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THE PURPOSES OF ENGINEERING ETHICS EDUCATION

Qin Zhu, Lavinia Marin, Aline Medeiros Ramos, and Satya Sundar Sethy

Introduction

Engineering ethics, as a field of applied and professional ethics, assumes an essential role in forming professional identity and the everyday decision-making for engineers. Clearly articulating and rigorously assessing the purposes of engineering ethics education (EEE) constitutes the foundation of successful engineering ethics programs. Furthermore, understanding the purposes of EEE is critical for all stakeholders involved in engineering education, including engineering students, instructors, engineering programs and institutions, employers, and accrediting bodies.

For instance, understanding the purposes of EEE can be a catalyst for actively involving students in the learning process. This aligns with research in the field of learning sciences, which emphasizes that students are most receptive to knowledge when they clearly understand their learning goals and expectations (Dotson, 2016). Moreover, the capacity to design more impactful, pertinent, and engaging learning experiences for students hinges upon instructors' understanding of the underlying purposes of EEE (Liow et al., 1993). Within the realm of engineering programs and institutions, a comprehensive understanding of the purposes behind EEE establishes a normative framework that shapes the outcomes and purposes of engineering education.

EEE has become central to most undergraduate engineering programs across the globe. When considering teaching engineering ethics to undergraduate engineering students, the question arises regarding its *modus operandi,* which includes whether an engineering ethics course is to be offered as an elective or a core module/course for an engineering program, what the learning objectives are, who shall teach engineering ethics, how engineering ethics shall be taught, and what assessment and evaluation methods should be used to evaluate students' learning. Researchers across the globe have been discussing these questions in their works. Hence, it is crucial to address these questions in this chapter as they are foundational for discussing the purposes of EEE.

A major contribution of this chapter is to construct a conceptual framework to systematically describe and compare various approaches to the purposes of EEE. It is worth noting that such a framework is inherently embedded with a tension between a normative approach and a pragmatic approach to the possible purposes of EEE. A normative approach is primarily interested in what the purposes of EEE should be. Starting from the risks and harms that engineering as a profession can give rise to and from asking how engineers can help make the world a better place, this

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approach posits first the ends of EEE without concern for the actual means of achieving them. If the ends are clear, then the means will follow. The other approach is pragmatic and starts from the question 'What can be achieved through educational practice?' This approach considers what has been done already and the limitations inherent to any educational endeavor: time, energy, and resources (material and cognitive).

The normative approach concerns what these purposes *should be*, given the needs of the engineering profession and of society at large. The pragmatic approach concerns what these purposes *are*, in educational practice and in policy making. Such descriptive formulations usually follow complex negotiations between multiple stakeholders and will be different based on each country's own priorities. The normative approach is one in an 'ideal world' scenario, while the pragmatic one is the result of 'actual world' situated outcomes of negotiations between the stakeholders. In order to differentiate the normative from the pragmatic approaches – and to show what these have in common – we will use a conceptual framework that illustrates the wide range of these purposes, strictly philosophically speaking.

Following this introduction, this chapter will address three key themes. First, before we delve into the purposes of EEE, we discuss some fundamental questions about the nature of the purposes of EEE. These questions have been extensively discussed and debated in the EEE literature and are interrelated. The question of whether engineers' moral actions should align with their personal morality or adhere to professional ethics is pivotal for establishing the legitimacy of the field of EEE. This consideration significantly impacts the purposes of EEE, or what we, as engineering educators, expect our students to learn about engineering ethics. Such a question is also connected to another critical question in EEE: whether engineering ethics is teachable. If engineering ethics is merely an application of personal morality in engineering, then since students arrive in undergraduate classrooms, either we have little to teach them about personal morality or we cannot teach students about engineering ethics (as personal morality is closely linked to an individual's early developmental stages, it is inherently shaped by their foundational beliefs established during that period) (Abaté, 2011; Harris et al., 1996; Veach, 2006). Alternatively, if engineering ethics is construed as professional ethics, encompassing "special morally permissible standards of conduct that every member of a profession wants every other member to follow" (Harris et al., 1996, p. 93), then it implies that not only is engineering ethics a subject that can be taught, but also that understanding it requires more than an individual's personal experiences. Finally, whether teaching engineering ethics is about developing ethical knowledge and skills or developing moral habits is crucial for discussing the purposes of EEE. Further deliberation on this question extends to exploring the diverse purposes of EEE, which are captured by a conceptual framework in the following section.

Second, to capture the diversity of purposes of EEE, we constructed a conceptual framework comprising six approaches to understanding the purposes of EEE: knowledge, personal traits, actions, values in artifacts, relations, and ecosystems. Arguably, the foundational assumption of individualistic rationalism underpins the first four approaches, which perceive engineers as entirely rational and autonomous individual decision-makers (Zhu & Clancy, 2023). Moral engineers are thus those who are capable of developing moral knowledge and behavioral tendencies in engineering practice or creating technologies to exert positive moral influences on society. Conversely, the remaining two approaches adopt a holistic perspective, emphasizing the interconnected nature of the world and the impact of engineering practices on this interconnectedness.

