Génova, G., González, M.R. Teaching Ethics to Engineers: A Socratic Experience. Sci Eng Ethics 22, 567–580 (2016).

DOI: https://doi.org/10.1007/s11948-015-9661-1

Teaching Ethics to Engineers: a Socratic Experience

Gonzalo Génova *(corresponding author)*
Departamento de Informática, Universidad Carlos III de Madrid, Madrid, Spain
ggenova@inf.uc3m.es
Instituto de Filosofía, Pontificia Universidad Católica de Chile, Santiago, Chile
gogenova@uc.cl

M. Rosario González
Departamento de Teoría e Historia de la Educación, Universidad Complutense de Madrid, Madrid, Spain
marrgonz@ucm.es
Departamento de Filosofía, Universidad de Santiago de Chile, Santiago, Chile
mariadelrosario.gonzalez@usach.cl

Keywords
Ethical education; Engineers' mentality; Online discussion forum; Fundamental experiences; Socratic dialogue

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Published online in *Science and Engineering Ethics*, 2015
The final publication is available at Springer via http://dx.doi.org/10.1007/s11948-015-9661-1

A previous, much sorter Spanish version of this paper was presented at I Jornadas Internacionales de Innovación Docente en la Enseñanza de la Filosofía, Universidad Complutense de Madrid, November 5-7 2014, Madrid, Spain.

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Abstract

In this paper we present the authors' experience of teaching a course in Ethics for Engineers, which has been delivered four times in three different universities in Spain and Chile. We begin by presenting the material context of the course (its place within the university program, the number of students attending, its duration, etc.), and especially the intellectual background of the participating students, in terms of their previous understanding of philosophy in general, and of ethics in particular. Next we set out the objectives of the course and the main topics addressed, as well as the methodology and teaching resources employed to have students achieve a genuine philosophical reflection on the ethical aspects of the profession, starting from their own mindset as engineers. Finally we offer some results based on opinion surveys of the students, as well as a more personal assessment by the authors, recapitulating the most significant achievements of the course and indicating its underlying Socratic structure.

Introduction

New approaches to the teaching of ethics to engineers have attracted a good deal of attention in recent years, as the awareness of the importance of the subject has grown since the 1980s (Herkert 2002). In general, a change of paradigm has been perceived as necessary (Schmidt 2014) for a number of reasons. First of all, teachers have had to counter certain prejudices on the part of engineering students, who generally understand ethics as something external to engineering, imposed from the outside on the daily work of engineers. Secondly, the traditional way of teaching ethics to engineers has emphasized either the importance of professional codes of conduct (deontological ethics) or the balance between good and bad consequences of professional practice (consequentialist ethics). However, this contrast between modern ethical theories is more misleading than helpful for the understanding of ethical concerns (Génova et al. 2007), and

promotes the spectator's point of view instead of the agent's (Whitbeck 1995). Furthermore, it has other underestimated drawbacks for the teaching of engineering ethics (Bouville 2008).

Consequently, there has been an increased emphasis on virtue ethics, with its undoubtedly strong roots in Western culture (MacIntyre 1981), as an alternative both to deontology and consequentialism. This has encouraged a shift of paradigm which escapes the limitations of the other two approaches by focusing on *the person* who acts, rather than *the action* itself; the emphasis, in other words, is on being good, rather than just doing good (Schmidt 2014). Stressing the agent's character rather than the external results of actions, virtue ethics more easily connects 'being a good person' with 'being a good engineer'. By reflecting on the practice of engineering as a particular form of human activity, it derives the responsibilities of engineers from knowledge of the nature of engineering and its context (Smith et al. 2014). Virtue ethics, by its very nature, is integral to practice, and therefore less likely to be understood by students as something external to engineering.

The rest of the paper is organized as follows. We present in the first place the material context of the course, and especially the intellectual context so far as engineering students are concerned, i.e. their previous understanding of philosophy in general, and of ethics in particular. Next we set out the objectives pursued within the course and the main topics addressed, as well as the methodology and teaching resources employed. We then display some results based on opinion surveys of the students, as well as a more personal assessment by the authors, recapitulating the most significant achievements of the course and indicating its underlying Socratic structure. Finally we conclude the paper after reviewing some related work.

Material and intellectual context of the courses

All undergraduate students in Universidad Carlos III de Madrid, regardless of the studies they are pursuing, must take 6 Humanities credits, chosen from a wide range of courses offered by the lecturers of the University. Availing of this opportunity, we began in February 2012 a humanities course entitled *Ethics for Engineers: between survival and dignity*.

