



COMPARING INSTITUTIONAL STRATEGIES FOR ENGINEERING ETHICS EDUCATION IN REGIONAL, NATIONAL AND EUROPEAN CONTEXTS

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ABSTRACT

This paper describes, at raw-data level, the results of a workshop at SEFI 2021 on “comparing institutional strategies for engineering ethics education in regional, national and European contexts”. It uses the curriculum typology of Goodlad. The results indicate the diversity of answers at the European scale for the ideal, formal, perceived and operational curriculum. Although there were some first contextual differences noticeable, the set of answers was too small to give an in-depth analysis, but it opens up a promising area for future research.

1. INTRODUCTION

Given the complex nature of engineering practice, artefacts and issues addressed by engineers, the provision of a solely technical engineering education is no longer sufficient for preparing graduates to provide services to the broader public. It is of crucial importance for engineering programmes to include ethics in their educational offer. The significance of professional ethics for engineering has been formalized beginning with 1989 in global accords, with the Washington Accord stating that graduates are expected to “apply ethical principles and commit to professional ethics and responsibilities and norms of engineering practice” (International Engineering Alliance, 2014). The emphasis of global accords on ethical and societal considerations in the practice of engineering is considered to have led to the establishment of engineering ethics education as a mandatory accreditation requirement in signatory countries, which in turn was linked to an enhanced presence of ethics in the

engineering curriculum in signatory countries [1]. At the same time, in many other national engineering education systems, professional ethics is not required for a degree, particularly beyond undergraduate degrees.

Based on existent studies and anecdotal evidence, there is a deep fragmentation of curricular approaches of Engineering Ethics Education [2]. The fragmentation and variation in how engineering ethics education is conceptualised and implemented is manifest along five major lines of enquiry: related to the goals of engineering ethics education, the method of implementation, the teaching and assessment methods employed, as well as in the coverage of issues [3].

There is a clear need to have more information on how this variation plays out at the geographical level as well on the reasons behind the differences in how ethics is implemented in different national contexts. Along with this, numerous challenges impact the implementation of ethics at the institutional level exist. The major challenges range from ensuring a systematic implementation in the engineering curriculum to staff expertise or balancing the insertion of ethics alongside other curricular elements. These challenges are often rooted in budgetary pressures, limited institutional resources for hiring instructors with an expertise in this area, insufficient space in the curriculum and lack of guidance [3: p16].

It is thus of high importance to analyse the contextual (institutional, regional, national, European) reasons behind this lack of emphasis on ethics education in engineering at the undergraduate and graduate level, as well as to map the individual or institutional views on the aims and purpose of engineering ethics education [should aim at]. The analysis should include skills needed in industry or valued by society, as well as the supporting arguments for the importance of ethics education.

The SEFI Ethics Special Interest Group therefore decided to organise a workshop as a first step to address this imperative. The aims of the workshop were (1) to map the institutional strategies for engineering ethics education considering the variety of regional and national contexts that make up the European engineering education landscape; and (2) to identify future next steps.

This workshop report describes the workshop set-up, provides the first results at raw-data level, and indicates possible next steps.

2 BACKGROUND

2.1 Institutional strategies for engineering ethics education

Several studies focused on the institutional strategies for engineering ethics education point to the uneven or deficient manner of implementing ethics (e.g. [1], [4], [5]). The study by Colby and Sullivan [4: p.330] analyzing 100 programs offered by 40 engineering schools in the United States revealed that few schools have “instituted systematic programs to educate for this broad sense of professional responsibility”. At the graduate level, Filush and Barakat [5]’s study covering most of the geographical

areas of the United States showed that only a very small percentage of universities had a full course or a subject of a course pertaining to professional ethics. These numbers reflect a deficit in the students' education on how to perform in a professional setting. In Ireland, a study analyzing the implementation of ethics in 23 engineering programmes highlights the unsystematic manner of implementing ethics, which is often regarded as a curricular “add-on” [1].

