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How to Teach Engineering Ethics? A Retrospective and Prospective Sketch of TU Delft's Approach to Engineering Ethics Education

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ABSTRACT

This paper provides a retrospective and prospective overview of TU Delft's approach to engineering ethics education. For over twenty years, the Ethics and Philosophy of Technology Section at TU Delft has been at the forefront of engineering ethics education, offering education to a wide range of engineering and design students. The approach developed at TU Delft is deeply informed by the research of the Section, which is centred around Responsible Research and Innovation, Design for Values, and Risk Ethics. These theoretical approaches are premised on the notion that technologies are inherently value-laden, and as such contain the possibility of fostering or hindering moral values. Each of these approaches encourages students to take a proactive attitude with respect to their projects and profession, thinking creatively about – and taking responsibility for – how to both prevent harm and do good via the technologies they help develop. To explain how this is put into practice, this paper sketches a brief history of ethics teaching at TU Delft, outlines current activities, and presents future plans for Bachelor and Master's level engineering ethics education at TU Delft.

Key words: Ethics, Social responsibility, Philosophy of engineering education

“Whether we are to have a good society or a bad one is powerfully influenced by the technologies we develop and put to use. For that reason the role of engineers and technical professionals is crucial. They are intimately involved in maintaining key social patterns and in inventing new ones as well. In that work they become, in effect, unelected delegates and



How to Teach Engineering Ethics? A Retrospective and Prospective Sketch of TU Delft's Approach to Engineering Ethics Education

representatives of the rest of us, charged with the work of building basic structures of our social and political future."

(Winner 1990, 58)

BEST PRACTICES FOR ENGINEERING ETHICS EDUCATION IN THE 21ST CENTURY

With explicit intention or not, engineers shape much of our modern world. The decisions made about the design, use, maintenance, and disposal of products, services, and infrastructures have far-reaching individual, socio-political, and ecological ramifications. This means that engineering decisions require explicit ethical reflection. That engineering comes with a high burden of moral responsibility may appear to many as a truism explicitly acknowledged by most professional organizations in their Codes of Conduct. At the same time, the ethical responsibilities and choices intertwined with engineering are often grossly underappreciated or even willfully undermined (Herkert 2001). In part, this stems from the still fairly common tendency to frame "ethics" as something separate from the education and practice of engineering (Bucciarelli 2008), hence seen as a task for others, the non-engineers. Fortunately, more and more engineering education programs have started to embrace ethics education as an essential feature of engineering and design curricula. The core idea is to instill not just technical skills in engineering students, but also to foster awareness of, and responsiveness to, the ethical values and consequences at stake in engineering contexts.

By itself, this trend to understand engineering more comprehensively is a laudable one. However, with the growing acknowledgement that ethics *should* play a central role in engineering education comes the challenge of determining exactly *how* it should be designed and taught. How will engineering students develop the moral sensitivity, creativity, and decision-making skills to take up the social, environmental, and political issues that they will be required to address, solve, or at least work within? What types of educational materials, in terms of form and content, best prepare engineering students for the ethical challenges they will face in their chosen professions? What are the "best practices" of engineering ethics education?¹

For over twenty years, the *Ethics and Philosophy of Technology Section* at Delft University of Technology has been at the forefront of engineering ethics education, offering ethics courses, lectures,

¹ These challenges are also the central concern of the SEFI Special Interest Group in ethics (<https://www.sefi.be/activities/special-interest-groups/ethics-in-engineering-education/>) SEFI is *The European Society for Engineering Education* and "considered the largest network of engineering education players in Europe active since 1973" (<https://www.sefi.be/about/>).



workshops, and seminars across the university.² Over the years we have made various adjustments with an eye to the question of *how* to best implement ethics in engineering and design programs. While we believe these adjustments are steps in the right direction, we continually strive to improve our approach to engineering ethics education. What follows is a retrospective and prospective sketch of how we approach the goal of educating those “*unelected delegates and representatives of the rest of us,*” (Winner 1990, 58) who will co-shape the technologies of the 21st century.

ENGINEERING ETHICS AT TU DELFT: THEORETICAL APPROACHES

The Ethics and Philosophy of Technology Section was established in the 1990s to provide ethics education for all engineering programs at TU Delft. The Section consists of philosophers specialized in ethics and philosophy of technology. Many members of the Section have multidisciplinary backgrounds, combining degrees in philosophy with degrees in STEM, social sciences and arts. This facilitates members of the Section to collaborate with various stakeholders at TU Delft. From the start, the approach to engineering ethics education was based on two principles: it should be developed in close collaboration with the engineering staff from the respective programs and connect well with the students, and it should be based on state-of-the-art research in ethics of technology. These have remained the guiding principles throughout the years.