Since then the course has been presented on four different occasions in three universities in Spain and Chile, where the authors recently conducted a research and teaching stay. The principal data from these four teaching modules are summarized in Table 1. Only in the case of the Universidad Católica de Chile is it a compulsory course for all engineering students.

University	**Dates**	**Type**	**Students origin (Studies, Year)**	**Class Size**
Universidad Carlos III de Madrid, Leganés, España	February-March 2012 14 sessions	Elective 3 credits	Various Engineering Degrees (3^{rd}-4^{th})	60
Universidad Carlos III de Madrid, Leganés, España	February-March 2013 14 sessions	Elective 3 credits	Various Engineering Degrees (3^{rd}-4^{th})	47
Pontificia Universidad Católica de Chile, Santiago de Chile	March-June 2014 28 sessions	Compulsory 6 credits	Mathematics and Natural Sciences (1^{st}-2^{nd})	69
Universidad Nacional Andrés Bello, Santiago de Chile	March-June 2014 28 sessions	Elective 6 credits	Informatics Civil Engineering (5^{th})	9

Table 1. Summary of the four teaching modules. (In the Chilean universities the courses were accorded 10 credits within their university system, equivalent to 6 ECTS).

In general the students displayed good intellectual capacity and academic records; they had a taste for rigorous scientific-mathematical thinking and for a scientific worldview. Their initial

interventions in class and in the online forum showed that most of them perfectly incarnated the two clichés common in our media culture as identified by Quintanilla (2012): first, that natural *sciences* have a monopoly of rational and objective knowledge; and secondly, that with enough time, and without the hindrances and prejudices of tradition, *technology* will solve all our problems. Indeed most college students in modern Western societies are indoctrinated with these two clichés.

In all cases students started with the *elementary philosophical training* they typically received in the last years of middle and high school. This training consists in a kind of instruction which, in our view, and in our cultural environment, is essentially a historical presentation of various philosophers and philosophical systems, without getting the students to grasp what the problems are that the philosopher inquires into and tries to solve: more specifically, without ever grasping *why they are problems*.

In a context where students have already discovered their own inclination for problem solving, this essentially historical approach leads them to develop a general perception of philosophy as *something alien to their own way of thinking*, thus consolidating the split between humanities and sciences (Schumacher 1973). As a result, these future engineers generally conceive philosophy not as a rigorous way of thinking, but as an ideological one, even one that is completely arbitrary.

With regard to the specific subject of the course, ethics was perceived at best as a set of *well-intentioned regulations*, intended to place limits on professional practice for the sake of society, but unrealistic in the competitive world in which we live. Additionally, students manifested a distrust of any kind of *ideological imposition* that might be used to motivate ethical reflection. Many would have said at the outset of the course, with a strong dose of skepticism: "Ethics is purely subjective, it lies outside the objective and measurable world in which we engineers work." Thus the teacher who wishes to prompt philosophical reflection in them must be well aware of the intellectual context of the students. On the other hand, curiosity, tenacity and the habit of rigorous and systematic reasoning can be considered advantages. The authors have not perceived a key cultural difference between the Chilean and Spanish students in relation to these considerations.

Course Objectives and Main Topics

The main purpose of the course is contained in the central word of its title: Ethics *for* Engineers. Therefore, not so much the specific ethics of the engineering profession, but above all *ethics explained to the mentality of the engineer*. We can characterize this mentality as: the real is what can be touched and measured, the prototype of rational thinking is mathematical-deductive reasoning, and the best results are obtained by following standard procedures. It is a priority from the outset, then, to address the difficulties of an engineering student in recognizing the specific value of philosophical thought and moral theory. One of the biggest dangers in a course of this kind would be to reduce ethics to a set of behavioral rules (an ethical code) that could be followed in a mechanical or quasi-algorithmic way, an "industrial standard of professional behavior." Students would be perfectly capable of learning the standard and the correct way to apply it, but they would not have dived into the truly philosophical and ethical questions: *Why this standard* and not another? What does the ethical imperative entail *for me*?

We do not deny the importance of ethical codes in education and in the exercise of one's profession, especially when they are not seen as closed regulations but as open guides, i.e. when their educational mission is emphasized (Gotterbarn et al. 1999), and when the person implementing them learns to look beyond the code. The code must teach that some forms of behavior are unacceptable, and that at the same time there may be more than one good answer for each ethical problem, not all of which can be contained within the code. Consequently, it is not a course objective to teach (even less to impose) a code of professional ethics, but to teach ethical reasoning and the centrality of moral attitudes (virtues). Nor is the aim of the course the reform of students' behavior: the deficiency to be remedied in them is not a lack of moral rectitude, but a lack of critical

sense, since this lack makes future engineers very manipulable. As a practical outcome, students are expected to learn to ethically assess –and include within the project documentation– the means, ends and benefits of engineering projects (perhaps under the guidance of some professional code of conduct).

