Being a Female Engineering Student: Lessons from the Industrial Engineering

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Abstract - **The increasing of women engineers' participation in a profession established as masculine, changes the traditional understanding of engineering. In Portugal, the available data refers that only 4% of female students are enrolling in engineering courses, representing no more than 19% of total engineering students, suggesting the existence of the largest gender imbalance of all the university degree level. The Industrial Engineering course of the University of Minho is an exception: 44% of female graduates during the last 30 years. Knowing that this course has a primary focus in the Portuguese manufacturing industry, with a strong male culture, how these female engineers face and respond to their career challenges? This paper intends to explore the main variables that influence career progression of Portuguese female industrial engineers. A questionnaire was developed to identify the paths of career progression of these professionals. Then, some interviews to female industrial engineers working in manufacturing industry were performed. They highlighted, among others, a major consensus that this area of specialization implicates a strong commitment not compatible with family demands. A different questionnaire was applied to female students (2nd year), in order to identify and perceive their expectation about their professional future career.**

Index Terms – Engineering education, Gender perspective, Survey.

INTRODUCTION

Engineering workplace has a very high numerical preponderance of men, and research suggests that women engineers are look as a variation of the male work. Historically seen as a masculine profession, engineering signify technical work and has an image of being heavy, dirty and involving machinery. Nevertheless, engineering has undergone a profound change in recent years. First, the computer technology and its advances contributed to "softened" the engineering field and also improved the engineer's analytical skills. Second, the concept of subject integration emerged as an important requirement for engineering practice and therefore the engineering field evolved to new areas of specialization.

A broader understanding of the engineering work with the integration of a gender perspective will influence the concept building.

A distinct field in engineering is the Industrial Engineering which integrates and organizes all the intervenients on the production process, namely the workers, machines, energy, materials and information and optimize their performance by using the available resources in the most efficient way. The University of Minho (UM), http://www.uminho.pt, was the first university in Portugal to have a curriculum with those characteristics, since 1976. Nevertheless the experience, during these years, the course has been adjusted to the technological developments and to the work market requirements, in order to graduate competitive engineers. The Engineering and Industrial Management course (EIM), http://www.dps.uminho.pt, firstly denominated Production Engineering, has a thirty years of experience, being an important contribution in the identification of an area in expansion and so excellent in the intention of increase the Portuguese productivity and competitiveness. The first Production engineer finished his course in 1982 and up to 2005 there were a total of 703 Production engineers. Of these, 56% are men's and the others 44% women. These indicators show a high predominance of the female sex in this course, what is not very usual, considering the Portuguese reality. The available data of the Portuguese Census 2001 [1], refers that in the fields of Architecture, Engineering and related professions there are 78% of men's and only 22% of women. However, engineering degree is the second most popular university student option. By comparison with their male counterparts, female students represent no more than 19% of engineering students, according to data from 2002/2003 [2]. When considering the total number of female students in the same period, only 4% of them were enrolling in engineering degree courses. This statistics suggests the existence of the largest gender imbalance of all the Portuguese university degree level.

We conclude that in Portugal a large amount of professional potential is being lost because woman are not being attracted to this field, perceived as a male profession with high reputation. Although the Engineering and Industrial Management course of University of Minho is an exception to the rule, we consider that it will be important to track these "brave" woman engineers as they move through their professional life cycle in order to answer questions like:

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Where are these graduate women? What functions they have or had? What is their actual professional situation? Are they doing additional courses? What reasons or motivations make them changing of work? If the industry has a male culture predominance, what challenges face the industrial engineers?

Being a woman engineer is an exception rather than the rule. Despite the graduate levels change, the cultural image of engineering is perceived as a masculine profession [3]. That image has a significant impact on society and contributed to engineering to be perceived as unsuitable for women [3, 4]. Others authors confirmed the notion of engineering as a male dominated job [5]. Results indicated that both men's and women engineers perceived only some areas of specialization in engineering as suitable for women: instrumentation, chemical, process and design engineering and electric and electronics engineering. Research also suggests that this masculine culture is not exclusive to the engineering workplace, the engineering classrooms has an analogous culture with courses designed for male students [4]. The women enjoy the practice of engineering and the problems experienced by some are not related with their technical skills as engineers [3]. The problems arose because of gender aspects in work organization and the solutions to solve such gender problems focus on the woman themselves. Women assimilate into the engineering industry by attempting to become 'one of the boys', knowing how to conform to the masculine engineering culture. Doing it well, are critical to women's success in the workplace [4].