Finally, we discuss normative analysis via two normative yet practical questions: 'Who should teach engineering ethics based on this wide variety of purposes?' and 'Who gets to decide on these purposes in practice, namely, who are the stakeholders involved in these decisions?'Both of these questions bear social and political relevance, as the qualifications, background, and disciplinary training of individuals qualified to teach engineering ethics play a pivotal role in shaping their understanding of engineering ethics, encompassing the purposes of EEE, and influencing how ethics learning outcomes are formulated (Barry & Herkert, 2015). Furthermore, more recent research has shown that decision-making concerning EEE is a socially constructed process, entailing power negotiations among diverse stakeholders (Martin et al., 2021). In recognition of the socially constructed nature of EEE and engineering education research, we begin by describing our positionality as a team of authors.

Positionality

The positionality of each co-author of this paper is shaped by our own set of personal and professional experiences. Qin Zhu is an associate professor of Engineering Education at Virginia Tech. Trained as both a materials engineer and philosopher in China, and later transitioning into the role of an engineering education researcher in the United States, he has adopted a cultural and critical perspective. From this perspective, he explores values, norms, and cultural assumptions embedded in the professional formation of engineering identity and the development and deployment of technologies, such as artificial intelligence (AI) and robotics. Lavinia Marin is a Romanian philosopher working in the Netherlands at TU Delft. In addition to her philosophical background, which is predominantly informed by the Western canon, Lavinia was trained as an electrical engineer and has worked for several years in a large state-owned company in Bucharest, Romania, which informed her vision on EEE goals in practice. Aline Medeiros Ramos is a Brazilian philosopher who received most of her postsecondary education in North America (New York and Montreal). She is now based in Canada at Université du Québec à Trois-Rivières. She specializes in medieval philosophy and ethics and has a background in classics. She teaches courses on the history of philosophy and professional ethics, primarily to engineering and medical students. Satya Sundar Sethy is a professor of Philosophy in the Department of Humanities and Social Sciences of the Indian Institute of Technology Madras. He specializes in applied ethics (engineering ethics, academic ethics), engineering education, consciousness studies, logic, and Indian philosophy. He was conferred with the ‘Young Philosopher’ award by the Indian Council of Philosophical Research, Ministry of Education, New Delhi, in 2017. He was also awarded a Scholar-in-Residence Fulbright Fellowship to carry out teaching and research tasks in Utah (USA) in 2022–2023.

Some fundamental questions

EEE is usually seen as essential to prepare future engineers for the complex ethical challenges they will encounter. A proper pedagogical path into this field requires the critical examination of some fundamental ethical questions. By engaging in this kind of reflection, we can gain valuable insights into the purpose and nature of EEE. Thus, we can ensure its continued relevance in rapidly evolving technologies. This section delves into some fundamental philosophical questions that determine or shape the definition and prioritization of the purposes for EEE. More specifically, it will address (1) the distinction between engineering ethics and morality, (2) the teachability of engineering ethics, and (3) the balance between theoretical knowledge, technical operationalizable skills, and moral habits in engineering ethics. Responses to these questions all have a profound impact on how the purposes of EEE are or should be articulated.

Engineering ethics, morality, and personal ethics

The first question to be explored revolves around the relationship between engineering ethics and so-called 'personal ethics.' By analyzing their similarities and differences, we can achieve a clearer understanding of the unique considerations and responsibilities that engineering ethics requires. Thus, we can articulate the distinct ethical framework required within the engineering profession.

In this chapter, we will not make any philosophical distinction between the terms 'ethics' and 'morality' (as this is outside the scope of this chapter). We will use the terms 'ethics' and 'morality' synonymously and interchangeably. Having said that, we will distinguish engineering ethics from personal ethics. While there may be some overlap between them, they differ in scope and focus in many ways. The first way they differ is in scope. Engineering ethics is a specific branch of ethics – namely of *applied* ethics – that deals with the ethical considerations and responsibilities of engineers and their professional practices. It concerns the impact of engineering decisions and actions on society, the environment, and other stakeholders. Personal ethics, on the other hand, may encompass an individual's beliefs, values, and principles that guide their personal conduct in various aspects of life, which are not limited to their professional role as an engineer (Martin, 2002). In short, while living in a society, every individual has developed personal ethics to conduct themselves in specific ways in their day-to-day life and to judge ethical matters. In contrast, engineers are people who have received specialized postsecondary education and learned engineering ethics in their educational path. They are expected to use that acquired knowledge in their ethical decision-making and evaluate whether an action (regarding an engineering task) is moral. The two also differ in context. Engineering ethics is primarily concerned with ethical dilemmas, deliberation, and decision-making reasoning within the specific context of engineering practice. It addresses issues such as professional responsibility, safety, sustainability, fairness, and the welfare of societies impacted by engineering developments. On the other hand, personal ethics applies to a person's overall behavior and choices in various contexts, including personal relationships, family, community involvement, and more. To be sure, they can – and often do – coincide, but it is not necessary that they do.

Another fundamental difference between the two regards the existence of a formal code of conduct in engineering practice, which is (often) absent in an individual's personal dealings. Engineers often adhere to a professional code, which provides guidelines and principles specific to their field. These codes are typically established by professional engineering regulatory boards and associations, outlining the responsibilities and obligations engineers should uphold in their professional practice. Thus, engineering ethics often intersects with legal and professional standards. Engineers are bound by legal obligations and regulations that govern their professional practice, and ethical misconduct can have legal consequences (Davis, 1998). On the other hand, personal ethics may overlap with legal and professional standards but are not bound by them. Personal ethics is guided by an individual's beliefs, values, and principles – which may or may not align with a specific code and are not necessarily written or institutionally upheld.