To achieve this it is necessary to critically examine some fundamental notions of ethics, and investigate how to apply them specifically to the professional practice of engineering. Considering the engineer's mindset described so far, the course is thus divided into the following themes, developed to a greater or lesser extent depending on the length of each module:

- **Freedom.** First, it is necessary to address the question of what it means to be free, and whether human beings are *really* free. It should be noted that many students are intellectually convinced that humans are ultimately nothing more than biological robots, whose decisions are the result of more or less complex neural processes: deterministic algorithms, or possibly indeterministic, but algorithms nonetheless. This idea is logically connected to the ontological materialism that is assumed by most of them. It is therefore necessary to criticize materialism (at least in its narrowest sense), but this is a delicate operation, since the defense of human transcendence is often perceived as a veiled intrusion of religious ideology (an error that the authors try very consciously to avoid). In order to highlight the radical implications of the idea of freedom, throughout the course there is much discussion of genetics, robotics and neuroscience, with a critique of the significance of the experiments by Libet and others (Libet 1999).

- **Experimental sciences and humanities.** Another issue requiring extensive treatment is the proper way of reasoning in the human sciences. It is necessary to show that *the real is not only what can be measured*, and to teach how to reason about realities that are not corporeal or empirically verifiable. As already mentioned, students start with the idea that the experimental sciences have a monopoly on rational and objective knowledge (epistemological positivism): what we can know, even only provisionally, is what can be verified by rigorous observations and measurements (facts, actual phenomena). On this basis, it is possible to accept ethics merely as the science of *actual* morals (sociology, anthropology, ethnography, etc.), thus confirming the undeniable historical and cultural variability observed in humanity; implicit in this view, however, is that none of these historical concretions would have real normative force on behavior, only psychological influence. Without denying the importance of the study of different cultures, one of the central ideas of the course is that *the core of ethics is not about what actually happens, but about what we should make happen* (i.e. our reflected actions and attitudes). Being able to argue why we should act in one way rather than another requires putting into practice a form of reasoning very different from the characteristic thinking of the natural sciences about spontaneous phenomena.

- **Utilitarianism and dignity.** The subtitle of the course ("between survival and dignity") indicates one of the key elements of the reflection we aim to stimulate in students: survival, whether of individual, tribe, nation, species, or even of life considered as a whole, is important (Verharen et al. 2013) but cannot be the ultimate foundation of an ethical approach consistent with the pursuit of human dignity. We do not intend to oppose the two terms as if they were incompatible antagonists, but to show the *superior value of dignity*. Without neglecting the importance of assessing the consequences of professional activities in the making of ethical judgments about the behavior and responsibility of engineers, the limits of either rule- or act-utilitarianism are demonstrated, both as a matter of principle as well as because of the practical difficulty of predicting and assessing the consequences of typical complex systems in engineering (Génova et al. 2007). In the same vein, and with reference to Game Theory, we examine the possible relationship between *virtuous behavior*

and professional success. In doing so we avoid facile simplifications, such as maintaining that they are incompatible or, conversely, asserting that ethics promotes success. Instead, we claim that ethics cannot be reduced to Game Theory without getting lost along the way. The concept of dignity leads naturally to the concept of person, also studied from the viewpoint and limitations of the Turing test (Turing 1950), so that students are introduced to issues of great metaphysical depth.

- **Engineering and ethics.** Ethics is the one branch of philosophy that engineers ordinarily cannot avoid when they encounter it (Schmidt 2014). Although a superficial view might suggest that ethics is something alien to engineering (except insofar as it imposes troublesome barriers to efficiency), the two actually have a strong bond that unites them: the interest in *changing the world* for the better. The difference is that the task of engineering is to optimize the means to achieve change, while the specific domain of ethics is to reflect on the ends that are desirable: *which change?* According to the Enlightenment program, the role of science and technology is to improve the material condition of humankind. Yet "what counts as an improvement" is a question that arises in engineering but cannot be answered from within it, thus manifesting its bond with ethics and values. Without this reflection on the ends, the danger is to fall into a relentless pursuit of efficiency and efficacy without knowing what for. That is, ethics (*praxis*) is introduced in the course through reflection on productive knowledge (*poiesis*), which is the kind of knowledge with which engineering students are more familiar and which they most appreciate. In this way we intend to present ethics in its most positive aspect, not as a barrier but as the real engine of technical progress.

