TREE – Teaching and Research in Engineering in Europe
Special Interest Group D6 "Ethical issues in EE"
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Preparing engineers for social responsibility

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Report of the TREE Special Interest Group D6 Ethical Issues in Engineering Education.

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Summary
This report describes the purpose, methodology, and outcomes of the SEFI TREE SIG D6 on ethical issues in engineering education.
The purpose of this SIG was to enhance the understanding of and discussion about two **key-questions**: (1) *Which* knowledge, skills, and attitudes should be transferred to future engineers through the engineering education in order that they will be adequately prepared for taking decisions and for acting in an ethical and socially responsible way? (2). *How* can/should that knowledge, skills, and attitudes be transferred to the students?
The methodology consisted basically of two **activities**: (1) argued theses about the key-questions have been solicited from individuals who are actively involved in the teaching of topics in the engineering curricula that are directly relevant for the two key-questions; (2) brainstorm sessions on the two key-questions have been conducted with individuals (members of the SEFI and IGIP organisations) who were interested in the key questions, but who were usually not actively involved in the teaching of relevant topics.
The **outcomes** of this SIG are a collection of argued theses about the key-questions, as well as written accounts of what has come out of the brainstorm sessions. The outcomes are believed to be a sufficient basis for a conclusion that the discussion about the requirements that should be imposed upon the engineering curricula in view of preparing students for social responsibility is an important and urgent one. It is hoped that these outcomes will serve as a valuable input to that discussion.

Key words
Engineering education; Engineers; Ethics; Knowledge, skills, attitudes; Social responsibility.

Contents

I. Introduction

Purpose/key questions

The **purpose** of the Special Interest Group D6 Ethical issues in Engineering was to contribute to the understanding of, and to promote the discussion about the requirements that should be imposed upon engineering education in order that future engineers should be adequately prepared for ethical and socially responsible conduct and decision making. More specifically, the purpose was to enhance the understanding of and discussion about the following two **key-questions**:

- *Which* knowledge, skills, and attitudes should be transferred to future engineers through the engineering education in order that they will be adequately prepared for taking decisions and for acting in an ethical and socially responsible way?
- *How* can/should that knowledge, skills, and attitudes be transferred to the students?

Methodology, nature and intended purpose of outcomes

The core activity of this SIG consisted of two workshops designed so as to collect and confront different existing views on the goals and contents of engineering education in view of the requirement that engineering education should prepare students for future ethical and social responsibility.

Two types of outcomes have been obtained. The first outcome is a collection of argued theses about the key-questions by individuals who are actively involved in the teaching of topics in the engineering curricula that are directly relevant for the two key-questions of this SIG. Some of these argued theses were prepared for and served as inputs to one of the workshops to be described later. Others have been solicited later. These theses will be presented in Section II below. We have also included the conclusions of a symposium of the student organisation BEST on a closely related topic. This symposium focussed on ethics in engineering education and sustainable development in engineering education. The symposium report was made available as an input to the SIG by a representative of BEST who participated in the SIG D6.

The second outcome of the SIG D6 consists of the results of brainstorm sessions about the key-questions of the SIG, conducted during the two workshops. The participants to these sessions were individual members of the SEFI and IGIP organisations who had not specifically prepared for the brainstorm sessions, but who were interested in the key questions. Most participants of these brainstorm sessions were not actively involved in the teaching of directly relevant topics or courses. The participants to the brainstorm sessions have been asked to reflect on the requirements that in their view should be imposed upon the engineering curricula in view of one teaching goal only: namely, that the engineering education should properly prepare its students for future ethical and socially responsible conduct. Hence, no efforts have been undertaken to balance or weigh the requirements imposed by this particular teaching goal with other requirements that must be imposed upon the engineering curricula (such as to transfer scientific and technical knowledge and know how). The results of these brainstorm sessions can be found in Section III.

An additional outcome of this SIG will be a collection of articles on the key questions of the SIG, to be published in the European Journal of Engineering Education (EJEE). The purpose of this special section is the same as this SIG's purpose, namely to contribute to the understanding of, and to promote the discussion about the requirements that should be imposed upon engineering education in view of preparing for social responsibility.

The outcomes of this SIG are intended to promote and contribute to the discussion about the requirements that should be imposed upon engineering education in order that future engineers should be adequately prepared for ethical and socially responsible conduct and decision making. No effort has been made in this report to draw up specific or definite conclusions regarding required contents of engineering education in view of preparing adequately for ethical and social responsibility. It is hoped, however, that the outcomes of this report show that the discussion about this topic is an important one. It is also hoped that these outcomes will serve as valuable input for this discussion.

The workshops

Workshop during SEFI 2006 Annual Conference, Uppsala, Sweden
The first workshop was conducted on June 30 2006, during the SEFI 2006 Annual Conference in Uppsala, Sweden. It was organised by the SEFI Wg Ethics in Engineering Education. The stated goal of the workshop was to identify requirements for the engineering curricula in view of the goal of adequately preparing future engineers for performing their profession in an ethical and socially responsible way. The workshop was designed in order to optimally serve the needs of the SIG D6 of the SEFI TREE Thematic Network. The workshop was designed and organised by H. Zandvoort (TUDelft, chairman of the SEFI Wg Ethics in Engineering Education and leader of SEFI TREE Special Interest Group D6) and B. Taebi (TU Delft).

This workshop consisted of two parts. In the first part, six invited speakers briefly presented and defended a thesis of their own choice regarding what is needed in engineering education in view of preparing the students for social responsibility. The thesis presenters had been invited (but not pressed) to indicate which of the three aspects Knowledge, Skills and Attitude their thesis was particularly addressing. During the Uppsala Workshop, all participants were invited to contribute their own argued thesis, which then would be included in the SIG D6 end report, subject to minimal formal requirements.

In the second part of the workshop all participants (+/- 20 persons) took on an active role. Three subgroups were formed to discuss the question what is needed in the engineering curricula in view of preparing student for social responsibility, along three main lines, i.e. knowledge, skills and attitude. This second part was concluded with brief plenary reports by each subgroup, supported by flipover sheets. It was understood by all participants that the categories of knowledge, skills and attitude are not independent of each other. For instance, the transfer of certain knowledge may have an influence upon one's attitude towards ethical or social issues, and vice versa, the presence of certain attitude may stimulate the mastering of certain knowledge or skills. It was nevertheless hoped that the distinguishing between these three categories would be helpful for a clarification of the key questions.

Workshop during Dutch National SEFI-IGIP study day, January 12, Eindhoven
The second workshop was conducted on January 12 2007 during a Dutch national SEFI-IGIP study day held at the TU Eindhoven. This workshop repeated, with about 15 participants, the second part of the Uppsala workshop, preceded by a short introduction by the workshop conductor (H. Zandvoort).

Contents of this report

Section II provides written accounts of “argued theses” relating to the key-questions of this SIG. You may find here:
The theses of Conlon, Van Hasselt, Heikkerö, Taebi, and Wagner which were originally presented during the Uppsala workshop.
The conclusions from a BEST symposium on the subjects of ethics and sustainable development in engineering education.
The theses of Zandvoort, Børsen Hansen, Porra, and Didier, which were written and added later on.

Section III presents written accounts of the brainstorm discussions in the Uppsala workshop.

Section IV contains some observations and reflections by the workshop chairman and SIG leader, Henk Zandvoort.

Section V consists of appendices. Here you may find data on the thesis presenters and the full report on the ethics part of the BEST symposium mentioned above.

II. Theses about requirements for the engineering curricula in view of preparing students for social responsibility

Of the argued theses to be presented below, those by Conlon, Van Hasselt, Heikkerö, Taebi and Wagner were originally presented to the participants of the Uppsala workshop, before the brainstorm sessions were conducted that will be reported upon in Section III. For a thesis of a sixth presenter, a representative of the student organisation BEST, no written account is available. To these five, theses by Didier, Børsen Hansen, Porra, and Zandvoort were later added. Also, the conclusions of a relevant symposium of the student organisation BEST were added.