Finally, engineering ethics strongly emphasizes the needs and interests of various stakeholders affected by decisions. Engineers must consider the potential impacts of their work on public health, safety, the environment, and other societal aspects. Personal ethics may also consider the welfare of others, but it may not be as directly focused on the broader or societal consequences of specific professional actions.

The teachability of engineering ethics

Since engineering ethics differs from personal ethics, the next concern is whether it is a subject that can be taught;, that is, we must determine the extent to which engineering ethics can be cultivated and developed through pedagogical interventions. This exploration will inform the design and delivery of ethics education programs, ensuring their effectiveness in enhancing ethical competence among engineering students.

Scholars acknowledge that engineering ethics is teachable to students in engineering and technology fields (Johnson, 2020). Sethy (2017) in his research findings reported that engineering students who completed the Engineering Ethics course stated that this course offered essential and interesting information about the engineering profession. While individuals may have personal values and moral frameworks that influence their ethical decision-making, as suggested above, the specific application of ethics in engineering requires knowledge and understanding of the ethical principles and considerations relevant to the field. We contend that engineering ethics constitutes a specialized body of knowledge that necessitates deliberate, focused, and empirical acquisition. Therefore, it cannot be assumed that engineers have some inherent ethical knowledge pertaining to their profession, even if they have some knowledge of personal ethics. This is because engineering ethics requires special knowledge due to its nature as a field of applied ethics. Hence, engineering students are required to learn about engineering ethics, thus the need for EEE. (For more about requirements *vis-a-vis* professional accreditation, see Chapters 32–36.)

EEE typically involves studying ethical theories (normative theories, for the most part; see Chapter 2), exploring case studies, and examining real-world examples of ethical dilemmas that engineers may face (Herkert et al., 2020; for more, see Chapter 20). It helps engineers develop the necessary skills to identify ethical issues and analyze their implications by identifying stakeholders and relevant decision-making principles. Thus, they can make informed decisions considering society's and stakeholders' welfare. Teaching engineering ethics also involves imparting knowledge about professional codes of ethics and regulations governing engineering practice. These codes provide specific guidelines and standards that engineers should follow to ensure responsible and ethical conduct in their work (for more, see Chapter 5).

While individuals may have different personal inclinations towards ethical reasoning, the ethics education offered in engineering programs should foster a shared understanding and awareness of the ethical responsibilities inherent in engineering practice. The primary goals of EEE are to increase student sensitivity to ethical issues (i.e., the ability to perceive and evaluate moral or ethical aspects and implications in a given situation), increase student knowledge of relevant standards, improve ethical judgment, and increase ethical commitment (Herkert, 2000; Davis, 2006). Further, it may be stated that the EEE assists engineers in developing a common ethical framework and practical knowledge to navigate complex ethical situations. In other words, a significant reason to justify that engineering ethics is, in fact, teachable is to examine whether there are tools that engineering students can be taught to use and to address ethical challenges in their future careers after engaging in engineering ethics learning experiences. For instance, instructors can use the 'drawing the line' methodology to explain the situation between accepting gifts and bribes (Harris et al., 2019). Furthermore, they can consider conflict resolution as a methodology to resolve two pressing facts – obligation towards the employer and ethical responsibility towards the public – when a question arises about whose well-being an engineer must protect (Feldhaus et al., 2015).

Acquiring knowledge and skills versus developing moral habits: Balancing technical expertise and character building

To understand how engineers can apply the ethics education imparted to them to their lived experience, we must examine the balance between two critical aspects of ethical competency: the operationalizable, practical skills engineering students acquire and the habit-like tendencies cultivated in EEE. (For more on competencies and how to assess them, see Chapter 26.)

Gaining operationalizable, practical skills in engineering involves acquiring theoretical knowledge and learning specific techniques as well as how and when to apply them. It is the kind of work that requires what the virtue philosophers often call craft, craftsmanship, or skill (*ars*, in Latin, or τέχνη in Greek, whence we get words like 'artisan' and 'technique,' respectively). Now, needless to say, one can be *technically* very good at engineering without being *morally* good. We can think of someone who possesses specialized engineering knowledge and an extensive array of technical skills that could – and would – design weapons of mass destruction or a technically flawless concentration camp. The results of this person's work would be technically good but morally reproachable. This person would be good in a very restricted sense (with respect to a specific kind of technique) but not absolutely speaking (Medeiros Ramos, 2021). Being morally good, or being a good engineer to be exact, involves understanding ethical principles, theories, and frameworks that can guide decision-making in engineering practice (see Chapter 2). It also involves cultivating ethical habits and tendencies that shape an engineer's behavior and professional conduct.

