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Analysis of professional ethics in Engineering Degrees

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Abstract

The role of engineering is closely related to its role in society. An engineer may be involved in supervising the work of a team; in negotiations; and always may have special responsibilities to ensure that work is safe, and to ensure it is not damaging the environment. We have analyzed the specific case of ethics in some engineering degrees. In our country, in recent years, the White Books of qualifications for Bachelor's Degrees of the industrial branches, possesses a mention to delivery an optional subject related to ethics and the acquisition of the competence of an ethical and moral responsibility. In the case of the School of Industrial Engineering at the University of Salamanca (Spain), this competence is not included as a subject in the definition of the degrees. Ethical responsibility is included in the same group of transversal competences as teamwork or critical reasoning. We have conducted a survey about ethics to different engineering students to get their feedback about the importance of ethical behavior, the ethics and professional responsibility, or the necessity of the associations of engineers (after they finish their studies).

Keywords: Engineering education, ethics, competences.

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1. Introduction

Since the second half of the twentieth century, applied ethics increased their presence in the curricula of the most illustrious careers in our society, where health sciences, medicine and biotechnology plaid a pioneering role in Spain. Other applied ethics as journalistic ethics, business ethics, ethics in public administrations, and the ethics of engineering with a variety of specialties appeared later.

In our days, the need for an ethical professional behavior has become especially visible in the economic and political fields (nowadays, the corruption occur as much in traditionally corrupt countries as in developed ones).

Current legislation entrusts professional associations the responsibility on professional ethics in our country (Professional Associations Act, Art. 5i, published in the Official State Bulletin of February 15, 1974): "organize the professional activity of the members in their area of competence, ensuring professional ethics and dignity, and due respect for the rights of individuals and also exercise disciplinary authority in the professional order".

The relation between the university and the professional ethics learning is obvious: engineering competences are expected by professionals, but also to use those competences doing an ethical job (Cobo Suero, 2009). Therefore, if the university is responsible for facilitating the learning of the professional competences, it should also be the responsible of the professional ethics learning that goes hand-in-hand with the practice of engineering profession. Some countries have noticed the importance of ethics as a discipline, and that is why the professional institutions associated with the different branches of industrial engineering have published ethical codes for their members (Bowen, 2008).

In other words, universities are required to develop in the students the skills and competences needed to build their own useful and meaningful knowledge, so that they could apply it to each situation and they will also propose sustainable and viable working options from an ethical point of view.

Although ethics subject is not included in the Engineering curriculum, some aspects are mentioned:

- Ensure the development of a set of capabilities that allow undergraduate students to ethically handle the contingencies of their job, their continuous updating and lifelong learning.
- Regarding the social responsibility, teaching should explicitly contribute to the ethical training of future graduates, their commitment to scientific integrity and solidarity with society.

We have analyzed the possible reasons for non-inclusion:

- Insufficient curriculum time. A long time is needed for basic and applied subjects that are essential for professional practice, so it is difficult to allocate curriculum time to the rest of matters.
- Engineering educators are usually not interested in ethical issues. It is well known a physics professor's answer referring to the nuclear weapons morality: "It is not a branch of physics, so I do not have to do it".
- Most of the graduates and future graduates consider that in the course of their work they will be evaluated by solving problems and achieve results in the best way and with the less time, and not by ethical considerations about the human, social, cultural and environmental impact of their projects, actions or technological decisions.

All this leads to the indifference to ethical issues. Science and technology provides knowledge, but ethics judges the lawfulness or not of what is done with them. To do what is mandatory, to do what everyone does and to choose the right thing are all different behaviors. Each professional has a duty to practice and transmit values, establishing the mechanisms to make them possible.

It is vital the relationship between ethics and environmental responsibility of engineers. Professionals should take into account the impact of their work in the middle social and cultural environment and the ecosystem and natural resources. Hence the need for engineers who are responsible for designing technologies, products and processes that minimize impacts on the environment. Engineers also need to be leaders in the process control industry, energy production, and waste treatment, which is a huge responsibility. This confirms the high degree of responsibility to the attitudes and actions of these professionals (engineers) in sustainable development.

