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Current issues and future directions in engineering ethics education

This paper reports on engineering ethics education (EEE)-related issues based on a comparison of three technical universities: Budapest University of Technology and Economics, Friedrich-Alexander University, and Istanbul Technical University. Besides the presentation of the current state of EEE, future challenges are also discussed.

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Introduction

This paper reports on engineering ethics education (EEE)-related issues discussed at the EELISA TechDiplomacy workshop in Budapest, October 26–27, 2023. After the in-person discussion, work was carried on remotely among the authors in order to cover additional topics and get more accurate information. Ultimately, this research paper was created in the field of EEE.

Besides the authors of this article, there were about three dozen people present at the workshop itself, ranging from senior academic staff through junior academic staff to PhD, graduate, and undergraduate students. Everybody in the audience had ample opportunity to contribute; audience input was, in fact, substantial, and we worked the feedback from the notes taken by several panelists into this report.

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Position in the curriculum

In this section, we provide an overview and compare the position and role of EEE at Friedrich-Alexander-Universität Erlangen-Nürnberg (FAU), Istanbul Technical University (ITU), and Budapest University of Technology and Economics (BME). Naturally, these three institutions are in no way representative of any group; however, the comparison is still worthwhile and some qualitative findings could be of interest to a wider audience.

At ITU, all science, technology, engineering, and math (STEM) students take a mandatory Introduction to Ethics course in the context of their related engineering program. For instance, students enrolled in the civil engineering program must take Introduction to Ethics in Civil Engineering in the first semester of their first year. The course earns them 2 ECTS credits and amounts to almost 6% of the overall number of credits they need to accrue, which is around 31.5 credits. This is a requirement of the accrediting body, ABET (Accreditation Board for Engineering and Technology); all ITU engineering programs must comply with ABET's standardization framework, which includes offering a mandatory introductory course on engineering ethics in addition to the elective courses.[1] Elective courses on ethics are, unfortunately, very limited, with just one available for 4 credits.

[1] Criterion 3 (Student outcome), Article 4: "an ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts." https://www.abet.org/accreditation/accreditation-criteria/criteria-for-accrediting-engineering-programs-2023-2024/

Although higher education institutions (HEIs) tend to approach EEE by means of a specific course dedicated to the subject, we should also take into account the ethical dimensions of other courses in a typical engineering curriculum. For example, how does a statistics or research methods course approach ethics? Does it emphasize the fact that science is falsifiable and that the research findings must therefore be shown to be reliable and valid, in such a manner that the researcher can be held accountable?

At BME, there is no universal approach to EEE. In a few curriculums (e.g. civil engineering, human-centered artificial intelligence [AI]) it is mandatory and tailored to the needs of the given discipline. For others it is elective and just one in a sea of over 100 elective courses, on subjects ranging from art to craftsmanship.

At FAU, none of the BA study programs we reviewed includes an explicit ethics module or a significant discussion of ethical topics within the existing curriculum. Similar to BME, the ethics courses and modules at FAU are elective only, i.e. optional, meaning that only a fraction of the students take these classes.

Paths to morality

Regarding the uptake of EEE, there are several crucial questions to discuss. One relates to the timing of such courses. Introducing students to ethics early in their studies (i.e. in their first year) would provide them a better framework on which to hang the rest of their engineering knowledge. A potential downside, however, is that looking at engineering ethics so soon is just too decontextualized; a later-stage engineering student with a related job or internship experience may be more sensitive to the pressures of the engineer's professional life and thus more open to ethics that may offer a framework for handling that pressure.

We want to emphasize that EEE should be embraced through a holistic approach to the overall education ecosystem. In other words, the issue of teaching engineering ethics could be approached much more simply be introducing ethical discourses in earlier stages of education. For example, ethics courses could be offered as part of secondary education and would then constitute a first layer for an ethical foundation of engineering practices. However, due to the lack of a consistent ethics education on the secondary level - except again in the context of electives - throughout the countries with EELISA association, this approach will not have any practical relevance in the foreseeable future.[2]

As we touched on earlier, the subject of engineering ethics should not be taught only through dedicated for-credit courses; ethical dimensions should also be stressed consistently in related courses across the curriculum. If we enable EEE to transcend the boundaries of specific "Ethics" courses, and to become part of all related courses, it will help students to compile a better overall understanding regarding their roles and responsibilities as future engineers, scientists, or scholars. This approach, of

[2] e.g.: School education in Germany is exclusively federally regulated, which results in 16 very diverse curricula.

course, will require renewing and rekindling academics' interest in teaching ethics, but this could be achieved by universities establishing teacher training programs for "teaching ethics in the digital age."