Thesis of Eddie Conlon re "knowledge"

Thesis

Engineers need to understand the context in which engineering practice takes place and the importance of engineers seeking to shape that context so that a sustainable engineering practice is possible. This involves understanding the wider social issues inherent in the design, choice, adoption and use of technology and the procedures for collective decision making including the role of law. Engineers need to understand how interests are generated and advanced to shape public policy. This requires an understanding of power structures deriving from the study of sociology.

Argument

"Men make their own history, but they do not make it as they please; they do not make it under circumstances of their own choosing, but under circumstances existing already, given and transmitted from the past" (Marx).

Sociology is concerned with the relationship between social structures and human action (agency). It has focused on the manner in which social structures both constrain and facilitate agency. Engineering ethics is concerned with the values of engineers. A set of values are posited which make for an ethical engineering practice. The focus is on the ethical behaviour of the individual engineer (agency). But in reality while engineers *may* be committed to ethical practices it is not always possible to behave ethically. There are some questions which cannot be effectively addressed by considering the spontaneous individual action of engineers alone.[1]

While my emphasis is on the context of the engineers work there is a requirement for civil courage[2] based on a commitment to securing a sustainable and just world. Individual action can make a difference: "By the fact of his (sic) living he contributes …to the shaping of his society and to the course of its history, even as he is made by society and by its historical push and shove"[3]. While teaching ethical principles to engineers is important it must be seen "as part of a larger web of actions inside many fields" that together make the world more ethical and sustainable.[4]

Consideration of the interaction of action and structure leads to a number of areas of enquiry:

- What meaning does social responsibility have for engineers (ideology)?
- What actions can they take to ensure they are socially responsible? This involves questioning the problems they are asked to solve.
- What constraints stop them acting in a socially responsible manner?
- How can these constraints be changed to facilitate social responsibility?

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1 See Fourez, GM (2001) "Engineers facing ethical debtes" in P. Goujan and B.H. Dubreuil, *Technology and Ethics*, Peeters, Leuven .

2 See Berner, B (2001) "Handling Ethical Dilemnas in Everyday Engineering Work" in Goujan and Dubriel op cit

3 Mills, CW (1970) *The Sociological Imagination,* Penguin, Harmondsworth.

4 Borson Hansen, B (2005) "Teaching ethics to Science and Engineering Students" *Report from a follow up symposium to the 1999 World Conference on Science, April 15-16, 2005,* Centre for the Philosophy of Nature and Science Studies, University of Copenhagen.

A key constraint for engineers is that they tend to be employees and work on projects framed by others and in organisations owned and controlled by others. In hierarchical organizations engineers occupy contradictory positions in that they are both employees and agents of capital, often holding formal management positions. Thus they are both part of the collective labour process and controllers of labour. They are both constrained and constrainers. Whether they design work to reflect ethical principles or not will be a direct reflection of the ethicality of the society of which it is a part.[5]

Implementation

There are a number of ways in which these issues can be handled:

1. Engineering students could be offered modules in sociology and politics.
2. Given that many engineers study management these modules should address principles of organizational behaviour and organizational processes.
3. Ethics modules should specifically deal with the obstacles and constraints inhibiting an ethical engineering practice.

Thesis of G.J. van Hasselt

Thesis

To preserve and sustain their competitiveness and attractiveness, it is imperative that courses in “ethics and engineering” incorporate non-western philosophies, cultural values and norms.

Argument

Courses in “ethics & engineering” intend to instil and cultivate an attitude directed at ethical considerations in the professional conduct of scientists, technologists and engineers involved with the applied sciences. The latter are universal: thermodynamics are the same the world over. The attitude towards ethical considerations and debate, as a manifestation of education, however, is fundamentally different when comparing e.g. Anglo-Saxon or European with other regions, such as Asia. A typical example is the restraint of (Buddhist) Chinese students when it comes to express an ethical opinion. Even publicly drawing a conclusion from (a mixture of normative statements and) technical facts is ‘not done’ in their culture.

Empowerment of Western students to ‘rise’ above this hindrance in communication and ‘cooperation’ requires a mixture of basic understanding, appreciation and ‘ethically founded’ willingness to emphasise with and take account of such cultures.

Students who develop such competence to deal with ethical issues in a truly global manner have a competitive edge; it enhances the reputation of the institute where they were educated.

Conversely, for non-western students, inclusion of e.g. Buddhist and Confucian essentials, provides a much needed ‘stepping stone’ towards the western philosophies etc and thence truly global thinking.

The ability to reason and argument on ethical issues in a truly global manner requires basic understanding of all major philosophies and religions as they impact and guide the professional conduct of the engineers etc.

Summary: European and (North) American courses on “ethics and engineering” have enjoyed a ‘head start’ relative to the other regions. That head start will, in a few years time, cause the proverbial retardation relative to the Juggernaut of Asian universities, unless the E&E courses adequately encompass all ethical philosophies of global stature.

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[5] See Legge, K (2006) “Ethics and Work” in Marek Korczynski et al., *Social Theory at Work*, Oxford University Press.

Thesis of Topi Heikkerö re attitude

Thesis
Volition aspects (ethos, attitude, pathos, will, underlying emotion) in technology need to be addressed in teaching ethics within the engineering curriculum. The first step addressing them is paying attention to the procedural character of various processes (research, design, learning, negotiation, decision-making, and reconciliation as processes). Another, stronger but more problematic, avenue is offered by a discussion on professional virtues of engineers.

Argument
No final definition of technology exists. Nevertheless, elements of knowledge, action, artefact, skill, and system, undoubtedly, are at work in technology. Since human action is impossible without desires and willing that engender an act, a volition aspect inevitably works in technological activities as well (Carl Mitcham: *Thinking through Technology*, 1994, pp. 154–160). This aspect, however, is more seldom addressed than the others. As ethics literally has to with *ethos,* addressing the volition element in teaching engineering ethics proves necessary. The volition element here refers to such things as ethos, attitude, pathos, willing, and emotions underlying action. In classical ethics these were treated under the rubric of virtues (e.g., *Nichomachean Ethics*). Discourse on virtues has gained a new relevance in ethics, especially in professional ethics, within past a couple of decades. Alasdair MacIntyre's *After Virtue* (1984) was the contemporary classic that changed the tide for virtue ethics. Engineering ethics can make use of this trend in defining professional virtues for engineers. These virtues attain their meaning within the engineering practice. As a general moral theory, virtue ethics, however, includes severe problems in contemporary culture: it presumes an essentialist anthropology and easily entails paternalism. Who tells what the humanity is to which the virtues should correspond? How accurately can "ethically correct" attitudes be taught? Nonetheless, the volition aspect should receive attention in teaching ethics to engineers. My second, "softer" suggestion for achieving this goal, in non-metaphysical and non-paternalistic manner, is to emphasize the procedural character of various processes in engineering curriculum. These processes include design as a process, research process, democratic processes, negotiation, decision-making, reconciliation, and learning. This can be done in ethics classes but the principle could penetrate the whole engineering curriculum as well.

Ethical thinking behind this suggestion is the tradition of social contract theories. Its liberal democratic variants can be supplemented with points of view from communitarism, discourse ethics, analyses of recognition *(Anerkennung)* processes, feminist philosophy, dialogue theories, and virtue ethics. These supplements provide a richer view of human life, a view that takes the volition aspect seriously enough.

Implementation
Practical teaching ideas following from this suggestion are, for instance, the following: 1. Structuring classes so that they in themselves are processes requiring moral deliberation (team work, sharing duties, research projects). 2. Use of drama, role play, and simulation of processes central in engineering praxis with an emphasis on morally tricky situations. 3. Reading fiction that describes relevant processes, discussing it, writing about it. 4. The same as #3 with movies, both fiction and documentary. 5. Writing assignments that require taking another person's role. 6. Introspective writing assignments that inquiry in one's own convictions and valuations. 7. Creating ethics classes corporeality, volitional life, personal interaction, and dialectic processes in mind. 8. Participating in, and/or researching, real life processes that involve conflicting interests.