Therefore, engineering ethics goes beyond mere theoretical knowledge and skill acquisition, which would only consider humans as makers or producers of artifacts or technology. It also involves the development of habit-like tendencies that influence an engineer's behavior and which considers humans as doers or agents in a broader sense. Ethical habits are ingrained patterns of behavior that are 'second nature' and reflect an engineer's character and values. These habits shape an engineer's day-to-day decision-making processes and actions, guiding them towards ethical conduct even in situations where there may be ambiguity or conflicting interests. The ethical habit (or disposition) that must be acquired (in addition to theoretical knowledge and skill) is practical reasoning (φρόνησις or *prudentia*, as it was called by ancient Greek and European medieval philosophers, respectively), and this virtue can be acquired through education and experience (Medeiros Ramos, 2022). For example, ethical principles related to practical reasoning in engineering can include a commitment to transparency and honesty in communication, a dedication to prioritizing safety and well-being, a proactive approach to addressing potential ethical concerns, and a commitment to continuous learning and improvement. Both aspects, theoretical knowledge and practical skills, as well as habit-like tendencies to act morally well, absolutely speaking, are essential in EEE and practice, as they work together to foster ethical awareness, responsible conduct, and the promotion of public trust in the engineering profession.

A conceptual framework for the purposes of EEE

The purposes of EEE are of several kinds, as reflected in the vocabulary already used for formulating learning goals in practice. In this chapter, we try to systematically conceptualize the kinds of purposes that engineering ethics pedagogy could aim for. Thus, we are looking at existing and possible purposes that the scholarship on EEE did not focus on.

In proposing this framework for classifying the purposes of EEE, we think it is more interesting to start from the normative approach. *What should we strive for, even if we currently do not have the means to achieve this in educational practice?* This approach is justified by the fact that our educational methods keep changing and improving, so the border between achievable and unrealistic keeps changing. Furthermore, if we know what we *should* strive for, we can alter our educational methods to pursue those goals or invent new methods. Yet, to see what is currently pursued and what is still missing, we first need a conceptual mapping of possible EEE goals that is as complete as possible.

The possible purposes of EEE that we identified encompass the following categories: knowledge, actions, personal traits, relationships, artifacts, and environments. We explain each category briefly and provide a summarizing table at the end. For each category, we also point at the kind of theoretical framework (in ethics or philosophy, more generally) used to posit such a goal, namely the normative grounds for having this as a purpose of EEE. When there are established pedagogical methods to achieve those purposes, we also list those.

Theoretical knowledge

This category includes all kinds of knowledge considered relevant for engineering ethics and that a student should acquire. This could contain anything from knowledge of ethical theories and principles to knowledge of values (definitions and operationalization), ethical decision-making principles, or codes of conduct. Anything that the student can memorize and learn counts here as knowledge. Knowledge can be further categorized and divided into Bloom's taxonomy of learning levels based on the complexity of the cognitive tasks required, from understanding to more sophisticated tasks such as reflection and application (Bloom et al., 1956). The theory informing a knowledge-centered purpose for EEE is moral epistemology. This theory assumes, from Plato onward, that to perform a good action, one must first know what good is in that situation (Floridi, 2013). Hence, knowledge must come before moral actions as a scaffold for them. In practice, a knowledge-focused approach is also informed by an assumption that engineers do not do what is right in certain circumstances simply because they do not know what the right thing to do is. Still, there is room left for discussion about what kind of knowledge is relevant in the ethical domain for engineers. Questions such as the following have not yet been answered in practice: *Is knowledge of general moral principles enough? Should codes of conduct be the main thing future engineers learn? Should ethical theories be taught as a plurality, or is only one theory enough? Should the focus be on theories as decision-making tools or as paradigms to think with?* Standard teaching methods in higher education will fit nicely with knowledge transfer as a purpose of EEE, such as commented texts, seminars, exams, essays, and lectures. Hence, knowledge acquisition needs to come before moral actions as a scaffold for them.

Action

This category starts from the assumption that we want to have ethics education in engineering programs to help students achieve and pursue the proper action in their specific context or, as some scholars put it, the right behaviors (Clancy & Zhu, 2023). Typically, for this class of ends, instructors would focus on contexts of action and the right actions for each context, analyzed through paradigmatic case studies. The case study–focused pedagogy (so-called microethics) falls neatly into this category. For example, one could teach starting from any engineering disaster (the Challenger explosion, the Rana Plaza collapse, the BP oil spill, the Tesla highway car crash, the VW defeat design, etc.[1]) and ask students what should have been done. There is no list of prescribed actions one should pursue, but there is a list of actions one should avoid, for example, taking bribes, overpromising features, lying, cutting corners in design or execution, and so on. Meanwhile, positive actions could be truth-telling/speaking up, whistle-blowing, sabotaging a project doomed to hurt many, and so on.

The problem with developing a list of 'positive' actions to prefer is that these are always contextual and case related. We want to avoid prescribing concrete actions in general, such as whistle-blowing, which should be only a last resort tactic. We also want to promote more constructive ways of disagreeing with one's work environment. Thus, action-oriented pedagogy is highly contextualized and relies on case studies. The list of desirable and undesirable actions remains open by default and cannot be prescribed in advance.

Action-oriented purposes for EEE assume that we want future engineers to do the right thing without caring how they arrive at this decision. They could do so by deliberation but also by being nudged into it; some biases and heuristics could be used to direct them (Clancy & Zhu, 2023), and hence, moral psychology would be a fitting framework (see Chapter 10). In moral psychology, we do not assume people to be rational agents. Instead, we describe their biases and heuristics and work with these as the starting material. While the question of how to achieve the right actions in the workplace can be pursued through various means, such as environment redesign, accountability procedures, and so on, in the ethics classroom, we do not have these means. Ethics educators will rely on case studies as exemplary and discuss them, hoping that students learn from these cases and apply the lessons to similar future cases. Case-study pedagogy is relatively easy to teach and one of the favorite methods of EEE; however, it has its limitations, which have been discussed extensively (Martin et al., 2019; see Chapter 20). Another approach favoring action-taking centers on performative techniques such as role playing or improvisation (see Chapter 24). In these performative cases, students enact the behavior from their own perspective while not yet knowing the end result. From a moral psychology perspective, performative techniques have the advantage of being affect-infused, and thus more memorable for students.