This paper is a contribution to the understanding of the Portuguese reality – women in engineering. This should be of interest of managers and academic concerned with female engineer's recruitment and retention.

MOTIVATION

Figure 1 presents the number of engineers in the EIM course of the University of Minho, since 1982, year of the first master, up to 2005. The first women finished her course in 1987, as marked in the figure. The number of male engineers was in general higher than the number of female ones, with exception in 1991, 1994, 1995, and 1996 with gender equilibrium. In 1997, exceptionally, we observed the highest gender balance difference, having a superior percentage of female engineers. This situation was considered as casual, since was not persistent. The data of Figure 1 strengthened the interest and importance of our study, since they show a high rate of the feminism sex in the course, *i.e.*, 44% opposed to 56% of the masculine sex, opposing to the Portuguese reality: only 4% of female students are enrolling in engineering courses, representing no more than 19% of total engineering students. Notice that this values only concern to the students that finish their degree and receive their diploma. It is known that some of the students, as they joint in the industry work placement, do not have time or even motivation to finish their degree. The present study do not considered these cases.

Knowing that this course has a primary focus in the Portuguese manufacturing industry, with a strong male culture, how these female engineers face and respond to their career challenges?

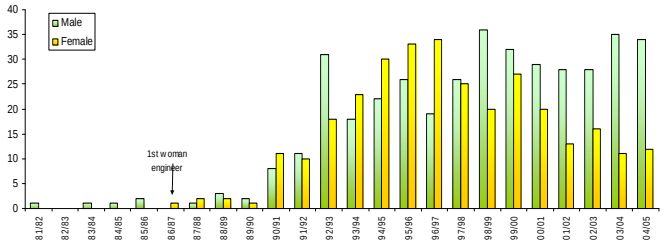

FIGURE 1.
EVOLUTION OF THE EIM - UM FROM THE BEGINING UP TO 2005, SEPARATE BY GENDER.

Trying to answer to this question and others, the authors divided the preliminary study into three parts: (1) development of an exploratory questionnaire to identify the professional path of the industrial woman engineers of the UM, (2) performing interviews to some industrial engineers and, (3) development of an exploratory questionnaire to all the EIM students at the moment in the second year of their degree.

EGI-WOMAN STUDY

I. Female Industrial Engineers Questionnaire

Which is the Portuguese reality, in particular the field of Industrial Engineering? Can we or not speak about Industrial Engineering in Feminine? The engineers in this area of activity 'live' or 'survive'?

To help to answer to the previously stated questions and many others, we performed a first investigative questionnaire, named EGI - Woman Study.

The first step of this study, with the aim to identify the professional path of the industrial women engineers of the UM, was to develop a questionnaire. Some preliminaries results were presented and discussed [6, 7]. The questionnaire was divided in three parts: (1) secondary and academic data, (2) professional path data and (3) personal data. In the first part, the woman engineer identify her first and last year of registration as an engineer student, her final graduation mark, if she was or not a full time student, and if she has a postgraduation. The second part identifies her path before and after graduation course, with an especial emphasis to her actual professional situation. The last part identifies her age, civil state and number of children.

All the questions were prepared as 'closed' questions and whenever possible the Likert five-point scale was used, in order to allow the respondents to express agreement or disagreement. The questionnaires were sent to the women engineers by electronic mail. This way is considered a fast, efficient and inexpensive mean of communication.

Until the end of the first part of this study, it was not possible to identify the e-mail addresses of all the women engineers. At first glance, this reality seemed a problem. However, from the universe of 311 female EMI engineers,

approximately 38% of them received an e-mail invitation to participate in our study. The invitation letter included the questionnaire and a presentation of the EGI-Woman Study. A total of 62 answers were received, considered as being representative to the study (around 54%). The analysis of the answers allowed us to create an average profile of the EIM woman engineer: 33 years old, with a professional experience of 8,7 years, married and with 0,61 children's, working in the manufacturing industry, and playing a part in the quality or production department.

Results indicated that only 45% of our respondents work currently in the manufacturing industry, 15% in Science and High Level Education (CES), 14% in Commerce and Services (C&S), 9% in Formation and Consulting (F&C) and remaining in others services (health, education and social services), as illustrated in Figure 2.