Another interesting question pertains to the issue of formal versus informal EEE. Do students need to participate in actual classes (formalized setting)? Perhaps, instead, they could enroll in Engineers Without Borders or undertake some community coaching. An advantage is that these charitable activities would not require any curriculum design, though they would still require an active on-campus life where students could be recruited. Furthermore, in today's highly competitive educational landscape, such extracurricular activities will most likely be considered a unnecessary luxury or time-consuming disadvantage, or just attract students, which have enough financial and timely resources to be able to afford them.

In terms of what motivates ethical conduct in engineering, we found that, besides internal morality drivers, compliance with regulations is an important external motivation. That is, ethics codes and regulations — the need for explicit ethical considerations in research and development — generate a demand for formal education. While regulation and compliance requirements help the EEE mission by providing a way in to the curricula, external pressures may be handled by a list of dos and don'ts, checklists, and other superficial methods that have long been known to be lacking as a basis of moral education. An example here would be the so called „Green Washing" of technologies and technology related practices, where marketing oriented methods like framing, wording and story-telling-techniques are used, to purposefully imitate ethic driven developing practices, without introducing ethical concerns in concrete practices.A provocative question that summarizes the problem of sustainably anchoring ethics in engineering studies could be: Can a society even afford to forgo a comprehensive ethical education for engineers when their work is having an increasingly extensive and profound impact on society, be it in AI research, robotics, algorithmic control and many other disruptive technologies?

Content

We found that a wide variety of approaches are in use when it comes to selecting the content of EEE. For instance, at BME the engineering ethics class begins with a meta-ethical overview that explains moral realism vs. anti-realism and consequentialism vs. deontology (Pettit 1989). This is followed by an introduction to the concept of divine command theories, without focusing on any religion in particular. Kant/Kantianism and Utilitarianism come next, after which moral anti-realism is exemplified through the social contract theory of Thomas Hobbes. Responding to contemporary anxiety, Just War Theory (Elshtain 1992) and the moral basis of the Geneva Conventions (Meron 1987) are explained. Finally, the discussion turns to cognitive biases, social pressures, conformity, and other potential obstacles to moral deliberation. The class uses engineering issues and case studies all the way through, as examples of various moral theories in practice. This course thus reflects the view that engineering ethics is just contextualized general ethics, rather than a subject with its own meta-ethical place.

The BME course on the ethics of AI is more focused. For instance, it looks at technological lock-in and, to some extent, technological determinism vs. social control (Héder 2021); the more epistemological issue of explainability (Héder 2023) and transparency; the responsibility gap and the bystander effect, exemplified through Peter Singer's work (Singer 2016); and the bias and/or fairness of algorithms, supported by *Justice as Fairness* by John Rawls (Rawls 2001). Social contract theory is also covered here in the context of whether new technologies require new social contracts and how these should be constructed. Finally, the course explores "the Machine Question" (Gunkel 2012), that is, the moral and social status of AI agents and possible ways of thinking about that; and the European Union's (EU) draft AI Act , together with the IEEE's (Institute of Electrical and Electronics Engineers) ethics standards on AI (7000-2021 and P7001; see Winfield 2021). A clear issue with both of the BME courses is that they are clearly Western-centric.

What is the difference between generic ethics and engineering ethics?

To answer this question, we should perhaps ask another: is technology — or, in this case, engineering — an end in itself or does it serve a higher public good? Is it a means to an end, or is engineering/technology an end in itself? In this sense, the most specific thing that differentiates engineering ethics from generic ethics is the emphasis on this intricate "end vs. means" issue in engineering and technology. We argue that engineering ethics embodies an innate obligation to or responsibility for the public good. However, this ethical standpoint poses a puzzle. With the today's unprecedented technological advances, engineers are much more capable of *doing*; *tekne*, derived from the Greek word for craft or art, can be understood in the context of this paper as engineering. However, there is a gap as regards how engineers can fulfil this expectation in society. In other words, the technology is advancing so rapidly that research on the means, actions, and codes of conduct by which engineers can fulfil their responsibilities in such a manner that they improve the well-being of the public is lagging behind. At least this is the case if ethics is limited to a very narrow understanding of objectively applied ethics in the manner of the dos and don'ts mentioned above.

Thus, there is an expectation vs. capability gap, and it is this gap that could be closed through a thorough EEE that constructs the necessary imperatives to delineate an ethical framework. Although this discussion sounds abstract on first hearing, it can be reified. One way of doing this might be the Capabilities Approach (CA) developed by Amartya Sen and Martha Nussbaum (Alexander 2016). CA purports that rather than predefined well-being conditions, there are constituent conditions for developing public well-being that can be identified. In this sense, the Sustainable Development Goals (SDGs; Katila et al. 2019) adopted by the United Nations (UN) in 2015 as an action framework for our responsibilities to end poverty, protect the planet, and maintain peace and prosperity, which are to be fulfilled by 2030, can be considered and defined as a framework that delineates the conditions for achieving the well-being of our societies and dignity for all livelihoods on the planet.