Personal traits

Many learning goals for EEE are phrased in the language of competencies or skills, for example, the competencies proposed in the handbook by Ibo van de Poel and Lambert Royakkers (2011), which proposes the following: "Moral sensibility … Moral analysis skills … Moral creativity … Moral judgment skills …; Moral decision-making skills …; and Moral argumentation skills" (van de Poel & Royakkers, 2011, p. 2). The basic assumption here is that moral decision-making in EEE relies on some character traits that students do not have from the beginning and that these character traits need to be acquired and put into practice in the classroom so that students can take these along in their professional lives. Such character traits can be discussed regarding virtues, skills, and competencies. The idea is that what the right action *is* is hard to predict for each case anyway and that knowledge by itself is powerless in making students choose the right course of action, so we need to train students to become better at making moral decisions themselves by sharpening their skills in the ethical domain. Just like one cultivates and practices some skills for critical thinking, mathematical thinking, design thinking, and so on, one can be trained in the moral domain. The primary difference in this category is whether one pursues discrete skills and competencies or aims for more holistic virtues (see, e.g., Chapter 22).

Traditionally, EEE has focused on skills and competencies since these are easier to measure and, hence, to operationalize – while virtues remain a fuzzy ideal that many scholars call for (Harris, 2008; Frigo et al., 2021). However, there is a shortcoming to the skills-focused approach: one could have the competencies but fail to deploy them in the required context. Meanwhile, virtues always have end-values embedded in them; hence, if one has the virtue of honesty, one cannot but act honestly when the time comes. The theory informing this purpose is virtue ethics – be it of the Western kind, such as Aristotelian or MacIntyre-ian, or non-Western, such as Confucian or Buddhist ethics (see Chapters 2 and 8). The fundamental assumption here is that the right character traits will lead to the best decision in a particular situation. Teaching such character traits is difficult in practice because the contact hours typically allotted in EEE settings are insufficient for shaping the character traits of students in the long term. Role-playing pedagogy has shown some promise (Martin et al., 2019; Chapter 24), as it puts the student at the center of the moral scenario and asks them to act exemplarily in front of others.

Design/values in artifacts

Another possible approach is artifact-centered. In this one, we do not care about what kind of persons the engineers are, nor what actions they undertake; instead, we look at the kinds of artifacts they create – what kind of apps, vehicles, bridges, processes, structures, or infrastructures they build – and we focus the moral scrutiny on these artifacts and the values embedded in them. As with actions, it is hard to prescribe a certain kind of design for the artifacts as universally recommended. Instead, we ask students to think about the values that should be embedded in their designs; from usability and transparency to privacy and justice, a plethora of values can be achieved (see Chapter 12). The theories informing this kind of purpose are value-sensitive design (Friedman et al., 2017; Hendry et al., 2021), design for values (van den Hoven et al., 2015), ethics by design, and responsible research and innovation (RRI). The pedagogical approaches for teaching this kind of purpose rely on students building artifacts themselves or evaluating others' artifacts. Approaches such as challenge-based learning (Martin & Bombaerts, 2022) and project-based learning (see Chapter 21) suit this goal well, provided that there is a clear ethics reflection component to the project. Some recent approaches use the approach of tinkering – understood here as playing with physical materials and modifying engineering artifacts - in order to embed certain values such as inclusivity, diversity, and empathy in existing artifacts, going beyond the typical values of usefulness and efficiency which are pervasive in engineering designs (van Grunsven et al., 2024). In addition, it must be stated that students need some basic ethical knowledge (as in the first purpose, i.e., theoretical knowledge, see Chapter 2) about values and their operationalization to design with values in mind. Pedagogies centered around ethical design are increasingly popular at technical universities and are used on a wide scale in EEE pedagogy alongside case-study approaches (van Grunsven et al., 2021).

Transitioning from individualistic approaches to holistic approaches

All four kinds of purposes mentioned thus far seem to start implicitly from a sort of methodological individualism, by assuming the autonomy of engineers to decide what they do, who they are, what to know, and what to design. In positing such purposes, it is assumed that, if we teach individual students to pursue the right action, to have the right knowledge, and to acquire the right competencies, the world of engineering will benefit as a result. Yet, engineers do not act alone in the world: they function in teams, systems, and corporations. Engineering professionals interact perhaps just as much as they act as individuals. The individualistic assumption is based on how EEE pedagogy is set up practically: we teach classes of students, but we evaluate them individually. If the evaluation is always about the students as individuals, then it becomes difficult to create learning goals for groups. Granted, there are team assignments in EEE (especially the ones that are artifact-focused), but ultimately, we want each individual to play a part in the team and we strive to evaluate their performance fairly, separate from the team's. This methodological individualism limits the formulation of possible purposes for EEE.