- **Conscience, autonomy and truth-seeking.** Possibly one of the most difficult aspects of the course, since it is a debate that is at the heart of modern moral philosophy. Throughout the course, students are encouraged to reflect on the knowledge of good and evil. Are good and evil, the moral value of actions, a reality that is discovered or constructed? Does the conscience *know* or *decide* what is right and wrong? Without prejudging the issue, the authors do not hold a 'neutral' stance in this regard, believing that the unqualified claim that values are constructed, and only constructed, leads to a moral relativism which leaves no rational reason to prefer some values over others. On the other hand, the position which holds that values are 'simply there', waiting to be discovered, is not fully satisfactory either, not least because it gives rise to ideological dogmatism on the part of those who attribute to themselves the capacity to define what is right and what is wrong. At this point it is necessary to distinguish between the *relativity of values* in themselves and the *relativity of our knowledge* of the values, a knowledge that will always be conditioned by our culture and the history of ideas. As an analogy, it is argued that our knowledge of the laws of nature is always relative (incomplete and still developing), though nature itself is not capricious or arbitrary.

In addition to the items listed above, other issues are also addressed: the primacy of ethics over law; public ethics and private ethics; the moral imperative; the necessity and possibility of professional ethics education; ethics to promote personal growth and to safeguard social peace; what is 'natural' in humans (especially considering that producing artificial stuff is also something natural); etc. All these issues provide opportunities for introducing names and central ideas of *key philosophers* in the history of moral philosophy: Plato, Aristotle, Epicurus, Augustine, Aquinas, Descartes, Hobbes, Rousseau, Hume, Kant, Stuart Mill, Nietzsche... The review is not exhaustive, but the students become familiar with these authors and discover what these and other philosophers have said, realizing its importance for them and their future career. The topics are not discussed sequentially or chronologically, but in a progressive deepening to facilitate the approach to the philosophical core of ethics.

Course methodology and teaching resources

The course does not take the form of theoretical lectures, but *participatory discussion* among the attendants, moderated by the teacher and stimulated by his or her questions, based on texts and case studies previously proposed, thereby applying the Flipped Classroom paradigm (Bergmann & Sams 2012). Great emphasis is placed on the importance of dialogue, where the seeker of truth is equally satisfied either with convincing or being convinced[1].

As a fundamental course support an *online discussion forum* (Wordpress blog) is used, in which the texts that will be discussed are published before each class. Students must participate in the forum with comments on the texts and with reflections that continue the discussion in the classroom; this activity is also evaluated, so anonymous comments are not allowed. Sometimes short excerpts from well-known commercial films are projected in class, with situations that illustrate the concepts to be clarified (Avatar, Toy Story, Amen, Harry Potter, Spiderman, The Truman Show, etc.). We use also 'thought experiments', role playing, small group discussions, etc.

In addition to general and specific literature on engineering ethics, students are required to study the ACM/IEEE Software Engineering Code of Ethics and Professional Practice (ACM/IEEE 1999; Gotterbarn et al. 1999). This text has been chosen because in its very preamble it highlights its educational purpose and the fact that the code cannot be applied to solve ethical problems in an algorithmic way. Students must submit at the end of the course a free-theme short essay (about 1500 words), which is graded for the appropriateness and depth of the arguments, as well as the clarity and correctness of language used.

In order to bring the subject closer to students, many examples from everyday life are proposed, in particular from the professional practice of engineering; fictitious situations appealing to the imagination of students are also proposed, such as robot stories and elements drawn from science fiction literature. All this seeks to connect the philosophical reflection with their surrounding world, trying to show that ethical thinking does not consist of abstract principles, but stems from the reality of life and professional circumstances. Since their minds are focused on understanding and building artifacts, some concepts are explained by analogy with the operation of machines; for example, showing the similarity –and, above all, the difference– between how an artifact knows (through sensors and information models) and the specific human way of knowing. The use of philosophical jargon (is/ought, categorical/conditional imperative, autonomy of conscience, good/norm/virtue, etc.) is kept intentionally to a minimum. In any case the required terms are progressively introduced, even subsequent to having explained the concept to which they apply, so that the technicality is 'invoked' to fill a terminological vacuum.