Thesis of Behnam Taebi: Socially responsible engineering

Thesis
Assuming that the students have already acquired a background in engineering ethics, I propose using the supreme moment of graduation to let the student become acquainted with the reality of social issues related to engineering and technology.

Argument
I assume that the students have already acquired a certain level of knowledge and skills which are relevant for dealing with the ethical and social issues. Concepts like responsibility and risk as well as philosophical concepts of ethics (e.g. utilitarianism) are currently included in the curriculum of engineering education at some (West-European) universities, for instance the *Ethics and Engineering* course, as we provide for Chemical Engineering and Applied Physics students at the Delft University of Technology since ten years[6].
Knowledge and skills constitute the foundation of a *house* called *socially responsible engineering*. This construction will, however, remain *roofless* without possessing the right attitude. But, how can we achieve that?

In ethics courses, we mostly discuss actual cases, such as the Challenger Launch decision in 1986. It is on the one hand very important to discuss these issues in order to explore how such decisions can cost human lives but they are, on the other hand, intangible issues for the student, as the student deals with them as virtual issues. Students should also - in addition to actually happened cases - be confronted with issues they can better connect to. A crucial phase in every academic study is the graduation project, which spans in the most engineering curricula a couple of (weeks or) months. I propose that a candidate engineer should be asked to discuss the ethical and societal aspects of the design or research she is dealing with in her graduation project.

Let the future engineers gain awareness about the societal impacts of their work. As technology is increasingly influencing the society around us, an engineer could discuss whether her work brings about any change in the society and to what extent she is responsible for this change. Those are difficulties an engineer will encounter later on anyway, but it is recommendable to give an engineer the opportunity to deal with them in the very reality of their own graduation work: the project they know better than any other *expert* and in which they – often for the first time - tackle a real existing problem.

The student is then obliged to devote a part of graduation thesis to this *social chapter* and defend it in front of the thesis committee. Defending a thesis is in many engineering faculties a very serious business, and the social and ethical chapter should be taken serious as well.

Implementation
I am aware of the fact that some practical problems must be tackled before this proposal can be implemented, starting with the fact that a philosopher/ethicist or someone else who is sufficiently qualified needs to be involved in the performing and evaluation of each graduation project. Another problem is that performing such a study is not expedient to each course, only courses that are concluded with a tangible project are eligible for such an additional societal study.

Yet, I endeavour to emphasise that the *supreme moment* of graduation needs to be used as a *finishing touch* of engineering philosophy and ethics courses, in which the student can freely apply the philosophical tools (such as responsibility) she has gained during the curriculum, in order to get acquainted with the social aspects of her work.
Putting the roof of attitude on a right time and in a right way, there will be a *shelter*, under which an engineer is better equipped and *could* act socially responsible.

Thesis of Natalie Wagner re attitude and knowledge

[6] H. Zandvoort, G.J. van Hasselt, J.A.B.A.F. Bonnet, “Ten years of teaching courses in “ethics and engineering” for Applied Sciences at Delft University of Technology. The story of a successful teaching model”, Proceedings of the 34th SEFI Annual Conference. Engineering education and active students. Uppsala, Sweden. 28 June – 1 July 2006. Per Andersson, Claudio Borri (Eds). Published by Uppsala University, Faculty of Science and Technology, 2006. ISBN 10: 91-631-8387-0.

Thesis
Students have an inherent concept of social responsibility before they begin formal education. This concept evolves and changes throughout the education program and needs to be nurtured along the way.

Argument
This will require a functional definition of what the social responsibility of engineers is, as well as some practical programs to re-enforce the learning process. I think that courses and project experiences related to the possible ethical situations that can be encountered should be offered. A strong moral base could be formed with work on humanitarian projects with other disciplines. I think that the inherent responsibility of an engineer should be openly discussed at all academic levels, as this would encourage the students to re-define their level of commitment to the social sphere.
Since I am currently a student and have been working with student directed projects in the humanitarian field, I have noticed that my ideas of social responsibility are echoed by some students and not by others. I see a lot of students working towards their paycheck after graduation, not really for the ideals of what engineering can accomplish. This to me is what needs to be addressed by curricula if the next generation of engineers is to solve the problems of today.
The format that I have seen work well is to get a team of students together to work on what at first is a simple engineering problem. Soon moral and ethical implications develop. For example, there is a school in Uganda that has mostly orphans as students. They have not enough water and what is in storage is causing illnesses. The outcome required is a suitable supply and storage for clean water that will meet the demands of the school. The ethical aspect is that the team needs to listen to the school's head master for direction, but the head master is convinced that flush toilets are needed equally as much as the water supply. Where does the authority for the students come from to tell the school what is the best solution? And how is the best design implemented when travel is hindered by civil unrest? These questions show the level of understanding that the engineering education can be facilitating.

Conclusions from BEST symposium re ethics in engineering education.[7]

There is a distinction between moral and ethics, as moral is something learned unconsciously and ethics is something learned by reflecting moral stands in a real world. It is both vital and necessary for the engineers to understand ethical issues that will occur during their carrier, especially as they are the ones making the discoveries and therefore need to stimulate the consequences of those. Engineers have to stand up for their positions in ethically questionable cases.
In European universities the way ethics is taught varies from specific courses on ethics, and from ethics being part of several technical courses, to not having any ethics taught to the students. In cases where ethics is taught, problems are faced concerning competitiveness of teachers, and lack of practical examples. The goal of courses on ethics should be to promote critical thinking. They should be compulsory, dynamic and interactive (real cases, case studies and so on).
The teachers should have theoretical knowledge but also practical and technical experience as engineers. During the discussions there was no conclusion reached concerning the time that these courses should be implemented (at the beginning of studies or at their end). A discussion about cheating took place as well. Unethical behaviour during studies might affect future behaviour. However in many universities the examination system seems to promote, or at least does not try to discourage that kind of behaviour. So the system should change in order to make it unworthy to even try.

[7] Adopted from *Ethics and sustainable development issues in engineering education*. Report of BEST Symposium on Education, Madrid. 27th March – 2nd April 2006. Board of European Students of Technology. Document date: 2006-Aug-07. An updated report that deals with the ethics issues discussed on this symposium is added as an appendix in Section V.

Conclusions from BEST symposium re sustainable development in engineering education[8]

The awareness of Sustainable development in our society exists, but mainly in terms of discussions and not as practical achievements. It is based on three pillars (economy, society and environment) but still today economy issues are to a certain level more important than others.
Engineers should be concerned about sustainable development and should have the duty of informing society and cooperating through NGOs or similar organisations.
Currently in engineering education in Europe there is a diversity of levels of implementation of sustainable development from secondary schools to not having even a choice of learning about it. On the contrary in the field of environmental engineering social and even more environmental aspects of engineering are thoroughly debated. There is an agreement that sustainable development is crucial for engineering education but not all pillars should be taken into account equally, but depending on a field of study. (E.g. the impact of the work of computer engineering on society is more important than on the environment.) Implementation of sustainable development resulted in leaving some discussions open. But what was agreed was:

- Introductory course at the beginning of the study.
- Should be part of some technical courses.
- Courses should be interactive (discussions, case studies, etc).
- Teachers should be up-to-date about new technologies.

There was an idea, although not strictly related to the topic, of an eco-consumption tax which would partly substitute different classical taxes.

Thesis of Henk Zandvoort re knowledge[9]

Thesis
There exists knowledge that is necessary for social responsibility of (scientists and) engineers but that is largely unknown to or at least poorly understood by (future) engineers. This knowledge should be transferred through the engineering curricula, as otherwise it will remain unknown.

Argument
For the effects of their work on society, scientists and engineers are highly dependent on the proper functioning of the legal and political systems and institutions. To a high degree, laws and political decisions determine how their results will be used and to what effect: whether unintended side effects will be controlled, whether risks will be contained, and whether costs and benefits will be distributed fairly. In short, it is laws and political decisions that determine whether the output of scientists and engineers will be beneficial and not detrimental to society. This holds both for engineers and for scientists, including the large majority of scientists working in fundamental science, as most of that fundamental science is being performed and/or financed because of the expectation of practically applicable results. In addition, the vast majority of engineers and scientists perform their work as employees of (either private or public) hierarchical organisations. These organisations both enable and constrain the work of engineers and scientists in essential ways, and have a pervasive impact upon both *what* engineers and scientists do, and *how* they do it. These organisations are created, and their functioning is determined, by the legal system.