Moving away from the individualistic approach, we acknowledge the basic fact that engineers act embedded in networks of relations, in environments, in institutional structures, and cultural contexts. These networks fundamentally constrain what engineers can do, know, design, or decide. To account for this limitation, we can map out two more kinds of purposes: relational and environmental purposes for EEE.

Relations

Engineers work in teams, are placed in corporate hierarchies, and relate to their customers, employers, and society at large. What kind of relationships and relational networks should engineers strive to cultivate or enter? The answer can be further separated into *qualities of relations* and *objects of relations*.

Qualities of relations encompass the kinds of relations that an engineer should strive to cultivate in the workplace: equal or hierarchical, collaborative, respectful, honest, multi-networked (meaning to strive to create relations that connect various networks of stakeholders), other-oriented (as opposed to self-centered, or self-serving relations), and critical (meaning that one can create networks of relations that are truth-oriented and in which peers hold each other accountable). One easily notices that there seems to be an overlap with virtue ethics here, but instead of asking what kind of virtues one should cultivate in oneself, here one asks how to cultivate meaningful relations in the workplace that promote virtues in the interaction. Thus, one need not be honest as a person, but if one's relations and networks are set up so that honesty is expected and encouraged in the interactions, the purpose is achieved. Theoretical frameworks that could inform the qualit y of relations end-goal are care ethics, Confucian ethics (Zhu, 2023), and workplace ethics (a smaller branch of business ethics; see, e.g., Chapter 11).

Objects of relations include care, maintenance, respect, equality, justice, and non-discrimination. This purpose is still relational but asks how to achieve specific group and societal values by enacting certain relations. Thus, the values are not instantiated by objects or artifacts but by relations. The relations could again be in the workplace (with one's colleagues), but they primarily involve stakeholders and broader society. For example, an engineer aiming to promote the value of maintenance in one's relations would probably think differently than an engineer focused on fostering maintenance through the objects one designs. In the latter case, one designs an object that is easy to maintain, with spare parts that can be easily found and replaced. Yet, in the former case, one thinks about the entire life cycle of the product and the people using it – how to make its usage less damaging, how to empower the end-users to engage in maintenance themselves, how to persuade society that it is easier to maintain rather than discard. All kinds of constellations of relations could be enacted to support maintenance as an end goal. A theoretical account to inform such a purpose could again be care ethics or Confucian ethics – or involve value theory.

Environments and systems

The term 'macroethics,' as coined by Herkert (2001), already encompassed how the practice of engineering has broad societal and environmental effects on our society. *Do we need then to discuss the environmental effects of engineering?* We think so because 'environment' here does not mean an ecological or natural category. Instead, it is intended to emphasize how the individual agents are connected – to each other, their artifacts, and the world around them. Environment as a concept captures this interconnectedness and mutual influence. In discussing the impact of engineering – as a profession – on the world around it, one could try to formulate purposes that do justice to this holistic view (see Chapters 7 and 9). One could strive for maintenance and non-destruction of the world but also for awareness of how one's actions affect the world. Another goal could be limiting suffering by creating systems that do not promote suffering or systemic oppression. Formulating concrete goals for this kind of purpose is notoriously difficult but worth trying. Still, one could argue that this environmental or systemic perspective should not be a goal for engineering *education*, and perhaps we should delegate it to the engineering profession as a whole by embedding it into ethical codes of conduct. Still, one should learn to think about the systemic effects of one's actions in the world, even as a student, because it may be too late to develop this awareness after graduating.

Several theories analyze the systemic nature of engineering ethics, such as science and technology studies (STS) or Luhmann's systems theory (Fuchs et al., 2023). There are several non-Western approaches particularly fitting for this scope, such as Buddhist ethics (Garfield, 2021; Bombaerts et al., 2023), *Ubuntu* philosophy (Mabele et al., 2022), and *Buen Vivir* (Estermann, 2006; Kopenawa & Albert, 2013; Viveiros de Castro, 2014). *Ubuntu* and *Buen Vivir* are non-Western traditions (from Africa and South America, respectively) centered on community – or on a more global perspective and a broader ontological scope – according to which humans, non-human animals, and nature as a whole are seen as being at the same ontological (and moral) level (Ewuoso & Hall, 2019; Mabele et al., 2022; Kopenawa & Albert, 2013; Viveiros de Castro, 2014). These two approaches are more thoroughly discussed in Chapter 8, alongside Buddhist ethics.

All six types of engineering purposes mentioned here are found at various levels of abstraction, for an analytical purpose, but these levels are not isolated in practice, as they contribute to one another and can be incremental. For example, the pursuit of moral competencies such as moral perception can have a systemic effect if one also becomes aware of one's systemic influence, or it can give rise to richer and more responsible relations. Artifacts designed with certain systemic values in mind can alter systems and shape the world we live in in ways that were not yet anticipated by their designers. There is interaction at stake between the systemic, relational, and individual levels, with the systemic level encompassing all previous ones. Table 1.1 summarizes our conceptual framework for dividing the types of goals for EEE.

Some practical questions

Who should teach engineering ethics?