In addition to the issue of the gap between expectations and capabilities, we also need to engage in a fundamental epistemological discussion about the nature of technology itself. In his highly influential essay „Die Frage nach der Technik" („The Question Concerning Technology") originally written in 1955, Heidegger states: „So ist denn auch das Wesen der Technik ganz und gar nichts Technisches."[3] (Heidegger 2000, p7). So, the idea of technology as a mere means to an end or even a tool with a particular purpose is highly questionable and maybe even dangerous: *„Am* ärgsten *sind wir jedoch der Technik ausgeliefert, wenn wir sie als etwas Neutrales betrachten; denn diese Vorstellung, der man heute besonders gern huldigt, macht uns vollends blind gegen das Wesen der Technik*."[4]

Technology at large, and especially engineering, is dealing directly with this two-sided aspect, the perception, or rather ideology, of technology as objective artefacts supposedly outside of society and the deeply social nature of technology itself. Heidegger's characterization of technology "as a frame" (Gestell) (Heidegger 2000, p20), as an enhancement of the body, but also as a skeleton reflects on the deeply interwoven relationship between humans and technology: Technology reaches within the user, especially the creator and carries with it much more of its world views, biases, needs and self-stylization, which in turn is influenced by the ideology of neutrality (see: Horkheimer 1947)

It has to be noted, that Heidegger developed his view on technology in discussion with Ernst Jünger, especially as a reflection to his work "Der Arbeiter" ("The Worker"; see Schwarz 1967). In Jünger's conception of it, the machine is also not at all a means to an end for a specific, rational task; rather, it is a tool to overcome the limitations of humans (which only refer to men). Jünger's workers were identical with soldiers, who serve a higher calling far beyond their concrete tasks and intentions. To take something of a provocative standpoint, we could argue that the "means to an end" aspect is negligible in comparison to the ideological value of technology as a way of the fulfilling for the "Übermensch" ("more man"). This aspect may be studied further in relation to the idea of technological solutionism (Morozov 2013) and the dark enlightenment movement (Peter Thiel 2015) or the different branches of the transhumanists movement.

As a concrete method regarding the practical application of EEE, the practice of engineering should always be reflected in terms of its potential implemented higher purposes (societal bias, political agendas, personal gratification, other forms of "higher callings") in relation to the public good. Cara Daggett's work on the concept of "Petro-masculinity" is a prime example for a supposedly "objective" technology trajectory, which rather feeds on ideological then technological necessities (Daggett 2017).

[3] „So the essence of technology is nothing technical at all" (own translation)

[4] „However, we are most at the mercy of technology when we regard it as something neutral, because this idea, which is particularly popular today, completely blinds us to the essence of technology." (own translation)

Current challenges and a constructivist approach

Teaching engineering ethics is complex and multifaceted, composed of different norms and ideas that work at different levels. Therefore, to be analytically facilitative, we would like to offer a toolkit based on an agent–structure model, with reference to social constructivism, so that we can unravel the existing challenges in the discipline of engineering ethics.

The word *agent* in this context refers to the actors that carry and transmit the ethics and responsibilities inherent in engineering, science, and technology — these include learners and teachers, HEIs, regulatory organizations, intergovernmental bodies, supranational bodies, the UN, the EU, companies, entrepreneurs, etc. These actors operate within a structure — the structure is the education ecosystem — that is in a mutually constitutive relationship with other agents. Hence, we embark from a constructivist point of view, by emphasizing this agent–structure relationship to identify the challenges we currently face at the agent and the structure levels.

First, at the agent level, the main challenge here is creating the appropriate pedagogical approach so as to break the resistance of STEM students to ethics, rekindle their interest, and make EEE a part of sustainable higher education. A related challenge pertains to EEE methodology. We need to construct a revised disciplinary understanding among academics as to the design of ethics courses and ethical dimensions across curriculums.

Second, at the structure level (i.e. in relation to higher education or a similar learning milieu represented by formal and non-formal learning systems such as universities, nongovernmental organizations [NGOs], engineering associations, companies, etc.; engineering programs and other undergraduate, graduate, and PhD-level programs are also considered structures), the key concern is curriculum design. When and how should ethics be integrated into programs and what weight should be given to it? The HEIs' current vision on ethics and the learning objectives and learning outcomes of programs and assessments needs to be coherently and consistently revised. It could even be beneficial, if tools and platforms could be created, which bypass traditional pathways of education, for example, an interdisciplinary certificate that is accepted across the board, at least in the EU realm. As a result, we could argue that the main challenge is to come up with a clear conceptual foundation to underlie EEE, based on an innovative learning approach. EEE needs to be revised from a sociotechnological angle, if we are to face the challenges of the current Anthropocene era that we are living through, emphasizing that human actions have a dominant impact on our planet.