An essential element of the methodology, one that reaffirms that the proper mode of reasoning in ethics is neither experimental-scientific nor logical-formal, is a constant referral to certain *fundamental experiences* that cannot be replaced by arguments (Spaemann 1982). These include life experiences which students can recognize in themselves, experiences that reason 'discovers' and can analyze: (1) I am free (I can really choose, I am not a biological robot); (2) it does matter what I choose, somehow I know that the alternatives are not equivalent; (3) feeling the obligation is not the same as knowing the obligation; (4) I am not alone, there are Others equal to me in dignity; (5) the different realities are captured not only as they actually are, but especially in relation to their fullness. These experiences occupy in the method of philosophical reflection a place analogous to experiments in the scientific method, though admittedly they are not measurable phenomena.

[1] Plato, Gorgias 458a, Socrates says: "Of what sort am I? One of those who would be glad to be refuted if I say anything untrue, and glad to refute anyone else who might speak untruly; but just as glad, mind you, to be refuted as to refute". Translation by (Lamb 1924).

Results of surveys

The surveys through which the students evaluated the course are included in a separate Appendix (in Spanish)[2]. The course had quite good average acceptance in terms of meeting their expectations. With a participation of around 75%, the question *Did the course meet your expectations? 1 = No, not at all, 5 = Yes, even more than I expected*, received on each occasion an average evaluation between of 3.6 and 4.0 (see class sizes in Table 1).

Among the topics that aroused most interest, the one entitled "Ethics of conviction, ethics of responsibility – Does the end justify the means?" stands out in the three surveys, even if it is a topic covered in greater technical complexity and requires reading a social sciences journal article (see the results for Universidad Católica de Chile in Table 2). The worst rated subjects in relation to interest, however, were different in each of the four teaching contexts.

Topics debated in class and in the online forum, based on brief reflections, case studies, fictional stories, 'thought experiments' and role playing games	**Interest (1-5)**
Is freedom something real? Is only what can be measured real? Is only the material real?	3.5
Is ethics rational? Can we reason about good and evil? Is ethical progress possible?	3.9
Ethics as discovery and as construction. The limits of consensus. Relativism.	3.6
The experience of 'ought to'. Ethics beyond genetics and culture.	4.0
The experience of ethical dilemmas. Are value systems arbitrary?	3.8
Is and Ought. What is natural in human beings? The naturalistic fallacy.	3.4
Conscience and moral autonomy. Who decides what is good and what is evil?	4.0
Ethics and law. Professional codes of conduct.	3.8
Scientific education vs. humanist education. Should engineering students learn ethics?	3.8
Ethics of conviction, ethics of responsibility. Does the end justify the means?	4.3
Responsibility in the face of systems complexity. Does everything depend on consequences?	4.0
The principle of survival and the principle of dignity. Which is the supreme value?	3.9
Professional success and ethical conduct. What is ethics useful for?	3.8
Case studies (safety level, professional secrecy, shared responsibility).	4.0
Average	**3.9**

Table 2. Average interest aroused by each topic in Universidad Católica de Chile. ***Assess the degree of interest of each course topic. 1 = The topic was not interesting at all, 5 = The topic was fascinating.*** **Similar results were obtained with slightly different questionnaires on the other occasions when the course was taught.**

Regarding the participation in the course forum, students posted a good number of comments (with an average of almost 10 comments per student, or 1 comment per student per week), peaking at 820 comments in the Universidad Católica de Chile, answered by 115 comments from the teacher on

[2] https://www.dropbox.com/s/cscsi3g2y6xg9nd/TEE-Surveys.pdf

that occasion. It is worth pointing out that comments were generally evolving over the duration of each course, from simple opinions expressed in a couple of sentences, to extensive and well-argued reflections of more than 500 words (note that the final essay had to be about 1500 words, so the comments were gradually approaching the length of mini-essays).

A Socratic experience

Whether the objectives have been achieved or not is something that cannot be assessed only numerically. Many students enjoyed the metaphysical approach of the course, something they did not expect, while others still demand a more specific focus on the engineering profession. Some survey comments show a very positive evaluation of both methodology and content, being grateful for the opportunity to discuss and think about what's important in life, beyond the routine and practices of other classes; some say they have learned to see the professional career of the engineer from a more critical perspective, or that their view of ethics has totally changed for the better; and some have even stated that the most interesting concept they have learned has been that of Metaphysics.