The research of the Ethics and Philosophy of Technology Section focuses primarily on Responsible Research and Innovation [RRI], Design for Values [DfV], and Risk Ethics. What unites these three approaches to ethics of technology is a rejection of the *value-neutrality* thesis of technology. This thesis holds that technologies are in themselves evaluatively neutral, and that only through human intentions and use can we meaningfully locate a technology's bearing on ethical values and consequences (Cf. Pitt 2011). By contrast, RRI and DfV maintain that moral values can be embedded in technologies, and that moral deliberation should be a fundamental procedural element at all levels of technological research, development, and governance. Further, it also opens up the possibility of situating moral values as design requirements (e.g., van den Hoven 2013; van de Poel 2013; van den Hoven et al. 2015; Doorn & Taebi 2018). As such, RRI and DfV reject the picture of ethics as an isolated sphere of reflection that only shows up intermittently in the engineer's activities (typically

² While most of our work in teaching is related to ethics of technology, we also provide courses in philosophy of science, engineering methodology and critical thinking, and scientific integrity (specifically for PhD candidates). For more information on our teaching visit: <https://www.tudelft.nl/ethics/>. Furthermore, our Section plays a major role in the integrity policy of TU Delft, which started with a “platform for ethics and technology” in the early 2000s and has grown into a complex, comprehensive integrity infrastructure: <https://www.tudelft.nl/en/about-tu-delft/strategy/strategy-documents-tu-delft/integrity-policy/>.



How to Teach Engineering Ethics? A Retrospective and Prospective Sketch of TU Delft's Approach to Engineering Ethics Education

after the fact, when something has gone terribly wrong). Risk Ethics, furthermore, emphasizes the intrinsically normative nature of the notions of risk and safety (Doorn & Hansson 2011) and foregrounds the importance of different stakeholders' ethical views on risk and safety (Roeser et al. 2012). Furthermore, Roeser has developed a framework to address the importance of emotional responses to technological risks as gateways to ethical considerations, offering a way of integrating emotional appraisals of all stakeholders in a way that grounds normative decisions (Roeser 2018). Risk Ethics underscores the ways in which decisions made during the engineering process that might appear innocuous and value-neutral in fact have profound impacts on different societal agents – impacts often not anticipated by the differently situated engineer, whose vision is itself often quietly shaped by feelings of unbridled technological enthusiasm.

In an educational setting, each of these theoretical approaches encourages students to take a proactive attitude with respect to their projects and profession, thinking creatively about – and taking responsibility for – how to both prevent harm *and* do good via the technologies they help develop. The questions we ask students are not limited to “Who is to blame?” but also, for instance, “How can we (re)design a system that is fairer, more inclusive, more sustainable, etc.?” This proactive approach to the engineer's individual responsibility, which aligns well with the engineer's creative problem-solving frame of mind, is also nuanced via discussions of different models of shared responsibility. This is often taught at a theoretical level via Ibo van de Poel and Lambert Royakker's textbook *Ethics, Technology, and Engineering: An Introduction* (2011), and also “lived” through various role-play exercises (e.g., Kroesen and van der Zwaag 2010; Doorn and Kroesen 2013), stakeholder analyses, and in-depth challenge-based learning exercises such as student project groups³. We consider these approaches the “signature” of ethics education at TU Delft. In the next section we go into more detail about how we have gone about implementing these approaches.

ENGINEERING ETHICS EDUCATION: IN PRACTICE

A Brief Overview of Ethics Teaching at TU Delft

In the late 1990s, all engineering universities in the Netherlands started to develop compulsory ethics education programs.⁴ At TU Delft, the gradual implementation of engineering ethics education was done by the Ethics and Philosophy of Technology Section in close collaboration with the

³ Some examples of the case-based exercises developed by TU Delft but also by the other 4TU universities are available in the online repository of educational resources of SURF: <https://zoekportaal.surf.nl/>.

⁴ These universities are TU Delft, TU Eindhoven and Twente University, and to some degree also Wageningen University, all members of the 4TU.Federation in the Netherlands.



engineering professors at other departments, who helped identify the specific ethical issues at stake in their fields of study, and frequently participated in the courses (e.g., as tutorial leaders). In most cases we developed stand-alone ethics courses tailor-made for a specific engineering program. We typically followed a fairly standard lecture-tutorial approach, though for reasons we discuss below we are moving away from this structure at the bachelor level. The lecture-tutorial set-up is useful for teaching engineering ethics for (at least) two reasons:

1. It provides a good structure for introducing students to various relevant ethical concepts and theories (via lectures) while also being able to delve into the details of specific discipline-relevant cases (via tutorials). Devoting a tutorial to the re-enactment of, say, the Challenger disaster, can avoid a concern raised by Winner (1990), namely that decontextualized case-studies can inadvertently contribute to the conception of ethics as a marginal, easily-dealt with subject matter. Instead, students can see and feel the multiple stakeholder perspectives in need of consideration, as well as the limits of individualistic conceptions of responsibility, when retracing significant moments of choice in the history of technology.
2. The tutorials also serve to make abstract theoretical approaches more concrete. Close engagement with concrete cases furthermore opens up critical reflection on the theoretical ethical approaches discussed in lectures. For example, a case that discusses the use of risk-cost benefit analysis can highlight hidden ethical assumptions in seemingly purely quantitative models, while also disclosing limitations of consequentialist approaches to ethics. In a similar vein, engagement with concrete cases can also give rise to questions about the real-life applicability of deontological approaches to decision-making for large scale societal problems, for which certain quantifying procedures may be unavoidable.

In short, the lecture-tutorial set-up can be used to confront students with engineering ethics as a complex, multi-faceted, and ongoing task. Ethical theory can serve as a useful – even necessary – resource, but no straightforward answers to ethical questions can be expected as new technologies can give rise to new ethical dilemmas, and they can also challenge ethical values or intuitions we once considered sacrosanct. At the same time, in our teaching we emphasize that this does not entail a relativistic approach, according to which “anything goes.” Rather, we emphasize that while some normative boundaries are (or should be) clear, there are also issues that are complex and context-sensitive, and therefore need to be examined from different perspectives – thus encouraging deliberation with others.

Current Developments: “Ethics 2.0”

While we have worked with stand-alone ethics courses for more than 20 years, over the last five years we have also started to develop a new approach. One of the main reasons for this transition



How to Teach Engineering Ethics? A Retrospective and Prospective Sketch of TU Delft's Approach to Engineering Ethics Education

is pedagogical, meant to do full justice to the idea that ethics is inherent to engineering and thus should – at least initially at the Bachelor level – be an integral part of the overall curriculum, as opposed to be taught in one seemingly isolated course.⁵ As such, we have been developing so-called *ethics learning lines* within various departments at TU Delft. These lines aim at fostering basic competencies in ethics (and philosophy of science, scientific integrity, and concerning diversity) for students. This is done by embedding ethics into the standard curriculum, connecting context-relevant cases with existing courses, cooperating with teachers of respective faculties, and using online teaching material.⁶ Once students have acquired a sense of the intertwinement of ethics and engineering, as well as some of the competencies needed to engage in ethical reflection and decision-making, they will (ideally) deepen their engagement with engineering ethics through thematic stand-alone courses in the Masters program.⁷ These courses are open to students from any faculty or programme of study, which allows students from different programs to work together on problems from different angles, in interdisciplinary ways. The thematic courses already developed tackle the following topics: climate ethics, water ethics, ethics of healthcare technologies, ethics of robotics, ethics of transportation, and ethics of technological risks.⁸

To further elaborate on our new approach to ethics, and also highlight some of the work that still needs to be done as we move forward, we will discuss next an example of an implemented ethics learning line. In the fall of 2015, our Section started the development of an ethics learning line in the civil engineering (CE hereafter) Bachelor program. Through a number of workshops and one-on-one meetings, representatives from our Section worked together with interested professors and lecturers from the first year of the CE bachelor. In what follows, we discuss the main steps that were taken and we give specific examples:

1. We discussed the six ethical competencies that, in the university's view, all engineers should have once they graduate from the TU Delft. These competencies are moral sensitivity, professional and social responsibility, moral analysis skills, moral creativity, moral judgement and decision-making skills, and moral argumentation skills.

⁵ The transition was also motivated by pragmatic considerations, namely the introduction of the Bachelor-Master structure in Europe after the Bologna declaration in 2002. Until 2002 there were no BA/BSc degrees offered at Dutch universities. Instead, students would follow a 4-5 year programme culminating in a university degree equivalent to MA/MSc.

⁶ For more details: <https://www.tudelft.nl/ethics/ethics/current-teaching-activities-at-the-ethics-section/ethics-teaching/ethics-20/learning-lines-bsc/>

⁷ This new approach was developed by our Section on request of the executive board of TU Delft and has been discussed with, and endorsed by, directors of education of all Faculties (schools) of TU Delft.

⁸ For an overview of the courses: <https://www.tudelft.nl/ethics/ethics/teaching-activities/ethics-teaching/ethics-20/> Some study programs may make more specific requirements, by limiting the choice for their students, or even prescribing a specific course. But our Section develops the courses in such a way that they are in principle open to all MSc students.