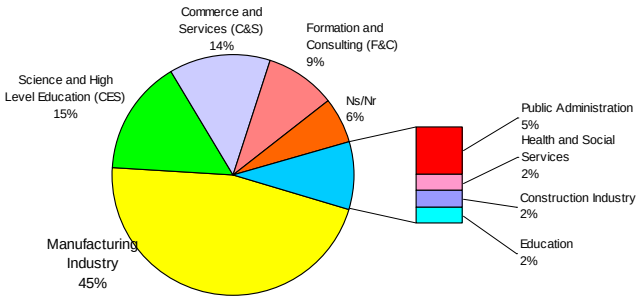

FIGURE 2.
ACTUAL SECTORS OF ACTIVITY OF THE EMI FEMALES ENGINEERS OF UM.

At this point, although 45% of our respondents work currently in the manufacturing industry, it was possible to verify that 74% of them already have worked in this area. This fact can suggest the existence of a rate of abandon. This was discussed in more detail during the interviews (see next section). In this group, 80% choose to take a Professional Formation in opposition to a Postgraduation and Master degree (34%), see Figure 3.

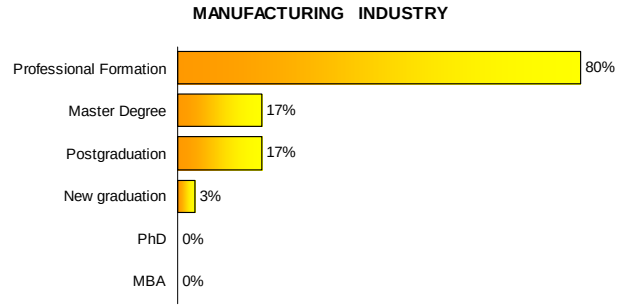

FIGURE 3.
MANUFACTURING INDUSTRY EIM WOMEN ENGINEERS POSTGRADUATION CHOICES.

More detailed information can be found elsewhere [7].

II. Interviews

After identifying the paths of career progression of the female industrial engineers from University of Minho with the help of the developed questionnaire several in-depth interviews were performed. These interviews regarded only the female industrial engineers working in manufacturing industry (45%, as illustrated in Figure 2). The interviews were the second step of the EGI-Woman Study. Knowing that there has been a progressive increase of female engineers [5], becomes essential to understand how these woman engineers, firstly, have been attracted to engineering and secondly, understand their careers perspectives and progression.

A group of seven engineers were taken as the study respondents. Two of them are engineers of large industrial textile companies, with more than twenty years working experience, others two with nine years working experience and the remaining three with six years working experience as engineers. This sample tries to be illustrative since each of the women engineers perform their professions at different areas: quality, production, logistics, commercial, product development, and provision.

The interviews were conducted at the offices of the respondents, with exception of three of them due to professional constrains. Each of the interviews was audio-video taped. After the individual identification and personality characterization, the discussed topics were: reasons for choosing engineering, first experience, working relations in the organization, factors that influences respondents in career advancement, married life, and its relation to careers. One of the respondents had recently quit her job. Three are singles and three have children, of which two are mid-career engineers.

In this paper only two of the previous topics will be analysed and discussed, emphasizing some of the obtained answers: family responsibility and career progression; and engineering career gender.

- **Family responsibility and career progression.**

This includes the identification of barriers in the career progression. Some responses are as follows:

> *Since I am very persistent, that makes people respect me, and being humble, yes we must be humble (…) We have to speak with them (workers and counterparts), we have to know how to approach to the people, because I find that from there we obtain everything.* (R1, married, two children, 21 years of working experience).
> *I have a hour to start working, but I do not have hours to return home.* (R4, single, 9 years of working experience).
> *It does not have super men's but also it does not have super women. I do not punish me, every day we take options in our life…* (R2, married, three children, 24 years of working experience).
> *Its impossible to think, that a woman engineer can have a professional career without any*

familiar assistance (R1, married, two children, 21 years of working experience).

- **Engineering career gender.**

This includes the identification of differences and limitations to be a woman engineer. Some responses are as follows:

> *I work very much in team, and one of the things that I am worry with is to work in team (…) because although having difficulties at the beginning for being men, and I already had chief of line women,... I have obtained results more quickly with men than with women.* (R4, single, 9 years of working experience).
> *We do not impose us as the fact to be chief, but, above all we are a person who the others must recognize talents, and if people recognize our capacities, to be woman or men makes no difference.* (R3, single, 6 years of working experience).