Curriculum extension in the future

There are several emerging topics to consider for addition to these curriculums. In order to include non-Western approaches, Ubuntu (Ujomudike 2016) ethics and Confucianism (Yao 2000) could be integrated. An increased emphasis on the Frankfurt School and on virtue ethics would not go amiss. Also, to enrich the curriculum with modern, internationally grounded theories, the CA (Akire 2005), mentioned earlier, could be introduced.

In terms of delivery method, the big post-Covid question, of course, is what role online elements should play in EEE. Here the workshop panelists aired their concerns about whether EEE is suited to online education, while also emphasizing that remote access might have an important role in removing barriers to EEE.

Online education is not fundamentally incompatible with EEE, and we could argue that we have an obligation to make it accessible for everyone. But we also believe in the power of public deliberation. With reference to Habermas, deliberation among equals by means of logic and reason helps to ensure legitimacy as regards the responsibilities of engineers.

Another direction to explore is whether there are different expectations from the different generations (Z and alpha) in general, and in relation to online content in particular.

Development of EEE has been rather slow so far because engineering is considered to be normatively neutral or amoral; thus, EEE is unnecessary. One of the most crucial aspects that needs extension is a sociotechnical orientation in engineering curriculums for ethics. There is a need for engineers to understand the ethical responsibility that accompanies their practices while they undertake research and innovation. This can be elaborated by focusing on challenges from the real world in cooperation with relevant stakeholders. One solution to this might be to adopt the principles of challenge-based learning for EEE, based on real-world issues/problems. To undertake such an approach, however, the instructors/tutors would first need to be trained. Thus, HEIs should develop a “training of the trainers” program to cover ethical, sociotechnical, and politico-ethical issues within a broader understanding of engineering training in order to be open to professionals, educators and scholars alike.

Another opinion calls for a more radical change in engineering studies. The field of engineering and the creation of technology must be understood as a highly normative endeavour as it has already been discussed above. Therefore, the normative aspects must be the foundation, not an expansion of engineering and technology studies; otherwise, students may not acquire the ability to critically reflect on their work as embedded in specific values, viewpoints, and ideologies. In this sense, engineering could not be engaged outside of ethical and social imperatives.

On TechDiplomacy

From a critical perspective, a reflection on the history and the methods of TechDiplomacy should be an integral part of any ethics curriculum in all engineering and technology-based studies. Not only is TechDiplomacy a “hot issue” in the contemporary, global struggle for talents between the old and the new superpowers in the *informatization age* — particularly in relation to the US, Northwestern Europe, the former Asian Dragons, China, India, and the rest of the BRICS alliance (Brazil, Russia, and South Africa) – but, with topics like intellectual property, standardization and safety regulations, and the potential of new bi- and multilevel collaborations, TechDiplomacy is also a critical means of so-called soft power. Added to this, the materialistic and geopolitical aspects of technology, like the mining of rare materials, are interlinked with TechDiplomacy, especially in the post-colonial regions, where most of these resources can be found. Regarding the exploitation of brains and ores alike, ethics is at the centre of TechDiplomacy and, therefore, of engineering in a global world.

Another approach to TechDiplomacy is to revisit Marcuse's (1941) account of the implications of technology and how "technocracy" could enlighten our efforts to rekindle interest in EEE, in addition to Arendt's (1958) account of the instrumentality of technology.

Concluding remarks

Perhaps this quote from "Some social implications of modern technology" (Marcuse 1941) is at least an interesting remark on the illusion that technology is a "neutral" force for the enlightened development of all humankind: "*Technics hampers individual development only insofar as they are tied to a social apparatus which perpetuates scarcity, and this same apparatus has released forces which may shatter the special historical form in which technics is utilized.*" It emphasizes that technology can be seen only through the eyes of the society that created and utilizes it.

In reflection of the previous discussion documented in the essay, EEE could not only be a add-on to engineering education. If we take the (ethical) challenges of a rapidly transforming VUCA[5] world seriously, we not only need technology that can deal resiliently with challenges such as climate change, pandemics, social inequality and military conflicts, but also engineers who can deal resiliently with the ethical challenges posed by authoritarian competitors and human rights issues.

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[5] VUCA is an ancronym mainly used in military and management enviroments. It stands for volatility, uncertainty, complexity und ambiguity and is regarded as a main driver for adoptive innovation.

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