The SGE 21 (from the Spanish Ethical Management System and Social Responsibility, available at http://sge21.foretica.org/about-us/) standard form is the first European management system that allows auditing and certifying processes in ethical management and social responsibility. This standard is also the first standard that establishes the requirements to be fulfilled by a company on the process of normalization of ethics. The added value of SGE 21 to organizations is to allow, on a voluntary way, audit processes and achieve certification in Ethical Management and Social Responsibility. It aims to analyze the role of industrial engineering professional within an ethics management system, and thereby establish requirements for industrial engineer to work in the implementation of an ethical system.

George Kieffer (1979) summarizes perfectly what is understood by ethics: a branch of the philosophical sciences that deals with the principles that govern the correct behavior. It is philosophy because his conclusions are only based on the reason through an ethical methodology; it means to take a decision based on the weighting criteria to the different principles, neither in the intuition nor in the random. Kieffer continues arguing that decision-making can be improved with the practice. This reminds us the gastronomic metaphor by Tomas de Aquino, to explain that to cook a delicious dish, we will need the culinary practice to carry out it, and not only the recipe. Therefore, to be able to choose the right decision, we must have the practice of taking ethical decisions habitually.

Even when we think that the ethics can serve us to obtain “the good life” (as Aristoteles), we continue wondering if it is really necessary. According to Rodriguez Dupla (2001), there are three main reasons for which the ethics is necessary:

- We are all aware what is correct and what not, but it is not infallible, we need a method that helps us to differentiate it: to review and consistent criticism.
- The very principles suffer confrontations between them, that is why to find the “formula” or criterion of weighting between a few fundamental and different principles becomes needed.
- We have our own moral or subjective perceptions influenced by our interest, pride, fear, etc. We need from the ethics to arrange the priorities and to try objectivity to our spontaneous morality.

These three points help us to define the scheme that we can develop to find the way to understand the need for ethics in student’s future profession, and on the other hand to elaborate a guide for this end.

In this paper we present an overall description of the relation between ethics and engineering studies and a research about the ethics and the engineering studies at the University of Salamanca. Section 2 describes the specific case of ethics and the engineering education, Section 3 focuses on the methodology and some results of this study; and finally, we summarize our conclusions in Section 4.

2. Practice in ethics education

Concerning the ethics in education, as ethics is the philosophical discipline that studies the moral dimension of the human existence, i.e. everything in our lives is related to the good and to the evil (Rodriguez Dupla, 2001), the ethics education may be done by means of seminars or subjects that explain the ethical principles that have to continue over student’s life and during their professional careers. This should be taken into account in all engineering students, not only in the case of industrial

engineering, but also in others as computer science – info ethics – they perceive this need because the actions of men can have repercussions worldwide and in very diverse areas (Vacas, 2004). That is the basis of the ethical principle of justice; the repercussion that our actions can have in third parties.

As was mention in (Takahara and Toshinori, 2013), the procedure for learning ethics is to explore the causes and background in the cases studied and then to evaluate what should be done. So, wrong behavior should be avoided and such cases do not occur again.

Probably it is a bit more difficult to deal, but the ethics are an eminently practical discipline, so it needs constant critical review, and the way to get it is by means of studying practical cases that already have happened or that could happen. The study of cases allows learning and recognizing the existence of ethical problems (Harris, Pritchard & Rabins, 2013), at the same time cases stimulate the moral imagination making us to anticipate the possible alternatives for solving them taking into account that the codes cannot provide ready-made answers to many moral questions that professional engineers practice generates.

Let us suppose the hypothetical case: What would happen if the material A (cheaper and not so good) was used instead of the material B (more expensive, better and safer than A)? We would analyze the consequences in the short and long term taking into account external factors and personal factors.

In 2004, an engineer from the US company Generals Motors (GM), realized that in some models the ignition switch was too sensitive to shock or vibration when he was in position “on” what caused the engine shutdown with the risk for its sudden off while the car could be in circulation. It was not until ten years later when GM began the removal from the market of these models, but not before they lamented the death of 56 people, according to sources of the company (Marketingdirecto, 2016). The negligence of not withdrawing these models in the industry since 2004 when they identified the problem was the cause of a long dispute still not finalized. Without wishing to thoroughly analyze this unfortunate episode, we focus on the engineer who realized the error. His behavior could not be appropriate, because despite having been notified to the company of its discovery, it may not do enough to maintain their professional values above the corporate power of the firm; it was a mistake as an engineer. In this case the ethical behavior was not adequate.