Nowadays to be a woman engineer seems not to be an issue as it was twenty years ago, as these two responses indicate:

> *It has an enormous difference between what they [male workers] say to us and what the reality is... I faced serious problems for being a woman...* (R1, married, two children, 21 years of working experience).
> *I feel myself equal.... you are woman that is an engineer...* (R5, single, two children, 6 years of working experience).

III. Second Year EIM Students Questionnaire

The last step of the EGI-Woman Study until now was the development and application of a questionnaire to the students of 2nd year of EIM. The main objective was to identify and perceive their expectation about their professional future career.

The questionnaire was divided in two parts: (1) personal and secondary academic data, and (2) reasons and perceptions. The second part of the questionnaire tries to identify the students' small academic path and their expectation about their future as engineers.

The questionnaires were distributed to a group of 28 second year students. The questionnaires were conducted in a traditional classroom where each student wrote is answer directly in the questionnaire paper sheet. In the group, 36% are female students, 70% of them with age around 19 years. Most of the female students, 31%, are in the EIM course as the first choice and similar percentage of male students, however as a second choice (Figure 4).

Most of the students, independently of the sex, have already been in contact with the industrial environmental: 70% and 78% for female and male students, respectively. The study visit during the secondary was the mentioned reason for 57% of the female students. For male students different reasons were mentioned: 36% because they have familiars that work in the industry and 36% because they work in the industry.

It was asked to the students to identify the order of a list of motives behind the choice of the course of Engineering and Industrial Management (1st, 2nd and 3rd order, higher order less important motive): (1) personal and professional achievement; (2) qualification to work in an engineering profession; (3) acquisition of new knowledge in the interest area; (4) professional choices; (5) familiar pressure; (6) working in the area; (7) secondary teachers influence; (8) course status; (9) possibility to work in a profession that will personally fulfil them; (10) high percentage of graduated; (11) influence of friends and secondary colleagues; (12) course curriculum; (13) well remunerated profession; (14) mean grade.

Independently of the sex, the attitude and motives behind the choice of the EIM course order are similar. Some of the obtained results are printed in Figure 5. Notice that parents' pressure in the course choice has almost no influence. The same opinion was recognized concerning the secondary teachers' pressure on the choice of students' graduation course.

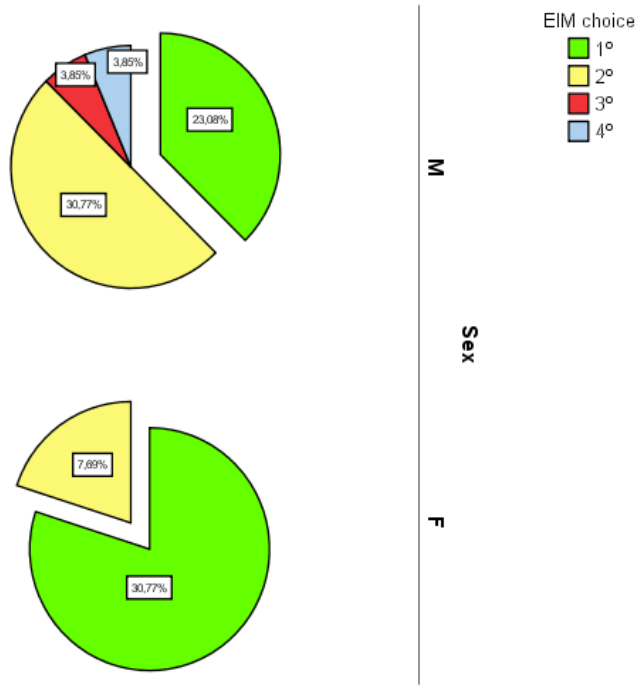

FIGURE 4.
EIM CHOICE ORDER PERCENTAGEM BY SEX: (M) MALE, (F) FEMALE, 2ND YEAR STUDENTS.

Personal and professional achievement was the motivation defined has being the most important motive in the course choice: 66% for female students and 76% for male students.