Unfortunately, it cannot be taken for granted that the legal and political systems are up to their tasks. Important flaws can be identified in the existing laws and in the existing procedures for political decision making, if considered from the perspective of an engineer or a scientist who

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8 Adopted from *Ethics and sustainable development issues in engineering education*.. Report of BEST Symposium on Education, Madrid. 27th March – 2nd April 2006. Board of European Students of Technology. Document date: 2006-Aug-07.

9 The thesis presented here has been substantiated and elaborated in H. Zandvoort, "Necessary knowledge for social responsibility of engineers", in *Proceedings of the 34th SEFI Annual Conference. Engineering education and active students. Uppsala, Sweden. 28 June – 1 July 2006*, Per Andersson, Claudio Borri, Ed. Uppsala University, Faculty of Science and Technology, 2006.

wants to perform his/her work in an ethical or socially responsible way, and/or who wants to contribute through his/her work in a positive way to society.[10]

However, laws and procedures for collective decision-making are man made, and can be *changed* by humans. Scientists and engineers could contribute positively to democratically effectuated change of these social institutions. A necessary condition for this is that they should be informed about relevant and well-founded knowledge that exists about these institutions and their functioning. Without that knowledge, they are not in the position to formulate sound opinions on the actual functioning of these institutions and on options and proposals for change. Here, "sound" is used in the sense of: consistent with existing relevant and well-founded knowledge. Such knowledge is termed here "necessary knowledge for social responsibility".

Such knowledge as has been characterised above exists. The following is a non-exhaustive list of subjects for which such knowledge is available:

(1) The procedures for collective decision-making.

(2) The foundation and functioning of law.

(3) The functioning of hierarchical organisations and of people who work in such organisations. (Hierarchical organisations in many respects play a dominant role in present day society; the great majority of engineers, like many other higher educated people, are employees of and hence are constrained in their work by such organisations.)

(4) The theory of decision-making under uncertainty. (Mastering of this theory can be said to be necessary for a proper understanding of the ethical aspects of technological risks.)

(5) Game theory (dealing with important relevant concepts such as prisoner's dilemmas and how such dilemma's could be "solved") and the theory and phenomenology of negotiation.

Implementation

For at least the first, fourth and fifth topic mentioned above, there exist excellent textbooks. The following is a non-exhaustive list:

Ad. 1. D.C. Mueller, *Public Choice III*. New York: Cambridge University Press, 2003.

Ad. 4. S. French, *Decision theory. An introduction to the mathematics of rationality*. Chichester/New York: Ellis Horwood/Wiley, 1986. (advanced level) D.V. Lindley, *Making decisions*. 2nd rev. ed. Chichester: Wiley, 1985 (introductory level).

Ad. 5. Mueller's text provides some of the most relevant concepts from game theory. An excellent book on negotiation that includes discussions of ethical aspects is H. Raiffa, *The art and science of negotiation*. Cambridge, Massachusetts and London, England: The Belknap Press of Harvard University Press, 1982 (1st ed.), 2003 (17th ed.).

In principle, it would be totally feasible to introduce in the science and engineering curricula effective courses based on these available textbooks. However, at present this is not possible from a practical point of view. As I have argued elsewhere[11], the effective transfer of the knowledge identified above requires considerably more study time than is currently available for "non-technical" topics in especially the "hard" science and engineering curricula. It is likely that the actual space allotted to topics such as the ones identified above is the outcome of an improper weighing of the competing demands that are imposed on the science and engineering curricula. Hence, a discussion about the contents of the (science and) engineering curricula should be (re)opened.

Thesis of Tom Børsen Hansen

Thesis

Ethics should be taught to science and engineering students as part of a strategy to solve the

10 For substantiation see H. Zandvoort, "Good engineers need good laws", European Journal of Engineering Education Vol. 30, No. 1, March 2005, 21–36.

11 H. Zandvoort, "Necessary Knowledge for Social Responsibility of Scientists and Engineers", International Conference on Engineering Education – ICEE 2007 September 3 – 7, 2007, Coimbra, Portugal. (forthcoming)

global problems of our times.

Argument[12]

Ethics is understood here as dealing with how to solve the global problems of our times. There is no complete agreement about what these problems are, but an array of scholars has tried to identify them. Thus, Klafki identified five epochal typical complexes of problems: The peace question seen in the light of weapons of mass-destruction; Environmental degradation approached as a global problem; Social inequality viewed as a socially and globally constructed phenomenon; The digitalisation and automation of the production machinery system and its potential consequences in form of unemployment etc.; And finally the increasing individuality and the related breakdown of the feeling of solidarity and social responsibility. UN's Millennium Development Goals provide us with another suggestion for what qualifies as the global problems of our times. The lack of complete or precise agreement about what are today's global problems does not disqualify the present argument. It only commits us to continue to discuss the topic. All problems referred to above are somehow related to the effects of science and technology upon society. This makes that scientists and engineers are involved in these problems in a specific sense.

Epochal typical problems cannot be reduced to only a question of individuals' ethical choices, but must also be solved on the structural level. International / regional / national / local communities and institutions of different kinds can and must contribute to the solution of the epochal typical problems of our time – or at least should not contribute to an escalation of the problems. But individual engineers and scientists – as all other citizens that make up these different communities – are also involved. Both individual responsibility and structural changes are needed: Individuals change structures, and structures form individuals.

A scientist or an engineer (or any other citizen) needs to be prepared to a commitment to help solving the global problems of today, which requires proper training. How one can contribute to solving (or how can one make sure that one does not escalate) the serious problems of our time may in part vary for different groups of citizens (scientists, engineers, journalists, politicians, businessmen etc.) according to skills, background knowledge, and fields of social activity. But first and foremost one must be able to recognise unethical actions and structures.

Engineers and scientists are trained to develop specific skills that enable them to contribute in certain ways to solve the pressing problems of our times referred to above. They may be well-trained to develop a special kind of future scenarios regarding the consequences of the techno-scientific development (early warnings, life cycles analysis, risk assessment etc.) and to solve certain kinds of problems in certain ways. However, they may not be well-trained to handle uncertainties, different interpretations of data / phenomena or to recognize ethical conundrums of their future profession.

The teaching of ethics to science and engineering students should be part of a strategy for solving the global problems. This idea translates into a pedagogical ideal that requires science and engineering students set up their own personal ethical orientation system, which cannot only be formed by internalising the main types of ethical theories (utilitarianism, deontology etc.) as these are dealt with in the field of academic ethics. The students need also to get acquainted with global ethics (e.g. Hans Jonas' imperative of responsibility and Ulrich Beck's cosmopolitan critical theory), corporate rules as well as national and international legal regimes, and the power structures of science and technology (e.g. funding and decision mechanisms).

Implementation

Ethics courses taught to science and engineering students must be tuned to the fields of responsibility, specific competencies and knowledge base of scientists and engineers. In the last few years I have been teaching such an ethics course to biochemistry, chemistry and nanotechnology students at the University of Copenhagen. The course satisfies the definition and goal of ethics stated in the argument, as it helps enabling the students to contribute to solving the

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[12] An expansion of this argument is found in Tom Børsen Hansen "Teaching Ethics to Science and Engineering Students", Center for the Philosophy of Nature and Science Studies, 2005, Available at http://www.teachingethics.dk/

pressing global problems of our time. The stated purpose of the course can be summarized in three skills: After the course the students must be able to

1. describe dilemmas, controversies and conflicts of techno-science as wells as paraphrase the analytical theories in a fair and correct manner,
2. apply relevant analytical theories on such dilemmas, controversies and conflicts, and hereby explain, understand or evaluate them, and
3. assess the quality of an analysis carried out by co-students as well as to evaluate analytical tools used in an analysis of a dilemma / controversy / conflict (was the analysis credible? were the tools well chosen for the analysis?)