2.2. Goodlad

As a framework for the workshop on institutional strategies for engineering ethics education, we used the curriculum typology by John Goodlad [6]. This typology focuses on the role of the institution alongside the role of the teachers and the learning outcomes of the students by distinguishing different representations of a course or curriculum: the intended, implemented and attained curriculum. It is therefore useful also in engineering ethics education redesign [7]. First, a course is described by its intentions. Course designers and other stakeholders develop their ideals when thinking about the aims of the course (e.g. [8]). During the design process, course designers will make these ideals tangible by using their views of students writing up the plans in a course guide and its accompanying teaching and learning materials. These formal documents usually do not (and cannot) cover all original ideals. Next in the process, teachers will interpret the intentions based on their own perceptions. They do this based on the characteristics of the students, previous teaching experiences and contextual factors (e.g. [9], [10]). These perceptions will also affect the teachers' operationalization of the actual teaching and learning (e.g. [11], [12]). Finally, based on their backgrounds, earlier experiences and interests, students, but also others involved, will experience the course in a certain way and deviate in their learned outcomes [13], [14]).

Table 1. Overview of curriculum representation and form with explanation (based on [2]).

Representation	Form	Explanation
Intended	Ideal	Vision (rationale or basic philosophy underlying a curriculum)
	Formal	Intentions as specified in curriculum documents and/or materials
Implemented	Perceived	Curriculum as interpreted by its users (especially teachers)
	Operational	Actual process of teaching and learning (also: curriculum-in-action)
Attained	Experiential	Learning experiences as perceived by learners
	Learned	Resulting learning outcomes of learners

In the workshop, we focussed the intended and implemented curriculum to generate knowledge on the interaction between the institute and the individual teacher.

3 METHODOLOGY

3.1 Workshop structure

The workshop took place online on Monday September 13th 3:15pm-4:15pm CEST. Twenty-two participants were present during the entire session. They came from

Estonia, Finland (2), Germany (2), Ireland, the Netherlands (2), Norway, Portugal, Romania, Russia (2), Switzerland (2), United Kingdom (3), and two from outside Europe (East Asia and Sub-Saharan Africa). The workshop structure consisted of a welcome, intro of the model (10'); individually answering the questions and looking at answers of other participants (15'); break-out discussions in which participants were asked two questions ("Which differences, similarities, remarks or recommendations would you like to formulate?" and "Do you have comments or ideas of improvement for the questionnaire?") (20'); wrapping up in plenum discussing overall views; and inquiring about interests in next steps (15').

3.2 Questionnaire

In the questionnaire, we focussed on the "perceived" curriculum, as we ask teachers. But we also ask for (perceived) links with the ideal, formal curriculum on one hand and the operational on the other. Questions were deliberately formulated in an open way to probe aspects that teachers would see as important. We formulated: "The following questions are about how you perceive the discussed topics. Give answers to the following questions in your own words for as far as you know about it. Answer the questions in general, as a rough average of your engineering ethics education as a whole."

Table 2: Goodlad curriculum forms and related questions

Level	Question
Ideal	*What is the vision of your institute regarding engineering ethics education?
Formal	*How is ethics articulated in your institution's vision or objectives?
Perceived	*What do you personally try to achieve in your ethics education? *How do your technical colleagues see (the role of) engineering ethics education?
Operational	*What is according to you the most striking at your university in the way engineering ethics education is organised? (% of total program, number of students, what are the topics, support for experimenting, free choice for you or obligation, political influence or pressure, sufficient training, ...)

For the reporting of this workshop, we provide below our own intuitive observations and do not develop further methodologies to interpret the results. Participants provided their informed consent to use the results to further redesign the research and the questionnaire. In the reporting, although important for the discussion on contextual factors, we deleted countries to respect the participants' privacy in the reporting of this workshop.

4 RESULTS

4.1 Ideal Curriculum

To the question "What is the vision of your institute regarding engineering ethics education?", four groups of answers emerged. Few respondents indicated they did not know. A few indicated the vision on ethics is mainly related to accreditation. About half

of the group indicated there is little or no elaborated vision at their university. The other half explained some of the particular visions. (See table 3)

Table 3: Ideal curriculum answers.

What is the vision of your institute regarding engineering ethics education?
Actually, I do not know this.
Related to meeting NATIONAL benchmark statements
Competencies required by the national degree ordinance
Ethics is not something that is frequently mentioned as a priority or strength of the school.
Unclear vision. SDGs are very important. Not per se a clear view on what "responsibility" means
None at this moment. A discipline worth ignoring. We hope to change this state of affairs.
The institution's official mission and vision refers to the importance of ethical education for engineering students, taking into account the impacts and challenges of the future.
That all students receive support to learn to develop an 'ethical perspective' on engineering and technology
Implemented in a dedicated course of professional practice (1st year, all student groups) & across the curriculum, in policy courses, design courses, work practice and as a mandatory section of the BA report
Ethics and responsibility are considered as capabilities in order to make informed and morally well-justified decisions. These capabilities should be taught right from the start in engineering programs.
Typically, engineering ethics is divided between the mandatory disciplines (Bachelor Programs: Intro to Sociology (module "Professional Culture"), Intro to Philosophy (module "Ethical Theory"); Master Program: Philosophy of Science and Technology). A special course of Engineering Ethics is only included in a limited number of the recently accredited programs (e.g. Computer Sciences).