Other survey comments are more critical, especially from those demanding greater attention to the analysis of case studies, or a more immediate approach to their professional futures. The final essay is really where the level of achievement becomes clear. Among the most significant attainments of the course, we note several which at the outset seemed to pose a difficult challenge for engineering students:

- They come to understand metaphysical concepts that are beyond measurable magnitudes.
- They ponder in depth such questions as: what is personhood, freedom, responsibility, etc.
- They recognize that ethics is not ideology, but a subject that can be thought through in a rigorous way.
- They see ethics in its most positive aspect, not as a barrier to professional success, but as the real engine of the technological progress that society needs.
- They understand the need to include an ethical assessment of the means, ends and benefits in each engineering project, from the point of view of corporate social responsibility.

Let us recall that the principal objective of the course is to introduce engineering students to the proper mode of reasoning in ethics, so different from the dominant scientific and technical mentality. The latter can be expressed as: "Only the experimental-scientific knowledge is rational; ethics is not an experimental-scientific knowledge; therefore ethics is not a rational knowledge". Given this initial skeptical attitude, it is not enough for the teacher to know ethics: he or she needs to know how to explain and make it accessible to the engineering mentality. To achieve this goal, the course adopts a *deeply Socratic structure* (Vlastos 1983, pp. 27-58):

- **Irony.** This consists of a (non-destructive) critique of the overrated experimental-scientific method. Engineering students assume that rigorous thought is axiomatic-deductive or experimental, and this is how they will try to understand what the philosopher says. The solution is not to give them alleged scientific arguments supporting ethical reasoning, but to reveal the limitations of the scientific method. It is even better if this is done starting from the actual practice of science and engineering, in order to demonstrate the need to reason differently, i.e. to reason in the philosophical way.
- **Maieutics.** It is important that the constructive phase rests on the experiences of students, in two ways: first, through a reflection on productive knowledge (*poiesis*), which is the lifeblood of engineering studies, with its emphasis on optimizing the means, while

disregarding the consideration of desirability of ends; and secondly, through a reflection on key experiences common to any human being. Starting from these experiences it is possible to teach another way of reasoning.

- **Dialogue.** Finally, the use of an *online discussion forum* is a very useful resource to keep the dialogue between teacher and student (and among the students themselves) permanently open, beyond the texts proposed for reflection, and beyond the walls of the classroom. An ongoing dialogue that lasts throughout the whole course, not restricted to lecture times. This dialogue is developed through a smooth process whose gradual nature is manifested in the evolution of students' comments within the course forum, from simple statements of opinion to extensive and reflected argumentations. Thus each time the course has been taught, a completely original dialogue is generated, wherein the first to learn is the teacher.

Some of the lessons learned by the teacher from students are, in general: correcting errors or imprecisions in some arguments, providing new interpretations of fictional stories and case studies employed in class, inventing new ways to solve certain proposed ethical problems without being dishonest, etc. A more specific example occurred when an analogy was proposed by the teacher to explain that human ends are discovered rather than constructed: if a bike rider can arbitrarily set the end of the race, then the race is meaningless. A student argued that once a race is ended, the rider chooses a new one, suggesting a continuous succession of races and ends. This is paradoxical, since the end must be reachable for the race to have sense; but, at the same time, the final end must be unreachable within life, so that it can continue to inspire the pursuit of virtuous life (nobody can claim to have reached the ethical life in all its fullness). Well, the analogy was not so good…

Related work

One of the main obstacles confronting the teaching of ethics to engineers is the prejudice that good reasoning is tied to quantitative data, math and science. One strategy to counter this way of thinking is to recover the centrality of emotion to moral reasoning (Sunderland 2014). Our approach emphasizes both the role of rigorous *qualitative reasoning*, as opposed to the reductionism to quantitative reasoning, and of *fundamental experiences* (Spaemann 1982), the latter being effectively connected with emotions. Besides, the appeal to personal experience is essential for providing a learning resource that helps students understand and retain knowledge (Dewey 1938).

The use of the traditional case-study approach in teaching engineering ethics has been criticized on the grounds that standard cases are usually described in such a fashion as to render the ethical problem too obvious and simplistic (Hoffmann & Borenstein 2014). Though this need not always be so (Davis 1997), standard cases can also make the mistake –a common one when teaching ethics– of misrepresenting moral problems as 'dilemmas', that is, as a forced choice between two unacceptable alternatives (Whitbeck 1995). We have avoided this difficulty by taking care to present each case study in a very open way, not so much as a problem to be solved, with all its details perfectly clear and having *one* solution, but rather as a stimulus to thinking and debating around ambiguities and variants of the presented case. Historical cases (Billington 2006) are especially useful when a personal point of view is adopted through the agent's own account of the facts, and when the emphasis is laid on all the stages leading up to a certain situation: a mere presentation of the final actions, which perhaps allowed for fewer alternatives, can dilute responsibility. A good example is Roger Boisjoly's repeated attempts to avert the Challenger disaster in 1986 (Whitbeck 1995): his personal account is focused on the whole development of events prior to the explosion, and not merely on the night before the flight, when the die was cast.