During the course the students work with six cases. Each case-study consists of texts that describe a concrete dilemma, controversy or conflict approached through the experiences of a few scientists or engineers. This approach makes it easy for the students to relate to the case. In addition, theoretical texts are provided taken from epistemology, ethics, sociology, political science, history etc. (analytical tools), which the students are supposed to apply to the concrete dilemma, controversy or conflict. The course has primarily an analytical focus (i.e. the second course competence), but the students are in all the cases asked to critically evaluate the involved structures (institutions or rules/laws), and hence have the opportunity to propose better ones.

Thesis of Veikko Porra re knowledge and attitude

Thesis

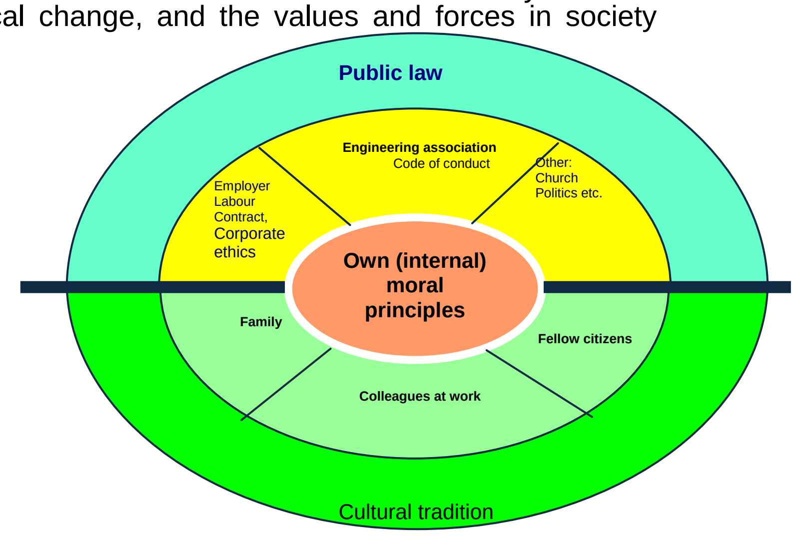
Teaching ethics to engineers should take the form of analysing the interests behind the codes of conduct.

Summary *of argument*

The imperative of sustainable development and the decay of techno-optimism have completely changed expectations on the professional role of engineers. In addition to the technical knowledge and skills engineers urgently need understanding and awareness of the long term changes in nature and society caused by technology. These changes are mostly non-technical and much more complicated than the technology itself. Therefore, revisions are needed in engineering curricula to strengthen the knowledge of engineers on human life, society, economics, and nature. The ethical keynote of engineering studies should be a balanced relationship between man and nature, and the equality of all people and nations in sharing the benefits of technology. The teaching of ethics should be based on understanding of the interests and motives of the institutions and people responsible for decisions on new technologies.

Arguments

The ethics courses usually begin with a discussion on philosophical ethics principles or the concept of ‘good life’. A different basis for ethics studies could be an analysis of the role of engineers in the technological change, and the values and forces in society controlling new technologies.



The starting point could be asking, what are the organizations and who are the people talking about ethics in engineering, and what are their interests in doing so [Porra 2004]. This approach would open a view to the multi-layer institutional system of modern society and to the roles of engineers in organizations.

The method proposed here could be called hermeneutical, because the moral norms are interpreted on the basis of authors’ intentions. Revealing the underlying values, interests, and mechanisms in society deconstructs the present well-established concept of engineering ethics. An analysis of the values and interests of the actors explains the purpose of the rules and clarifies their implementation in daily work.

‘Nothing is possible without men; nothing is lasting without institutions.’. The words of Jean Monnet describe the important role of organizations in our technological society. The organizations control the development of most new technologies, and the salary dependence of their staff incl. engineers increases the political power of organizations[Galbraith, 1983]. Most engineers are employed by either enterprises or public organizations serving the technical needs of society, and are members of some engineering association. Consequently, the interests of the employer organizations and engineering associations have a strong influence in the ethics of engineers.

The codes of conduct of engineering associations and the corporate ethics of the employers consist of external moral norms that an engineer is expected to follow in addition to his/her personal internal moral principles. All other social groups and institutions: family, colleagues, religious communities etc. have their own similar norms. The sanctions, honour and shame connected with all these –often conflicting – interests give moral guidance to every engineer during the career limiting the freedom to personal ethical decisions.

Implementation

Extensive obligatory undergraduate studies on human and social aspects of technology will be necessary to educate a new generation of engineers who are willing and able to carry social responsibility of their professional work and new technologies. Case studies and role plays are most suitable to illustrate and identify the actors and the responsibilities of the engineers in conflict situations.

Thesis of Christelle Didier

Thesis

Teaching “corporate social responsibility” (CSR) can be a good means to introduce ethics in engineering education. It enables a reflection on both individual engineering responsibility and collective responsibility (collective at the level of the company, or the profession, or the trade-union…), and it may contribute to link both levels.

Arguments

The definition of CSR given by the European commission, in 2001, is: “the voluntary integration of social and environmental concerns in the companies’ daily business operations and in the interaction with their stakeholders”. Why should we deal with “corporate social responsibility” in engineering education? The question is worth being asked in a context where acknowledged scholars in the field of management assess that CSR has nothing to do with ethics (Capron, 2006). Actually, this position reveals a misunderstanding of the ethical dimension of management (of any theory in the field of management). It also reveals a misunderstanding of the work of ethics, business ethics as well as engineering ethics. According to those scholars, ethics would concern exclusively business leaders’ attitudes and individual values and attitudes. And on the contrary, “CSR” would concern other socio-economic actors as well as the civil society. It would deal with much wider issues than ethics does. Actually, the focus on social responsibility has also been developed by many scholars in the field of engineering ethics (and taught by many teachers) since this discipline emerged in the 1980s.

Actually, the concept of engineering ethics seems to have various meanings, even in the United States where it was born. This range of definition may explain the misunderstanding of CSR scholars. In American literature, we can find at least five accepted definitions of engineering ethics:

1. A creation of standards of conduct to help solving moral problems. For Michael Davies, professional ethics is, a sort of wisdom that can and should to be transmitted: “ethical standards for engineers are like the other standards that they use, not discoveries, but useful inventions”.

2. A reflection dealing with the moral implications of judgments and decisions of engineers. For Robert Baum who was one of the pioneers in the 1980s, engineering ethics is not limited to the resolution of problems identified as being moral, but “deals

with judgments and decisions made by engineers (individually or collectively) that imply moral principles in one way or another".

3. A critical reflection about an official professional ethics. According to Louis Racine, Luc Bégin, and Georges Légault , the co-authors of the handbook Ethique et ingénierie, "… ethics plays a forecasting and critical role regarding a profession's official code of ethics". The situation in Quebec is of special interest because the professional code of ethics there is enforced by law.

4. A method of philosophical analysis of moral problems caused by engineering. For Mike Martin and Roland Schinzinger, co-authors of the textbook Ethics in Engineering, "… the issues of engineering ethics are greater than the moral problems engineers have to deal with". In this approach, engineering ethics concern not only engineers, nor even individual technical decision makers, but all people involved in technical decisions, all stakeholders.

5. An interdisciplinary reflection on moral problems that arise within engineering. Carl Mitcham prefers to place engineering ethics in the field of "science, technology, and society" studies (STS). He asserts that in our engineered world, engineering ethics is far from being just an engineer's affair. On the contrary, it is something everyone should think about.

If teaching engineering ethics may still mean in a few places learning how to apply a code of ethics to real situations, in most cases, it also deals with the consequences of engineering (designed and made by engineers but also many other people) in the world (the natural, material and human world). The ethical reflection on engineering practice will have to deal with social impact as well as environmental impact of engineering. Therefore, engineering ethics should cover topics that are developed within the area of corporate social responsibility and on the related area of sustainable development.