4.2 Formal Curriculum

To the question “How is ethics articulated in your institution’s vision or objectives?”, some state it is not or cannot be articulated. Most respondents refer to values that the university wants her students to have, like responsibility, integrity, openness, and respect; or they refer to important societal aspects as sustainability and diversity. One respondent’s university explicitly refers to digitalisation. (See table 4.)

Table 4: Formal curriculum answers

How is ethics articulated in your institution's vision or objectives?
It is not a part of our institution's vision/objectives.
As of now, the capabilities mentioned are not covered at all and are only about to be introduced as optional. The institution with which I am affiliated with is not in a position to make such teaching mandatory .
So far insufficiently operationalized from the national degree ordinance

Sensitize to the responsibility of the engineer
Sustainability and Gender Equity are named as strategic priorities for the school and we have a vice president responsible for these themes.
Through university values - 3 of which are confidence, integrity, responsibility ; our university "motto" is 'for the Common Good'; our new strategy (2030) is aligned to the UN SDGs ; desire for open access publishing.
as responsibility towards people and the environment , following the profession's standards of conduct
That our education should contribute for humanity and for a better future , for sustainability , for openness and respect
The vision includes educational goals around societal impact including ethics but ethics does not look very not pro-eminent in it
The expected educational outcome is "commitment to social responsibility, sustainability and diversity "
Our mission as a school is to: "Develop the next generation of engineers through relevant skills and life-long education to bring practical solutions to eco-societal problems ". The ethics is reflected in mentioning the impact to society. Relevant skills & life-long learning, reflects due diligence and responsibility as a professional.
It was only this year that the need for ethical education was debated in a body of the institution (in the pedagogical council). The debate was held with professors and students and resulted in a recommendation that, when there was any remodelling , the curricular plans would include ethical education. Currently, the curriculum plans for several engineering degrees are being remodelled, however, only the curriculum in electrical engineering has included ethics training in its curriculum.
It is one of the learning objectives of all curricula.
All bachelor programmes are offered ethics educations by the Ethics department as part of our modular education
We have a CDIO based learning outcomes syllabus where ethics is included.
Companion on the path of a digital future

4.3 Perceived Curriculum

To the question "What do you personally try to achieve in your ethics education?", some refer to the content of ethics courses or to understanding ethics itself and its relevance. Raising ethical awareness is mentioned by several respondents, as are moral or critical thinking and ethics for the design process. One respondent referred to the ethics of care in education. One respondent referred to ethics as a personal development. (See table 5.)

Table 5: Perceived curriculum answers

What do you personally try to achieve in your ethics education?
Include at least some ethics related content in the course I'm responsible for, mostly through topic specific ethics questions.

Students develop an understanding of how ethics can/ should influence the practices of engineers. Students develop the self-confidence to be able to advocate for ethical practice in their work and study.
a broad understanding of ethics (ethics as sustainability, policy, design, community engagement, safety a.s.o), awareness of considering the perspectives and characteristics of different groups in the design and decision-making process of engineering
Articulate the relevance of ethics to our students (it's not their favourite topic)
appreciation of the application of the principles.
Taking into account the short time I have for this training (about 7 hours) I try to raise awareness of the importance of professional practice with ethics and the ethical dimension of engineering (at a macro-ethical level).
raise awareness, change attitudes is what I hope for, but I remain "humble"
To make students ethically aware.
I try to develop an ability for moral thinking. To give students a moral tool-box: theories and concepts that are useful in their professional and day to day activities.
I try to enable students to analyze and consider moral questions in a self-determined way that is also well-founded in critical thinking.
Focus on practical ethical reasoning ; search for the " existential pleasures of engineering "
Train skills in making judgments including ethical aspects
The ability to identify ethical issues in complex situations and be able to reflect upon them and address them. Considered particularly relevant in relation to sustainability issues and so called wicked problems.
Student can recognize the ethical issues and seek for support internally or externally
Part of technological design , not derivative to it
To get students to think and include ethical thinking as part of the design process
Provide engineers in innovation projects with methods that enable them to evaluate and select their product ideas against an ethical, social and sustainable background.
I separate pedagogy (ethics of care) from the ethics that students should develop as a consequence of participation in the learning activities (dual imperatives of dominant global forms of ethics and local contextual communalism approaches to ethics)
To develop ethically minded engineers. I try to do that in the group design-build-test CDIO projects where they need to consider ethical design of their products and this is also reflected in their assessments as well.