In the engineering ethics literature, it has been widely debated *who* should teach engineering ethics. Exploring such a question is crucial for understanding the purposes of EEE since the positionality, academic training, and disciplinary norms all potentially impact how engineering ethics instructors define and enact these purposes. In the United States (and other countries as well), historically, the qualifications desirable for someone to teach professional ethics, including engineering ethics, have been unclear. Scholars have expressed concerns regarding both engineers and non-engineers (humanities and social sciences scholars) teaching engineering ethics. For instance, McGinn (2018) expressed concern about having engineering instructors cover ethical issues in engineering courses, as they often lack formal training in ethics – and thus, their consideration of ethical issues is likely to be "intuitive and not grounded in ethics fundamentals" (McGinn, 2018, p. 9). In addition to the concern about engineering educators lacking sufficient training in ethics, Newberry (2004) noted that most universities do not have a reward system that motivates engineering faculty members to develop the background for ethics instruction. Therefore, the question becomes whether formal training or even degrees in applied ethics or philosophy should be considered indispensable for someone to teach engineering ethics. Barry and Herkert (2015) indicated that many engineering faculty members without formal training in either engineering or philosophy have been teaching engineering ethics and trying to achieve course objectives.

There have also been concerns with philosophers or humanities scholars teaching engineering ethics. For instance, in an empirical study conducted by one of the co-authors of this chapter, a Chinese engineering faculty member summarized two significant limitations of solely relying on humanities and social sciences professors in the teaching of engineering ethics at his institution:

Table 1.1 Our conceptual framework for dividing the types of goals for EEE.

Category of purpose for EEE	*Examples from this category*	*Theoretical frameworks fitting this purpose*	*Pedagogical approaches*
Individualistic, token-oriented			
Knowledge	Moral knowledge: ethical theories, codes of conduct, values, ethical decision-making procedures.	Moral epistemology	Bloom's taxonomy of learning goals. Readings, seminars, exams, lectures.
Action	Undesirable actions: taking bribes, over-promising features, lying, cutting corners in design or execution, etc. Desirable actions: cooperation, truth-telling, double-checking, preventive maintenance, talking to stakeholders, speaking up in a team.	Moral psychology	Case-study pedagogy (microethics), deliberation. Role-playing/ improvisations.
Personal traits	Ethical skills or competencies (such as moral intuition, moral sensitivity, moral decision making, moral imagination) and virtues (honesty, determination, courage, etc.).	Virtue ethics (Western or Eastern)	Role-playing/ improvisations.
Values in artifacts	Values to be embedded in design. Negative constraints for design: dark-patterns, deceptive or manipulative design, harmful designs.	Value-sensitive design/ethics by design	Challenge-based learning. Project-based learning. Any design-centered task.
Networked and holistic			
Relationships	Qualities of relations: equal, hierarchical, collaborative, respectful, honest, multi-networked, other-oriented, critical. Objects of relations: care, maintenance, respect, equality, justice, non-discrimination.	Care ethics; Confucian ethics; workplace ethics; value theory	X
Environments and systems	World-maintenance, non-destruction of the world, awareness of impact on the system, limitation of suffering and oppression.	Buddhist ethics; *Ubuntu* philosophy; *Buen Vivir;* Systems theory; STS	X

One issue is that the number of humanities and social sciences faculty cannot fulfill the teaching requirement … Every year, our university recruits thousands of graduate students. As this [engineering ethics] course has become a required course for graduate students, even if one section can accommodate 200 students, we still need to have dozens of sections. In this sense, we are short of humanities and social sciences faculty who are able to fulfill

> this teaching requirement. The other limitation with having humanities and social sciences faculty teach engineering ethics is that they tend to overly theorize engineering ethics. Such overemphasis on theorizing engineering ethics might be okay to students with [a] good humanities and social sciences background. However, for the majority of engineering students, their humanities and social sciences background is weak. These students will have challenges learning engineering ethics and keeping pace with the instructor. Finally, there will be some negative emotion towards engineering ethics among these students.
>
> *(Zhang & Zhu, 2021)*

Barry and Herkert (2015) suggested that, in addition to engineers and moral philosophers being considered qualified for teaching engineering ethics, instructors trained in interdisciplinary fields such as the history of science and technology, technical communications, and science and technology studies should also be considered qualified – insofar as they are enthusiastic about discussing ethical issues in and the social implications of engineering. Barry and Herkert (2015) did not specify that faculty from those interdisciplinary fields need engineering expertise. However, their training programs often expect a basic understanding of engineering, ensuring these individuals are equipped for interdisciplinary exploration of themes connecting engineering and technology. Again, the question of who is qualified to teach engineering ethics is highly debatable; however, the diverse backgrounds of engineering ethics instructors will undoubtedly influence how they conceptualize ethical issues and prioritize ethical learning outcomes. These diverse backgrounds will also influence how they understand and explain EEE's general and specific purposes. In the following section, we delve into these concerns by examining the perspectives, interests, and expectations of university faculty members and other key stakeholders involved in EEE.

Who decides on the purposes of EEE?

This section reflects on the multiple stakeholders of EEE, including the broader social, cultural, and political contexts in which they are situated. These stakeholders shape how EEE is created and the purposes of EEE are formulated. More specifically, this section discusses the primary stakeholders for EEE, including their values, motivations, and needs for promoting EEE. Doing such an analysis allows us to understand better the social forces that help shape the definition and implementation of EEE purposes. By considering the potential stakeholders of EEE beyond students and teachers, we see that academic institutions, professional organizations, industry stakeholders, and ethical experts can all evaluate their respective roles and responsibilities in shaping the purposes of EEE. Various stakeholders have always advocated for engineering ethics, and EEE should thus be considered a collaborative effort.