What has often been missing in the teaching of engineering ethics since the 1980s is due attention to the meso (company) and macro-level (law, political system). One of the reasons was that the early American teaching of engineering ethics has been focusing for a long time on the micro-level of ethics, addressing exclusively the ethical dilemma's as they may be encountered by the individuals. The hope was that these dilemma's could be handled through codes of ethics for engineers. On the other side, what is often missing today in the emerging teaching of CSR at the university is the focus on individual responsibility, and of the unavoidable ethical dimension of the concept "social responsibility". Engineering ethics (in its wider definition) may benefit from the actual interest of the economic and academic world for CSR. It may also improve CSR teaching by asking good questions.

Engineering students may analyze CSR reports and answer the question (as if they were employed there): how does my company's policy in relation to social responsibility (and sustainable development) changes the context of my own social responsibility as an engineer? How does it transform the constraints? Opens or closes spaces?

Engineering students may study some company's whistleblowers policy and ask the question: How does my company's policy toward whistleblowers widens or limits my chance to put forth my own social responsibility? to take the risk to express my disapproval when based on ethical considerations?

Engineering students may reflect upon general ethical issues of engineering and answer the question (example): How can I, as a social responsible engineer, take part to the decisions or reflections that will influence my company toward more sustainability (through my work team, through the hierarchical relationships, through a trade-union inside or outside the company, through a professional association that takes part to national discussion…?)

Implementation

The ideas developed in the above argument can be implemented in engineering education in several ways. We leave this issue for the reader.

III. Results of the brainstorm discussions about requirements to engineering curricula in view of preparing students for social responsibility

Below, written accounts of the brainstorm discussions in the Uppsala workshop are presented. For two of the three subgroups, running texts are available. These texts were prepared by Behnam Taebi and Henk Zandvoort on the basis of the flipovers that supported the plenary presentations by the subgroups in which they had participated. For the third subgroup (the one on “knowledge”) only the flipover text itself is available.

Knowledge

The knowledge-subgroup has reported in a condensed form which has been left essentially unaltered here below. The catchwords and phrases that follow can best be taken as indicators of the different topics that should receive attention in the engineering curricula. They do not usually indicate what exactly should be taught/learnt about these topics.

- Factors affecting the awareness of differences
- Based on competing values so students can make a choice:
    - individual versus collective
    - profit versus need,
    - state versus market and
    - growth versus sustainability.

- Level of organization/workplace (employees and managers)
- Different cultural and global contexts
- Role of engineering in different contexts
- Whistle blowing legislation
- Impacts of decisions on society
- Technical knowledge to make these decisions safely

Ability to:

- Decide on the most appropriate technology based on assessment of risk:
    - costs versus benefit,
    - to whom and
    - tragedy of the commons.

- Understand social, business and technical discourses
- What criteria do we use to evaluate the problem?
    - Philosophy of science
    - Argumentation and debate
    - Critical theory

Skills

An important learning goal that was considered in this group is the ability to identify the ethical issues and problems that will be encountered during the professional practice. The question is which skills are needed to identify such issues and problems and to deal in a responsible and appropriate way with these issues and problems.

The group emphasized the role of the engineer in the society and her influence on the public opinion. An engineer should be able to analyze and evaluate the broader context in which she performs her professional work, as that context has a large influence on the ultimate effects of that work. An engineer should also be aware of the constraints that surround the engineer’s decisions (e.g.: economic (cost) considerations versus safety, and more generally, the influence of the organization on professional decisions). A critical attitude is needed. That means that one needs to learn both to be self critical and to question *the rules or definitions of the games*. Students need also to know how to communicate ethical concern within organizations (“non-dramatic ethical issues”).

Students should also be prepared for active citizenship, which includes a responsible execution of their political rights and duties. It was remarked that engineers need to possess leadership skills, not merely as a professional but also as a citizen.

The group also considered the question how the skills identified above should be taught, i.e. how the learning goals should be accomplished. In the opinion of this group, stand alone courses are needed as well as proper attention through the curriculum, in which case studies are considered to be important.

Attitude

This group started from the consideration that it is the duty of the engineering schools to stimulate and facilitate the development of social attitudes of their students. Two main instruments were presented: service learning and active learning.

Service learning. The following examples of existing service learning activities were mentioned:
- Engineers without borders international: http://www.ewb-international.org/
- Engineers without borders USA: http://www.ewb-international.org/
- Engineers for a sustainable world: http://www.esustainableworld.org/
- Engineers for a better world: http://www.mines.edu/stu_life/organ/ebw/
- Engineering project in community service (EPICS): http://epics.ecn.purdue.edu/

Active learning. It was this group’s opinion that active forms of learning are desirable. Examples include case studies such as the Challenger space shuttle accident and the Chernobyl nuclear accident, as well as design projects, which may start already in the first year. Discussions of major societal issues related to technology are advisable; e.g.: nuclear power; Three Gorges dam (China). Such issues invariably involve trade-offs between different social values. It was also mentioned that a philosophical framework is needed in order to enable the engineer to identify and reflect on such value issues.

IV. Observations and reflections of SIG leader

Below, some observations and reflections are presented that relate to the outcomes of the brainstorm sessions conducted during the workshops. They take the results of both the Uppsala and the Eindhoven workshop into account. In addition, remarks are being made regarding the role of lifelong /recurring learning.

Observations and reflections on the workshop outcomes

Attitude

Observation. The participants to the workshops stressed that the teaching institution has an important role in instilling the proper attitude in the students: to stimulate their sensibility to ethical and social aspects and problems of technology, and to instil in them a readiness and willingness to act in order to solve, prevent, or at least diminish ethical and social problems related to technology. This point was an outcome of the Uppsala workshop, but it was particularly stressed by the participants in the Eindhoven workshop. Many participants considered this as a very important, perhaps the most important issue when it comes to preparing students for social responsibility. The participants were clear that "instilling the proper attitude" requires motivated teachers, and more than that, requires the active support of the teaching institution. The word "role model" was termed here. It was remarked that individual teachers can (and should) act as models for their students, but they also stressed that the consistent and active support of the teaching institution is a requirement.
Reflection. This consistent and active support of the teaching institution might perhaps take the form of an explicit, consistently sustained institutional code of conduct and of policy. Currently, there are not many institutions of engineering education that actively endorse an ethical or societal code. This distinguishes them from the professional organisations of engineers, which organisations very often have formulated codes of ethical conduct for their members, and also from many private companies, who increasingly publish ethical codes as well. A case can be made that the current ethical codes of the professional organisations or business companies are by no means sufficient from the point of view of safeguarding ethical and socially responsible behaviour. But at the least, the mere existence of these self imposed codes of professional organisations and of business organisations embodies an acknowledgement, from the side those who endorse them, that respecting the law is not sufficient for socially responsible conduct.

Skills

Observation. An issue that was often mentioned in the workshops is this. Skills like communication skills are a necessary requirement for engineers to effectively deal with ethical and social issues, and hence these skills need to be transferred during the engineering education.
Reflection. It could be conjectured that these skills to effectively deal with ethical and social issues are not essentially different from the communication skills that are considered more and more necessary in view of other aspects of the profession of engineers, and that for that reason are receiving more and more attention in the engineering curricula. However, this conjecture is up for testing.

Critical reflection and knowledge

Observation. It was stressed in various ways during the workshops that, in order to prepare the students for social responsibility, the educational programmes should stimulate and enable critical reflection by (future) engineers about the impact of technology upon society, and about the contextual conditions that may determine whether that impact is positive or not.[13]

[13] The importance of critical thinking was also stressed in the BEST report that was quoted in Section II above.

Reflection. Critical reflection requires, in addition to a (critical) attitude, also reasoning skills as well as relevant knowledge. Whereas the opinion of the workshop participants that students should be trained in critical reflection was quite strongly felt, the workshops have rendered only limited answers to questions like what should be important topics for critical reflection, what kind of (reasoning) skills should be transferred, and what kind of knowledge might be involved? Perhaps, more time and exchange is needed for a group of interested people involved in different aspects or parts of engineering education to arrive at shared and detailed answers to questions like these.