4.4 Operational Curriculum

To the question "What is, according to you, the most striking at your university in the way engineering ethics education is organised? (% of total program, number of students, what are the topics, support for experimenting, free choice for you or obligation, political influence or pressure, sufficient training, ...)", some respondents

indicate it is not or not enough represented. Many respondents refer to the “embeddedness” of ethics in the curriculum. A few comments seem to target the organisation of the ethics program, such as based on CDIO or imbalances in different parts. Two respondents indicated ethics as a controversial topic, in providing it as a university or as a subject teachers want to avoid. (See table 6)

Table 6: Operational curriculum answers

What is according to you the most striking at your university in the way engineering ethics education is organised?
Ethics is so far not yet covered in engineering education at all.
It is not really organised . Some programmes (life science) include required courses. All have optional courses (mostly taught from philosophy perspective - not engineering) and some teachers integrate a bit into technical courses. But there is no strategic overview/ oversight.
Very little time and is not integrated across the curriculum in each year. Have it in first year and final year.
Right now completely underrepresented . We, SUB GROUP, try to integrate Engineering Ethics into the Curricula.
Opportunity to be more embedded is missed.
The fact that it is not part of the curriculum .
divide specialized local 'professional' ethics courses and a general ethics course
Very few courses have ethics integrated , those which do seem to mainly address research ethics (mostly from a practical point of view, e.g. doctoral courses)
Decentralisation . Unclear how different engineering programs include ethics
It is embedded into the large CDIO team-based projects (the design-build-make projects) where we run 4 throughout their degrees
Uneven divide : Large part (13%) of bachelor, but nothing in masters; A lot of room and finances for experimenting, support and training .
It is totally a free choice for us; our approach so far is about academic integrity.
All students address ethical issues from year one, but these sessions are too 'light touch' . I suspect they are not getting enough support to internalise the tools they need to think through ethical issues
too few people that feel comfortable teaching ethics /number of students and given the emphasis put on ethics in the vision statement
The need for ethical training is a very controversial topic that raises a lot of opposition: in some cases, because teachers think it is not necessary, others because they think it is totally ineffective, others because it steals space to teach technical-scientific content and others because they consider that ethical education should be included in the curriculum just to "feel good", but for that a discourse is enough and structured training with specific time and content is not necessary. In COUNTRY there are no official indications or recommendations either from the government or from the entities that oversee higher education institutions or engineering. This leads to a vacuum in this area which leads to a residual presence of ethical education in engineering courses.

The university has a philosophy department, but this **does not affect engineering studies**. In engineering ethics is not covered systematically in all curricula. It is compulsory for all in doctoral studies, but addressed just occasionally by earlier courses. New master's course includes a slice of ethics in computer science and electrical engineering.

4.5 Remarks on the questionnaire

As to the question “Do you have comments on the above questions if they would be used in a European-wide questionnaire?”, most respondents had no comments. Some respondents mentioned the individual perception of these institutional questions.

5 SUMMARY

The report of the workshop is a very first step. We are aware that the set of teachers participating in an SEFI Ethics Special Interest Group is very biased and that our questions give personal views of institutional issues. Nevertheless, it gives us first ideas of what possible answers to the questions can be and if the questions themselves are understandable.

We mapped the answers to the four questions. This gives first impressions of what people can answer. It already indicates the diversity of answers at the European scale for the ideal, formal, perceived, and operational curriculum. Although there were some first contextual differences noticeable (e.g., the role of national influence in UK and Norway, for example), the set of answers was too small to give an in-depth analysis. We therefore refrained from dealing with this here.

Participants showed interesting in continue to work on this. If you are interested in participating as well, feel free to contact g.bombaerts@tue.nl.

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