The parallels between ethical and engineering decision-making can also be exploited to 'naturalize' engineering ethics. Both ethical and engineering problems have in common that some possible responses are unacceptable –there are wrong answers even if there is no unique right answer– and some are better than others, thus contradicting the frequent assertion that "there are no right or

wrong answers" to ethical questions (Whitbeck 1995). They also have in common that the rational selection of a choice cannot be arrived at by arithmetic when alternatives are 'on a par', i.e. when one of the alternatives is better in some relevant respects, but worse in others, so that there is no obvious truth about how the items compare globally (Chang 2002). In fact engineers do not usually work by solving closed multiple-choice problems, but rather open, creative design problems. Closed or 'convergent' problems are those whose solution "can be written down and passed on to others, who can apply it without needing to reproduce the mental effort necessary to find it" (Schumacher 1973); by contrast, open or 'divergent' problems cannot be solved by logical reasoning alone, since they do not have a unique and universal solution, but one that originates in the agent's virtues and crafts. Therefore the analogy between ethical problems and design problems is also very much connected with virtue ethics and the proper reflection on the nature of engineering as a human activity.

Using games to teach engineering ethics exploits also the parallelism between ethical decisions and design decisions: both are processes that very deliberately weigh up the value of alternative solutions (Lloyd & van de Poel 2008). As such, they are largely dependent on the agent's ability to imagine, since the role of imagination is essential to the process of deliberation, as Dewey (1922) argued, in that it allows the agent to 'experiment' in advance with the consequences of alternative situations. The use of games and activities that expand imagination, then, can provide an excellent basis for connecting theoretical reflection with practical action, since 'feeling' an ethical concept is part of 'knowing' about that concept. The use of science fiction stories (following the long tradition of using fictional literature for moral education) has also been experimented with to teach engineering ethics (Berne & Schummer 2005). We have incorporated all these ideas in our methodology with the use of robot stories, 'thought experiments' and role-playing games.

Essays are still the preferred way to assess the development of epistemological beliefs and moral judgment in students (Han & Jeong 2014). We have complemented this with the assessment of students' participation in an online discussion forum (a blog). The use of a technological medium such as a blog enables digital natives (Prensky 2001) to have greater engagement with the course subject, and can be an effective way of increasing participation in and enjoyment of this complex subject (Voss 2013). A forum that is permanently open throughout the course resembles also the Flipped Classroom paradigm (Bergmann & Sams 2012). On the other hand, this modern technological resource is very well adapted to an ancient style of teaching, the *Socratic dialogue* (Vlastos 1983), that has always been essential to Western moral education. Other recent experiences confirm the importance and benefits of dialogue outside the classroom, giving opportunities to escape established hierarchies, roles and patterns of thought (Wickson et al. 2015).

Conclusions

Given the initial context of the students they were working with, the authors feel fully satisfied with what has been achieved in such a short time. Virtue ethics has experienced a revival in recent years, as modern formalistic ethical theories have exhausted themselves. We think this course is innovative in its selection of topics and in its methodological approach, specifically aimed at the typical engineer's mindset. Our efforts have been focused on deriving professional ethics from professional practice, from the very nature of engineers' activities and their way of thinking. We do not attempt to contradict their mentality, or give them something they do not have in the first place; but we do show that the scientific worldview (which is by no means necessary for successful engineering practice) is insufficient when it comes to addressing ethical issues. Even better, we show that ethical thinking can be developed in continuity with the core of engineering thinking (creative problem solving and the aspiration to change the world for the better), so that ethics and engineering can illuminate each other in their respective pursuit of good and original ways of decision-making beyond standard or quasi-algorithmic procedures.

Acknowledgments

This work is part of the research developed within Project FFI2012-37670, "Fundamentos filosóficos de la idea de solidaridad: amor, amistad y generosidad" (philosophical foundations of the idea of solidarity: love, friendship and generosity), supported by the Spanish Ministerio de Economía y Competitividad.

References

ACM/IEEE (1999). Association for Computing Machinery / Institute of Electrical and Electronics Engineers, *Software Engineering Code of Ethics and Professional Practice*, v5.2, 1999. Available online (http://www.acm.org/about/se-code/).