Specific needs and opportunities of lifelong / recurrent learning

While discussing the requirements to be imposed upon the engineering education, no differentiation was made during the workshops between the different stages of the engineering education and training. However, a strong case can be made that, for the teaching goals that were the topic of this SIG, recurrent and lifelong learning should play a special role. The following arguments can be brought up for this.

1. As soon as an engineer has graduated from his/her initial education track, he/she will as a rule be fully absorbed by the demands imposed by his/her job. As a rule, someone who wants to take a course on a topic that is not considered important by his/her employer, will have to find the time and money that are required to take the course at his/her own resources. He/she will receive no remuneration for such an activity, and will have to allocate some of his/her own leisure time for the activity, even if the job is usually fully absorbing and hence the leisure time barely needed.
2. On the other hand, a couple of years of practice in a real job in a real work organisation may enhance one’s sensitivity for the ethical and social aspects of engineering end technology. Hence people might be particularly receptive for post initial courses in this domain.
3. Finally, it may be argued that real work experience is even necessary as a proper background to reflect on some of the “boundary conditions” in which engineers do their work, and which in large part determine the ultimate effects of their work. One issue that can be mentioned here is (critical reflection on) the working of (hierarchical) organisations and how these organisations constrain the work of engineers.

V. Appendices

V.1. Data on thesis authors

BEST, Board of European Students of Technology, is a constantly growing non-profit, non-representative and non-political organization. Since 1989 BEST provides communication, co-operation and exchange possibilities for students all over Europe, aiming, thus, in assisting students to become more internationally minded and broaden their horizons. Towards this direction 76 Local BEST Groups (LBGs) in almost 30 countries are creating a growing, well organized, powerful, young and innovative student network.

Tom Børsen Hansen holds a M.Sc. in Chemistry and a Ph.D. in University Science Education. He is an External Lecturer at the Center for the Philosophy of Nature and Science Studies, Faculty of Science, University of Copenhagen and the Director of International Network of Engineers and Scientists' Projects on Ethics (http://www.inespe.org). He teaches philosophy of science and ethics to undergraduate and graduate science students as well as to high schools teachers. His research is currently directed towards clarifying the idea of "the socially responsible techno-scientific expert."

Eddie Conlon is the Assistant Head of the Department of Engineering Science and General Studies. He holds a Masters Degree in Sociology from University College Dublin. His interests include the sociology of work, industrial relations and the general education of engineers. His recent focus has been on educating engineers for social responsibility. He has also written and lectured on the Irish model of social partnership of which he is a critic.

Christelle Didier is Maître de Conférences en Sociologie, Département d'Ethique de l'Université catholique de Lille, Chercheur associé au Lasmas-CNRS, chercheur associé au Lem-CNRS.

Joep van Hasselt is the managing teacher for the courses that cover the societal context of the curricula in the Faculty of Applied Sciences of Delft University of Technology. He holds an MSc in chemical technology (Delft 1970). He became associated with the Delft University in 2003 after a career in the chemical industry. His current activities concern the operational management, but particularly also the development of the (coherence between the) courses covering entrepreneurship, process and product design, and ethics from the sustainability point of view.

Topi Heikkerö is researcher at the Center for Social Ethics, Department of Systematic Theology, University of Helsinki. He holds MTh (theological ethics and philosophy of religion) and MA (theoretical philosophy). Mr. Heikkerö is currently finishing his doctoral dissertation "Ethics in a Technological World." The dissertation aims at mapping the discussions on ethics and technology as well as assessing four major approaches to the thematic. He has participated in ethics teaching in the University of Helsinki and in Colorado School of Mines.

Veikko Porra is professor emeritus of the Electronic Circuit Design Laboratory of Helsinki University of Technology, Finland. He has for a long time been and is presently active in the Committee for Engineering Ethics of TEK, the Finnish Association of Graduate Engineers.

Behnam Taebi graduated from Delft University of Technology as an engineer in materials science. He works in the Philosophy department of the faculty of TPM of Delft University of Technology. He teaches ethics courses for several BSc and MSc programmes in engineering, and he performs a PhD thesis on technology and democracy: decision making about developments of nuclear energy.

Natalie Wagner is a sophomore in Economics and Business. She is the Undergraduate research assistant for the Hewlett foundation as well as the current President of Engineers for a Better World. She is originally from Boulder, Colorado.

Henk Zandvoort is associate professor in ethics and technology at Delft University of Technology. He did a master's degree in physical chemistry and in philosophy of the natural sciences, and a

PhD in philosophy, all at the University of Groningen. Between 1986 and 1997 his main assignment was at the Dutch Ministry of Education and Sciences, in a range of policy functions related to higher education and university research. He has been associated with Delft University of Technology since 1991. He teaches courses on ethical aspects of technology and engineering for different MSc programmes. His does research on conditions and methods for responsible and coherent assessment, management, regulation, and decision making regarding risk generating technological activities.

V.2. BEST report “Ethics in Engineering Education”

Author: Irene Mantzouranis, PhD student, National Technical University of Athens, Greece, and member of the BEST Educational Committee.

Abstract

BEST through its Educational Programme, run by the respective committee with the support of the Local BEST Groups, aims in providing a tribune of expression for the students of engineering education to bring forward their point of view in issues concerning their educational future. Ethics was one of the two subjects discussed in the BEST Symposium of Education that took place in Madrid the previous year. In the Symposium the current situation of Ethical courses in the European Technical Universities’ curricula was defined, while a general discussion on whether and in what form should such courses exist occurred. The outcomes reflected a set of guidelines not only about the course structure itself, but also on the characteristics a competent teacher should have and in which year could such a course take place.

1. Introduction

BEST, Board of European Students of Technology is a constantly growing non-profit, non-representative and non-political organization. Since 1989 BEST provides communication, co-operation and exchange possibilities for students all over Europe, aiming, thus, in assisting students to become more internationally minded and broaden their horizons. Towards this direction 76 Local BEST Groups (LBGs) in almost 30 countries are creating a growing, well organized, powerful, young and innovative student network.

BEST strives to help European students of technology to become more internationally minded, by reaching a better understanding of European cultures and developing capacities to work on an international basis. Therefore BEST creates opportunities for the students to meet and learn from one another through our academic and non-academic courses and educational symposia. “Learning makes the master”, but the final goal is a good working place, therefore services like an international career centre are offered, to broaden the horizons for the choice on the job market. BEST’s priority is to offer high quality services for students all over Europe. Thus, BEST strives to bring all the partners in the “student – company – university” triangle closer.

The Educational Involvement of BEST is the responsibility of the Educational Committee of the organization. The European Union and other Institutions organise programs in direct relation to the improvement of the quality and value of engineering education in Europe. The Educational Committee participates actively in such projects, and becomes a dynamic connection between the students of BEST and these projects. Results and contributions deriving from this participation have already been published and highly valued in both completed projects, such as E4, as well as on ongoing projects (e.g. TREE, ReVe).

The aim of such involvement is to give regular students the opportunity to share their ideas and visions on higher education and to get their voice heard at a higher level.

It should be noted, however, that BEST is a non-representative organization that does not produce political statements. Thus it acts only as the medium by which students as individuals are brought in contact with the process of change in education, and make their voice heard.

2. BEST Symposia on Education

BEST Symposia on Education are educational BEST events, where students are gathered to discuss educational matters, express their own ideas and point of view. The Symposia usually last for a week and are attended by twenty to thirty students and from different parts of Europe and representatives from EU educational projects, universities and/or from industry. In this way the heterogeneity of the participants concerning the educational background and knowledge is reassured. The themes discussed on Symposia usually reflect current topics, each one of them having one to two themes on which the participants are invited to focus. A Symposium consists of daily lectures, which are given by professors or other professionals, including often industry

representatives, working closely with the discussed theme, and then followed by discussion groups, where each topic is studied from various aspects, in order to bring up the different views of the participants. The conclusions and results of these discussions are then gathered and summarised into reports, which present the opinions of the participants and suggestions for further development and/or improvement that could be made concerning the topic at hand.
Besides the discussions on educational matters in order to give tips on its development, the events are also enriched with a social aspect in their attempt to gather and link together European students of technology and improve their knowledge of other cultures and the host country in particular. This is achieved through different social events arranged outside the official program of the Symposium. Thus intercultural connections are not only promoted through educational discussions but are also created in practice.
One must remember that the function of Symposia is not only to gather feedback from students and get different views on how to improve education, but a Symposium is also a channel to get students involved in the process of improving their own and their children's education, and send the important message to students that improvement on education is all the time done, although it might be hardly visible.