2.1. Ethics in industrial engineering

The term profession (Harris et al., 2013) could be defined as a way of life, not only a job or a career, and a profession is not a “mere” occupation. Some characteristics of a profession are the following.

1. Extensive period of intellectual training.
2. Professionals’ knowledge and skills.
3. Control of professional services in their area.
4. Autonomy in the workplace (including individual judgment and creativity in carrying out their professional responsibilities).
5. Ethical regulation (regulate themselves for the public benefit).

In particular, the tasks of professionals of Industrial Engineering are to design, improve, and install integrated systems of people, materials, information, equipment, and energy (Koelling, Beruvides & Tankoonsombut, 1996).

In engineer’s case, ethics is no longer limited to an individual’s code of conduct; in fact, it is related to the ethical practices of groups, workers, and companies (Wang and Thompson, 2013). Engineering students, and also engineers used to ask why they should study ethics, because they consider themselves ethical individuals. The personal morality and the professional ethics are not the same, “ethic” and “moral” are no interchangeable terms (Barry & Ohland, 2009). Professional ethics is not

the personal morality, neither the moral beliefs of a person, nor the common morality (considered as the moral beliefs of almost everyone). The professional ethics is consider as the set of standards adopted by professionals insofar as they view themselves acting as professionals (Harris et al., 2013).

2.2. Curriculum of the Bachelor's Degree

The Bologna Accord signed by most of the European universities, brought important changes in university education, especially in the educational system itself, and in technical engineering careers (http://www.ehea.info). At the University of Salamanca, we changed from 3-year careers called Technical Engineering in Electricity, Technical Engineering in Mechanics, Technical Engineering in Electronics and Automatics, or Technical Engineer in Computer Systems to 4-year degrees: Degree in Electricity, Degree in Mechanics, Degree in Electronics and Automatics, or Degree in Computer Science, respectively.

The curriculum of the Bachelor's Degrees in the different branches of Industrial Engineering, at the Higher Technical School of Industrial Engineering at the University of Salamanca, is divided into 4 courses (8 semesters). In Electrical Engineering, Mechanical Engineering, Electronic and Automatic Engineering Degrees, at the University of Salamanca, the courses are divided as follows: 60 credits (European Credit Transfer System) with basic subjects, 126 credits with compulsory subjects from each branch, 42 credits with optional subjects, and 12 with the capstone project. In the case of Computer Science is similar: 60 with basic, 138 with compulsory, 30 with optional subjects, and 12 with the capstone project.

There is no subject related to ethics, neither compulsory nor optional subject. Each teacher includes the professional ethics aspects in their classes but it is not considered in the Degrees' curriculum. As was detailed by Wang and Thompson (2013), current ethics courses do not usually include training on international related ethical practices. In order to overcome this deficiency, some new teaching material, pedagogical methodology, and curriculum modification should be considered.

As was mentioned before, the White Books of qualifications for bachelor's degrees of the industrial branch, available at the National Agency of Evaluation of Quality and Accreditation website (http://www.aneca.es), include an optional subject related to ethics. The White Books incorporate a section with specific competences and skills about academic and professional training with relation to the industrial role or the educational role. Those competences were proposed by some European institutions of accreditation that they adapt, in major measure, to the directives established by the process of Bologna.

Some of the proposed specific skills, that might be also considered like transverse or generic skills are:

- Individual and team work.
- Communication.
- The engineer and the company.
- Environment and sustainability.
- Direction and project financing.
- Intercultural competences.
- Lifelong learning.
- Ethics

The only one that is almost a subject is Environment and sustainability. The rest are included as small parts of some modules in different disciplines.

The White Book of Bachelor Degrees in Industrial Engineering (Proposal of the Higher Technical Schools of Industrial Engineering) also includes some competences and skills that an engineer graduating should have acquired:

- Basic knowledge of science and technology.
- Personal skills and for the business.
- Ethical and social competence and responsibility.
- Mentality of basic application.

The ethical and social responsibility is considered above the average values of the importance that the graduates give to the skills. And the same skill is also above the average values of the importance that the employers give to the capacities and skills.

