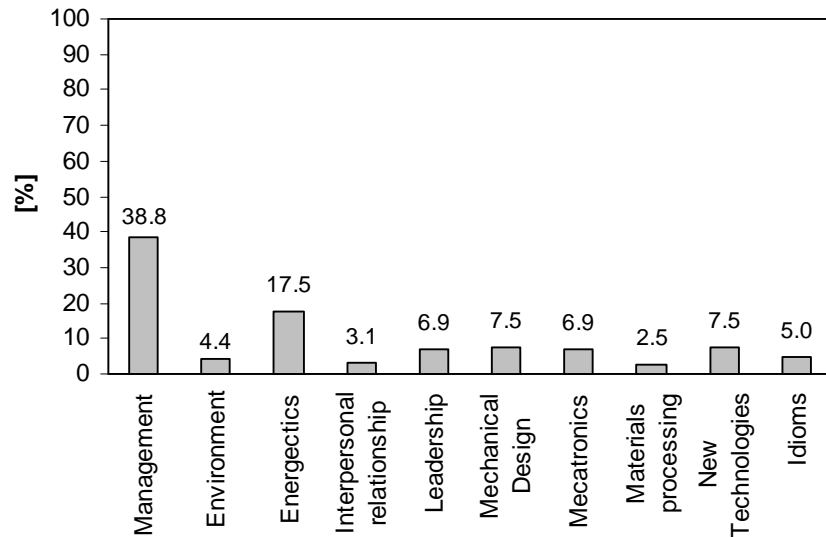


Figure.14: First priority for thematic areas of interest in post-graduate courses.

5. Concluding Remarks

In this paper, some results from a study carried out at the University of Minho were presented and discussed. This study is concerning with the initial training of Mechanical Engineers, within times of change of educational paradigm within the context of the so-called Bologna Process. It was a study of the conceptions and experiences of Mechanical Engineers in regard to their initial training, the transition to the labour market and their perspectives on further training and professional development opportunities. In the sequel of this process, the roots and aims of the Bologna Declaration were also presented.

If, in general, results point to the correspondence between expectations and reality and a balance globally positive in regard to Mechanical Engineering Course, on the other hand, the respondents feel dissatisfied in relation to some aspects which need to be reorganised within the context of a restructuring process of the course. Data suggest that Mechanical Engineers feel dissatisfied in relation to the support of the University when searching the first job, as well as the access during the course to lab activities. Mechanical Engineers were more satisfied with the duration of the practicum and the adaptation to the University of Minho. They highlight as aspects to be improved within the context of Initial training the need to a permanent up to date in scientific terms of the subject matter, the existence of short-term practicum in enterprises throughout the course, a more hands-on approach, a greater emphasis of the learning of transversal competencies related to the labour market, and a deeper articulation between the University and the labour market.

On the other hand, Mechanical Engineers described the beginning of the careers as being difficult and easy, which depended on a number of factors. They said that they looked for support from colleagues from work, superiors and chiefs, lecturers from the University and supervisors to solve the problems and difficulties such as lack of experience, relating to other people, adaptation to the work environment and the lack of preparation from initial training.

As far as further training and professional development are concerned, themes include, among others, Environment, Energetic, Interpersonal relationships, Leadership, Project, ICT, and so on. They also prefer an intensive course after work, guided by specialists from industry. These and other findings suggest implications for the restructuring of the curricula, for the articulation and pedagogical coordination and for the pedagogical training of teachers at higher education.

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