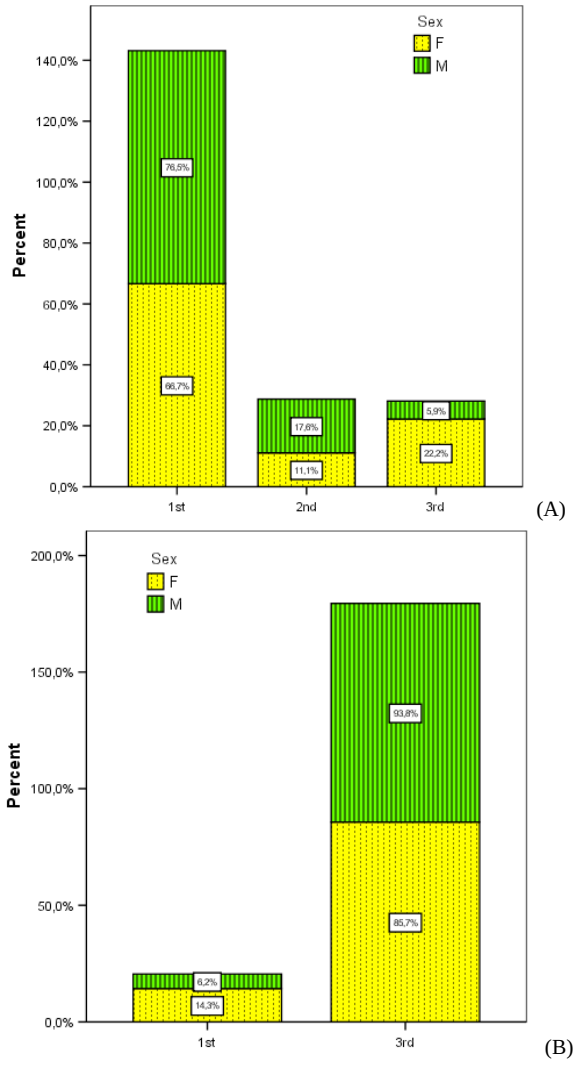

FIGURE 5.
OBTAINED RESULTS FOR: (A) PERSONAL AND PROFESSIONAL ACHIEVEMENT AND (B) FAMILIAR PRESSURE.

COMMENTS AND ON-GOING WORK

Engineering degree is the second most popular university student option. A distinct field in engineering is the Industrial Engineering with a crucial focus in the Portuguese manufacturing industry, with a strong male culture. The Engineering and Industrial Management course of University of Minho is an exception and not the rule: 44% of female graduates during the last 30 years. This paper intends to explore the main variables that influence career progression of Portuguese female industrial engineers and in other hand, understand the actual engineering 2nd year students expectations.

The presented results are a part of a project work named EGI - Woman Study which main goal is to contribute to a gender-specific perspective concerning Portuguese woman engineers' career progression.

It was possible to identify the average profile of the female EIM of UM: 33 years old, with professional experience of 8,7 years, married, with 0,61 children. At the present time, only 45% of the female engineers work in the Portuguese manufacturing industry, namely SME'S traditionally characterized by familiar management, with a strong investment in the Professional Formation in opposition to a Postgraduation and Master degree. These results are part of a preliminary questionnaire.

Guided interviews helped and promoted a discussion of how woman engineers perceive their career progression and a conscience that, in some way, this implicates a strong commitment not compatible with family demands.

The performed interviews regarded only the female industrial engineers working in manufacturing industry. A sample of seven engineers was taken as the study respondents. Each one performs their profession at different areas: quality, production, logistics, commercial, product development, and provision. All of them identified barriers in the career progression. It was interesting to confront their professionals' experience: mid-career versus 6 years work experience as an engineer. Nowadays to be a woman engineer seems not to be an issue as it was twenty years ago. The interpretations of career progression based on the information obtained from these interviews are still in study. Several main topics are still in exploration: understand how these woman engineers have been attracted to engineering and understand profoundly their careers perspectives and progression.

In order to identify and perceive engineering students' expectations about their professional future career, a questionnaire was developed and applied to the 2nd year EIM students.

From the analyses of the 2nd students' answers, female students are not familiarized to the industrial environment in opposition with male students. To mention that of the male students, 36% already work in an industrial environment. This can be an opportunity to the university teachers in order to fill this gap, increasing the contact to the industrial environment through the students.

ACKNOWLEDGMENT

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