The purposes of EEE are often considered integral to the *professional formation of engineers*, and academic institutions are typically considered responsible for transmitting theoretical knowledge and technical skills to students (at least at the outset of students' engineering careers). Engineering ethics is thus taught as an indispensable part of engineering curricula in most universities and colleges (and global accords and accreditation standards play a significant role; see Chapters 32–36). Academic institutions have a crucial role in providing foundational knowledge and offering dedicated courses or modules on engineering ethics. As noted above, faculty members with different backgrounds may perceive the purposes of EEE differently. For instance, professors and instructors in engineering departments may consider that a significant purpose of EEE is to teach students practical skills for solving ethical problems in the workplace – comparable to using scientific and technological skills to solve engineering problems. Thus, many of them incorporate ethical discussions (Chapter 25), case studies (Chapter 20), and ethical decision-making frameworks (Chapter 2) into their teaching of technical content.

In contrast, ethicists, philosophers, and professionals with similar expertise and background in ethics may consider teaching other aspects of morality – such as moral reasoning skills, moral sensitivity, and moral tendencies, which are key concepts in humanities and social sciences – to be the purposes of EEE. Their insights and knowledge can provide a deeper understanding of ethical theories, frameworks, and reasoning processes. Nevertheless, raising difficult ethical questions and teaching students how to address them should not be relegated to the 'token ethicist' or philosophy instructor but should be embraced by most – if not all – engineering instructors. Collaboration among experts can enrich the teaching of engineering ethics and ensure a comprehensive exploration of ethical issues.

There are, however, other stakeholders who play an essential part in shaping what should be the purposes of EEE. Professional engineering organizations, such as the National Society of Professional Engineers (NSPE) in the United States or the Institution of Engineering and Technology (IET) in the United Kingdom, often consider the application of professional codes of ethics as a central purpose for EEE. They develop and promote codes of ethics specific to the engineering profession. These organizations can contribute to teaching engineering ethics by offering guidance, resources, and training programs for engineers. They can – and often do – organize workshops, conferences, and seminars focused on professional ethical issues in engineering, often made explicit in codes of ethics (see Chapter 5).

In addition, employers in the engineering industry also influence and help interpret and shape the purposes of EEE. Their understanding of the purposes of EEE often emphasizes the role of engineers in reconciling their professional responsibilities, corporate social responsibility (CSR), and ethical obligations arising from their role as employees. These industry players play a crucial role in EEE by integrating ethics into their onboarding processes and continuing professional development programs. Employers can provide case studies and scenarios relevant to their specific industry to help engineers apply ethical principles to real-world situations.

All in all, collaborative efforts among academia, professional organizations, and industry should be favored as they can enhance the teaching of engineering ethics and provide diverse approaches to the purposes of EEE. Joint initiatives can be established to develop curricula, share best practices, create case studies, and facilitate discussions on ethical considerations in engineering practice.

Concluding remarks and future directions

Defining the purposes of EEE holds paramount significance for the engineering education community. It is problematic and potentially dangerous when engineering educators design ethics-learning activities without critically examining *the purposes of these activities* and assessing *whether these purposes are justified* for educating ethically and professionally competent engineers. Failing to consider the purposes of EEE can lead to adverse outcomes. At a minimum, it can undermine the effectiveness of teaching engineering ethics, manifesting as a misalignment between the curriculum and the purposes of EEE. At its most severe, the omission of certain elements from students' learning experiences can have far-reaching consequences. These consequences can range from immediate (depending upon, e.g., whether specific learning activities prioritize moral reasoning over moral empathy), to more enduring impacts (e.g., the cultivation of moral identity, values, and lifelong ethical development).

The actual purposes of EEE are closely tied to the contextual and sociocultural milieu. To put it differently, these purposes are frequently shaped by the values and ideologies of various influential collectives and entities. Accreditation bodies, professional societies, industries, engineering faculties, and individual educators each possess their own political agendas and motives for shaping these objectives. The multi-dimensional framework we constructed for this chapter (Table 1.1) can help educators reflect on the purposes and objectives embedded in the ethics learning programs designed by themselves and others – so that their programs encompass the theoretical foundations and pedagogies that enable these objectives. In other words, such a framework can facilitate educators in attaining alignment among the purposes of EEE, theoretical foundations, and pedagogies they use.

The purposes of EEE are socially constructed and vary from country to country based on unique historical, political, and cultural contexts (for more on this, see Chapters 32–34). The analytical framework we – a group of scholars hailing from diverse cultural backgrounds – have constructed and presented (Table 1.1), embraces both the individualistic and holistic aspects of EEE, incorporating perspectives from both Western and non-Western traditions. It can function as a comprehensive framework for delineating, implementing, and evaluating the purposes of EEE, catering to the needs of engineering educators and policymakers globally.

We recommend future research to explore the purposes of EEE including (1) how engineering educators and policy-makers perceive their own purposes for EEE; (2) the extent to which these purposes influence curriculum, teaching methods, and policy formulation; (3) how the diverse purposes in the engineering education ecology align with students' values and aspirations in the engineering profession; and (4) how different EEE purposes can synergize to develop well-rounded engineers capable of working across cultures.

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Note

1 Several examples of cases discussing engineering action and behavior can be found here: https://search.edusources.nl/communitys/4tu-ethics

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