3. Methodology and some results

To find out if engineering students considered important ethics and to know the level of knowledge they have of professional ethics, we have developed a short survey of 11 questions, with which it seeks to determine, among other things, the degree of importance given to this discipline.

The population of the survey was 84 students, from different grades of Engineering: Electricity (5%), Mechanics (15%), Electronics and Automatics (12%), Computer Science (37%), Geological (21%), and also Chemical degree (8%).

The questions included in the survey were these:

1. What degree of knowledge do you have about the ethics meaning?
2. And what about the ethics in the work place?
3. Do you think that ethics exists in the engineering work place?
4. During your studies, does anybody shared with you anything about ethics in your future work as an engineer?
5. Rate the need for knowledge of ethics for your professional future.
6. Rate the need for the existence of a code of professional ethics Engineering
7. Rate the importance you give to the next competence: “The Engineer must act with ethics, professional responsibility and social commitment, considering the economic, social and environmental impact of its activities in the local and global context”
8. Skills and competencies. What do you think about the following statement? The graduate engineer should have between their skills and competencies: Competition and ethics and social responsibility.
9. Ethics and professional responsibility. What importance do you give to ethics and professional responsibility of the engineer?
10. Rate on a scale of 1 to 5, the importance of ethics for you.

And 5 YES/NO questions:

11. Do you know the SGE 21 standard?

12. Do you know what the acronyms COGITI and COPITI mean? (Only for students of Industrial branch)

13. You know what is a code of ethics?

14. Do you have evidence that there is a code of ethics for engineers in your area of knowledge?

15. Are you interested in knowing more about professional ethics in engineering?

Each question is rated on a 1-to-5 Likert scale, being 1 the worst case (strongly disagree) and 5 de best one (strongly agree). (Likert, 1932)

The Cronbach's Alpha reliability coefficient of the survey was calculated and we get a value 0.80, which means that the survey is reliable.

The assessment of the need for ethics knowledge in their professional future is very positive, 87% of the students who participated in the survey considered it very important. 94% of surveyed students do not know the SGE 21, the standard for the evaluation of Ethics and Social Responsibility Management in organizations.

We also asked them (only to students of industrial branches) for the meaning of the acronym COGITI and COPITI (Professional association of Industrial Technicians and Technical Engineers), only 1% answered positively to the question.

Moreover, 65% of respondents do not know what a code of ethics is, and 93% say they have not heard of existence any code of ethics for engineering. In contrast, 92% of students value the existence of a code that collects ethical values in the professional field of engineering. And 95% responded positively to the necessity of the ethical competence in their engineering curriculum.

To the question Q15 more than 75% answered positively. In the general assessment of the importance of ethics has been, on a scale from 1 to 5, 94% answered between 3 and 5.

4. Conclusions

As Industrial engineering is a regulated profession, it should include all the requirements detailed in the Order CIN/351/2009, of February 9, 2009, by the Ministry of Science and Innovation from the Spanish government. It is very interesting that professional ethics is part of the engineers' curriculum but there is no specific subject to acquire that competence.

The survey raised two important conclusions: on the one side it shows that students' knowledge on professional ethics is quite poor, not aware of any rule or entity professional environment related to ethics. But on the other hand, they are positively motivated to acquire knowledge and skills in this field because a high percentage of respondents consider it very or quite important. We have appreciated a growing conviction that it is necessary to include professional ethics in the curriculum of higher education.

It is possible that the implementation of a core course on ethics in engineering may not be necessary, but trainers have to become aware of the importance of addressing these issues during the courses days. This should be in that way to make students to be familiar with the terms and values that will use during their professional careers. So, they will not have to carry responsibilities for taking wrong decisions during of their work time.

The three reasons given by Rodriguez Dupla (2001), to consider ethics as necessary, serve as the basis to develop a scheme to understand the need for ethics in their future professional career and to develop a guide for this purpose.

The importance of the engineers work is that in some cases if they make a mistake, people will die. We have all hear of some engineering errors, like Tacoma Narrows Bridge, and how it collapsed in 1940, the Firestone tires that causes accidents, or the 'defeat device' in Volkswagen engines. Most of the errors could be avoided if the ethic code is taken into account.

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