2. We identified suitable moments in the CE curriculum to embed ethics theory and assignments. For instance, the course “Construction Materials and Sustainability” encourages students to develop their moral judgment skills by normatively assessing the Dutch government's CO2-reduction measures.
3. We designed the specific exercises through which these ethical competencies were to be addressed. Skills like moral sensitivity and argumentation are, for instance, promoted in an exercise for “Hydrology” focused on the different stakeholders affected by the construction of a large dam or reservoir. Delving into its history, students discover the ways in which different stakeholders were impacted differently by the construction of a dam or reservoir, with values like safety, cultural heritage, sustainability, financial autonomy, and equality at stake. Students develop their moral sensitivity by immersing themselves in the perspective of one stakeholder and identifying the values relevant to them. They practice moral argumentation by defending their perspective and by responding to the perspectives of others in a lively roll-play debate.

It was the explicit ambition not to add too many new elements in the existing courses, but rather to make the ethical elements and choices that engineers encounter on a day-to-day basis explicit. It turned out that many ethical elements and deliberations were already present in the existing courses, but simply not labelled as such. - At the end of the Bachelor program students are asked to write a reflection on how they developed the six ethical competencies. As of September 2016, all students who start a CE Bachelor program are required to successfully complete the ethics learning line.

Although the ethics learning line was quite positively evaluated in the recent six-year accreditation of the program, there are still some challenges. Our Section is currently doing research (funded by the 4TU.Center for Engineering Education) on how to best implement and teach ethics in engineering (and design) departments.⁹ While anecdotal evidence indicates that students see the value of engaging with ethics throughout their bachelor trajectory, at the same time, student feedback suggests there is also plenty of room for improvement, both at the level of form and content. One of the challenges we have encountered is finding the right way to progress to a higher cognitive level of the six ethical competencies. Initially we opted for a pragmatic approach for the ethics learning line at CE. Exercises focused less on introducing robust ethical theories, but rather appealed to students' moral intuitions, to foster reflection on how ethical choices are implicitly operative in the CE context. This low-threshold approach was adopted both for the sake of the CE educators (who, with relatively little knowledge of ethical theories, were being asked to introduce their students to CE's ethical dimensions) and for the sake of the students, who, we expected, would be more inclined to engage with ethics in this practical manner. However, anecdotal evidence

⁹ See: <https://www.tudelft.nl/ethics/ethics/research-on-education/comet-4tucee-project/>



How to Teach Engineering Ethics? A Retrospective and Prospective Sketch of TU Delft's Approach to Engineering Ethics Education

suggests that many students actually prefer to delve deeper into moral theory. Figuring out how to balance this with the expertise (and desires) of their CE professors, and with time constraints, is one topic for our future research. Best practices concerning engineering ethics education, particularly for the learning line approaches, thus also entail a stance on how to “teach the teachers,” especially since many of these teachers themselves received their training as engineers at a time when ethics was (at best) seen as a marginally relevant matter. One approach we are considering is to use “blended” learning elements, making succinct lectures on ethical theory available online. We are also developing a database of case-based ethical exercises with our partners in the 4TU Center for Ethics of Technology.¹⁰

LOOKING AHEAD: TOWARDS NEW MODES OF ETHICS TEACHING

At TU Delft we continue to explore what forms of teaching and assessment are best suited for engineering ethics. It is our experience that a multiplicity of teaching and assessment methods are desirable and that a sole emphasis on language-based assignments, specifically essay-writing, might not be sufficiently responsive to “the engineering student’s” ways of thinking and learning. Ethical reflection can take on different shapes and occur through different media, and we take it to be our responsibility as educators to offer a maximally inclusive learning environment. One route we aim to incorporate in the future is the use of art-projects in our ethics teaching. We have already been exploring this in small scale art, performance, and film projects, and aim to find ways of scaling this.¹¹ Gamification is another method we suspect has great potential for getting students invested in the ethical dimensions of their work, and for fostering critical ethical thinking.¹² In short, identifying how our ethics exercises can be rigorous, as well as engaging and effective, is key as we move forward in our efforts to train future engineers to be responsive to the ethical dimensions of their profession.

Winner (1990) warned that the root cause of engineering’s ambivalent relationship to ethics can be traced back to how engineers are educated. At TU Delft we have spent the last twenty-plus years striving to answer this challenge, centered on the idea that ethics is not something “out there” but rather a core element of engineering education and practice. That has guided the inception and developments of ethics teaching at TU Delft, and will continue to do so as we strive to further improve the form and content of our ethics education in the years to come.

¹⁰ <https://www.tudelft.nl/ethics/ethics/current-research-projects-on-ethics-education/surf-project/>.

¹¹ See for example the course *Art, empathy and ethics*: https://studiegids.tudelft.nl/a101_displayCourse.do?course_id=48728.

¹² See for example the card game developed by students of the course *Water Ethics*: <https://www.delta.tudelft.nl/article/spelen-met-water-maar-dan-serieus>.



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