Bergmann, J. & Sams, A. (2012). *Flip Your Classroom: Reach Every Student in Every Class Every Day*. Washington, DC: ISTE - International Society for Technology in Education.

Berne, R.W. & Schummer, J. (2005). Teaching Societal and Ethical Implications of Nanotechnology to Engineering Students Through Science Fiction. *Bulletin of Science, Technology & Society* 25(6): 459-468.

Billington, D.P. (2006). Teaching Ethics in Engineering Education through Historical Analysis. *Science and Engineering Ethics* 12(2): 205-222.

Bouville, M. (2008). On Using Ethical Theories to Teach Engineering Ethics. *Science and Engineering Ethics*, 14(1): 111-120.

Chang, R. (2002). The Possibility of Parity. *Ethics* 112(4): 659-688.

Davis, M. (1997). Developing and Using Cases to Teach Practical Ethics. *Teaching Philosophy* 20(4): 353-385.

Dewey, J. (1922). *Human nature and conduct*. Prometheus Books.

Dewey, J. (1938). *Experience and education*. New York: MacMillan.

Génova, G., González, M.R., & Fraga, A. (2007). Ethical education in software engineering: responsibility in the production of complex systems. *Science and Engineering Ethics*, 13(4): 505-522.

Gotterbarn, D., Miller, K., & Rogerson, S. (1999). Software Engineering Code of Ethics is Approved. *Communications of the ACM*, 42(10): 102-107.

Han, H. & Jeong, C. (2014) Improving Epistemological Beliefs and Moral Judgment Through an STS-Based Science Ethics Education Program. *Science and Engineering Ethics* 20(1): 197-220.

Herkert, J.R. (2002). Continuing and Emerging Issues in Engineering Ethics Education. *The Bridge* 32(3): 8-13.

Hoffmann, M. & Borenstein, J. (2014). Understanding Ill-Structured Engineering Ethics Problems Through a Collaborative Learning and Argument Visualization Approach. *Science and Engineering Ethics* 20(1): 261-276.

Lamb W.R.M. (1924). Loeb Classical Library edition of Plato in Twelve Volumes, Vol. 3 translated by W.R.M. Lamb. Cambridge, MA: Harvard University Press.

Libet, B. (1999). Do We Have Free Will? *Journal of Consciousness Studies* 6(8-9): 47-57.

Lloyd, P. & van de Poel, I. (2008). Designing Games to Teach Ethics. *Science and Engineering Ethics* 14(3): 433-447.

MacIntyre, A. (1981). *After virtue*. Notre Dame: University of Notre Dame Press.

Prensky, M. (2001). Digital Natives, Digital Immigrants. *On the Horizon* 9(5): 1-6.

Quintanilla, I. (2012). Techné: la filosofía y el sentido de la técnica. *Common Ground España*, 2012.

Schmidt, J.A. (2014). Changing the Paradigm for Engineering Ethics. *Science and Engineering Ethics* 20(4): 985-1010.

Schumacher, E.F. (1973). The Greatest Resource -- Education. In *Small Is Beautiful: A Study of Economics As If People Mattered*. London: Blond & Briggs.

Smith, J., Gardoni, P. & Murphy, C. (2014). The Responsibilities of Engineers. *Science and Engineering Ethics* 20(2): 519-538.

Spaemann, R. (1982). *Moralische Grundbegriffe*. München: Beck Verlag. (*Basic Moral Concepts*. London: Routledge).

Sunderland, M.E. (2014). Taking Emotion Seriously: Meeting Students Where They Are. *Science and Engineering Ethics* 20(1): 183-195.

Turing, A.M. (1950). Computing machinery and intelligence. *Mind* 59: 433-460.

Verharen, C., Tharakan, J., Middendorf, G., Castro-Sitiriche, M., Kadoda, G. (2013). Introducing Survival Ethics into Engineering Education and Practice. *Science and Engineering Ethics* 19(2): 599-623.

Vlastos, G. (1983). The Socratic Elenchus, in *Oxford Studies in Ancient Philosophy* 1: pp. 27-58.

Voss, G. (2013). Gaming, Texting, Learning? Teaching Engineering Ethics Through Students' Lived Experiences With Technology. *Science and Engineering Ethics* 19(3): 1375-1393.

Whitbeck, C. (1995). Teaching ethics to scientists and engineers: Moral agents and moral problems. *Science and Engineering Ethics* 1(3): 299-308.

Wickson, F., Strand, R. & Kjølberg, K.L. (2015). The Walkshop Approach to Science and Technology Ethics. *Science and Engineering Ethics* 21(1): 241–264.