3. Outcomes

Thus, Ethics issues were extensively discussed during the Symposium on Education that took place in Madrid, from March 27th until April 2nd 2006. In the Symposium participated 21 students originating from 15 Universities situated in 14 different Countries. Besides the students-participants, 6 Professors, both from the local University and other Institutions, with expertise in the field contributed in the discussions, bringing consequently valuable input and arguments. The assembly was also enriched by four students that are members of the Educational committee of BEST, who undertook the task of facilitating the discussions, ensuring this way that the time was equally balanced, for every opinion to be expressed and debated on.
So as to assure a good quality event a number of preparatory actions took place: Students were selected to have a multidisciplinary engineering background, varying from freshmen to PhD level. Topic introductions were prepared and distributed to them before the event, for everyone participating to have at least a common starting basis. Furthermore, a session in the beginning of the Symposium was dedicated to introduce the subject to the participants, while during the event the experts and professors through case studies and discussions provided information to the participants on different aspects of Ethics.
It is widely agreed that the importance of engineers in today's society is great and obvious. Therefore, the ethical issues engineers are facing and the decisions they make influence society as a whole and consequently the discussion on ethics in engineering education is of big importance. What is more, when students reach to the level of higher education, their character and ethical values are in a great extent already shaped, so they possess a quantity of knowledge on ethics. The question that automatically rises is whether this knowledge is enough for young engineers. In this framework the participating students discussed about defining Ethics in general, presented the current situation of courses on Ethics in their universities, talked about necessity of Ethics in Engineering education and the ways it should be implemented in the educational system.

3.1 General Knowledge on Ethics

It has been noted that in today's life, people learn about ethics constantly, even without being fully aware of it. Society, religion, family, culture, media, traditions share each a part, of a different percentage though, in influencing each persons ethical beliefs. Although the awareness of ethics is of very high level, the level of knowledge of each person and every society is not the same. Also, common ethics are learned because of the factors mentioned above, while this is not the case when professional ethics are concerned. Additionally one should take into account the distinction between morals and ethics, ethics being the practical reflection of some morals. Morals are unconsciously learnt during childhood, but ethics are learnt while confronting with problems throughout a lifetime. Ethics as a field of study are universal, but the perception of ethical correctness differs in each culture. Moreover, ethics are changing throughout the years, as a result of the continuous changes in society.

3.2 Ethics in Current Engineering Education

The current university education, as observed in the discussions, has many different levels of Ethics enclosure in its curricula, varying from complete ethics courses to a total absence of the discussed subject. More precisely, there are universities that have a complete mandatory course on Engineering Ethics or Ethics integrated in other courses. In the latest case the material is often based on the will of the professor(s) responsible for the course. Even when Ethics are taught, the situation is often complicated, leading thus to bottlenecks in precisely defining the quality and quantity of such education:

- The course is elective and not all the students are taking part because of the big number of courses offered.
- The material is extensively theoretical, not focusing to real life situations, eliminating thus not only the appeal among students but also its necessity in the curricula
- Professors have an improper approach, making the course unattractive and tedious
- The methods that are used are inappropriate.

As pointed out from the information gathered, Ethics are not systematically included in the Engineering Education curricula in European universities, leading thus to inadequate results in terms of evaluating the Education in the field.

3.3 Ethics in Engineering Education: is it necessary and why?

The next step to continue the discussion was naturally the necessity of such education. It was noted, therefore, that such necessity emanates from the problems that engineers face in their daily professional routine. Consequently, them being critical about the information they receive is of great importance. Education in Ethics is thus expected to provide them more confidence when engineers are in need of standing up for their own opinion, resisting outer pressure if needed. Another aspect of their personality that could be further developed through practical and rich in examples ethical course is critical thinking. Hence, in everyday situations, the young engineers will be better equipped not only to solve dilemmas in a more appropriate way, as far as Ethics are concerned, but also the long-term consequences of engineering discoveries could be more carefully evaluated. It was remarked that Ethics play an important role in the situations, in which gaps in the legal system exist and every professional has to decide how to proceed further.

3.4 Implementation of Ethics in Engineering Education

Since a consensus was reached on the importance of Ethics in Engineering education the participants went a step further, seeking ways and ideas to implement Ethics in the engineering curricula. The idea of having a course on ethics was supported by all the participants, but not as an optional course. The existence of a compulsory course was more appealing. Furthermore, it was thoroughly discussed, how this course should look like:

- the course should give a direction of thinking that would make people more aware of their actions. By introducing a certain level of criticism, automatic behaviour would be excluded from decision making.
- a vivid interaction both between students themselves that enrolled to the course and between the students and the teacher should be pursued. In this way more ideas could derive and be discussed in class and more sharing could exist.
- the course should include: case studies, examples from real life combined with problem–solving methods.
- although theory and definitions are not so attractive to students, they should not be neglected, in order for students to acquire a solid basis.
- optionally the first contact with ethics should be before university, and it should refer to ethics in general and latter on professional ethics lectures should be taking place in university.
- the course should be as dynamic as possible, reflecting the dynamic change of the society throughout the years: as the time is changing the material should also change. It should be kept in mind that besides society also technology is under constant changes that should be also considered in changing the material.

Besides the design of the course, participants and experts debated also on the persons responsible for delivering such courses and came up with specific suggestions about suitable teachers:

- the person should not possess only theoretical knowledge but also a practical background, acquired by former working experience as an engineer or optionally by having attended special training sessions on ethics.
- cooperation among two persons would be ideal: an engineer with rich practical background in everyday situations and problem-solving capabilities an and philosopher more theoretically oriented.

One of the matters also discussed was the grading. It was noted that the existence of grading would increase the interest and motivation of students during the course. Nevertheless, the grade should not be based on a classical exam, but on the activities during the course and a final project.
Furthermore, concerning the placement of the course in the curricula, no agreement was reached on whether the course should be in the beginning or in the end of the studies. The two contradictory issues raised were that if the course is held in the beginning of the studies, the students will learn to act from the very beginning, whereas the existence of a course in the end of the studies would offer more to the better preparation of the engineer for his/her professional life.

4. Conclusions

There is a distinction between moral and ethics, as moral is something learned unconsciously and ethics is something learned by reflecting moral stands in the real world.
It is common ground that a big need exists for engineers to understand ethical issues that will occur during their carrier, especially as engineers are often the ones making discoveries and therefore need to stimulate the consequences of those. Furthermore, engineers have to stand up for their position and their opinion in ethically questionable cases. For these reasons the teaching of ethical issues should be included in the mandatory curricula.
In different universities the way ethics is taught varies from specific ethical courses, ethics being part in a number of technical courses to not having any ethical subject present. In cases where ethics is taught problems arise concerning competitiveness of teachers, and lack of practical examples. The goal of Ethical courses should be to promote and exercise critical thinking. They should be compulsory, dynamic and interactive, becoming thus more interesting and appealing to the student.
The teachers should not only have the theoretical knowledge to support such course, but also practical and technical experience as engineers. During the discussions there was no conclusion reached concerning the exact place of such a course in the curricula.
In summary and conclusion, the answer to the question “Should Ethics be included in the engineering education?” is becoming every time more obvious and the need for such education is indisputable. Therefore, the discussion should further evolve in finding solutions on the “how” and “where” ethical courses should be implemented in order to have a concise plan and agreement from all parties involved (students, teachers, professional engineers etc).