MAPPING ENGINEERING ETHICS EDUCATION

Roland Tormey, Tom Børsen, Shannon Chance, Thomas Taro Lennerfors, Diana Adela Martin, and Gunter Bombaerts

Introduction

Bringing together and editing a handbook feels like a humbling task. The term 'handbook' typically refers to a reference book, a source to which one can turn to find the fundamental information needed to complete a professional task. Many engineers will be familiar with classic handbooks like Perry's (1950) *Chemical Engineers' Handbook* or *Marks' Standard Handbook for Mechanical Engineers* (Marks, 1978). Academic handbooks such as Routledge's *International Handbook of Engineering Education Research* are a little different in style, but they still convey the sense that they are a point of reference, the first place to go if one wants to understand a field. Implicitly, they convey that we know what the professional tasks are in a field and we know the fundamental information needed to complete them. Writing and editing a handbook would undoubtedly be more straightforward in a context in which the field in question was mature, the professional tasks well defined, and the required information readily identifiable. What made our editorial task daunting was that this did not feel, to us, to be the case with engineering ethics education (EEE).

We knew there were quite a few excellent engineering ethics textbooks (e.g. van de Poel & Royakkers, 2023; Fledderman, 2014; Lennerfors, 2019) that could serve as an introduction to engineering ethics for students and which could implicitly provide a course structure and pedagogical approach for new engineering ethics teachers. Yet, when we dug a little beneath these textbooks, we found differences in perspectives regarding the content to be taught, who should deliver it, optimal teaching methods, effective assessment strategies, and the subsequent actions based on assessment results. Alongside these differences, we saw unrecognized similarities: authors working on the same themes and ideas but from different disciplinary perspectives and without substantial interaction with each other. Our task, then, felt less like we were describing a clearly defined terrain and more like we were mapping a previously unmapped space, one in which many people had been working, often in collaboration with each other and sometimes in splendid isolation from those who were (intellectually) nearby to them. Our hope with this handbook was to create a map of EEE that would allow others – teachers of engineering ethics, engineering ethics education researchers, and especially graduate students who are new to the research area – to find their way more easily in the EEE terrain, to recognize the pathways that connect ideas and positions and the topography that separates them, and to allow them to better understand the range of perspectives and approaches that make up the terrain of engineering ethics education. Yet we were also con-

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scious that we were mapping quite a diverse space, which was home to people who spoke different languages, had different epistemologies and different disciplinary methods, cared about different things, and lived in different places. In mapping the space of engineering ethics education to make it more navigable, we wanted to respect the positions of those within the space. All this fostered our sense that framing such a handbook was a profoundly humbling task.

In the pages that follow, we will explain something about our process in doing this, in the hope that our decisions make sense to those who bring engineering ethics education into being and to those who will use this handbook to do so in the future.

Identifying the 'space' of engineering ethics education

In thinking about the content of a handbook to map the space of engineering ethics education, we needed to think about what that space is. One way to reflect on the space between engineering, ethics, and education is to imagine a Venn diagram with three sets, partly overlapping, representing engineering, ethics, and education respectively. The space of EEE emerges as the common space expanded by the three sets. Thus, this handbook provides a rich overview of the common space between engineering, ethics, and education, and we will, in the following text, begin our reflections within 'engineering' and see where that leads us in terms of filling in the space of EEE.

Engineering

We are, first and foremost, educating future engineers. Engineering must be central to our discussion of ethics education – engineering and its various subfields, or disciplines, help set crucial boundaries and focal points for investigating ethics – *engineering ethics* – and how to teach and learn it. The first two sections of this handbook provide perspectives from disciplines outside engineering, seeking to explain how foundational ethics concepts and perspectives from other disciplines tie to engineering education. The third section, 'Ethical issues in different engineering disciplines,' provides a glimpse of the many ways that ethics is applied, considered, and practiced in the various subfields/disciplines of engineering.

Specifically, the third section discusses what content should be included in ethical teaching in five different engineering disciplines: civil engineering, mechanical and aerospace engineering, electrical and electronic engineering, chemical engineering, and software engineering (Chapters 14–18). The section concludes that the content of EEE needs to overlap with, or in other ways relate to, the engineering discipline in which engineering ethics is taught. If there is no connectivity between the ethical content and the engineering content surrounding it, students who are developing an engineer's identity will be unable to find meaning in the ethical issues taught and may thus reject ethical content as irrelevant and without meaning (Lönngren, 2021). Relating engineering ethics to particular engineering disciplines can be achieved in different ways. It can be done by including ethical questions within the list of questions asked in conventional engineering exercises of a technical character. The idea here is that ethical questions be asked side-by-side with technical questions. When a material's properties are discussed, ethical questions regarding its origin, the environmental costs for obtaining it, its health features, and such can be probed – opening up the discussion for ethical deliberation and reflection. Section 3 identifies several issues that can be related to specific technical content of engineering disciplines. Ethics teaching can depart from and be related to the ethical codes within specific engineering disciplines. It can present the unexpected and broader socio-techno-ecological implications of concrete historical engineering solutions, including the implications for employees, users, the environment, and public health. It can also discuss actual use, including potential military appli-

cations in engineering. It can discuss how engineering solutions relate to colonial structures and whether they promote diversity, equity, and inclusion. The crucial point is that ethical issues discussed in engineering ethics classes must be related to and exemplified with illustrations from the specific engineering discipline. Case studies, role plays, and exercises need to reflect specific disciplinary activities, issues, and dilemmas.

Section 4 (comprising Chapters 19–25) expands on different teaching approaches in EEE. Some of these overlap with teaching approaches used in other parts of engineering education, for example, project work, extra-curricular activities, internships, or design activities. When there are overlaps in the teaching approaches between engineering ethics education and engineering education in general, it is not difficult to add ethical questions or integrate examples of ethical issues in relation to, for example, humanitarian engineering or engineering project work, or to include an extra-curricular guest lecture from industry in which they speak about their ethical challenges. Engineering design is one area where this handbook includes many ethical tools to incorporate into the design process: value-sensitive design, participatory design, and empathic design, to mention just a few.

An important point is that engineering students have typically not come to study to become mini-philosophers, or to earn a bachelor's or minor in philosophy, sociology, or anthropology. Rather, the ethical content will often engage them most when it represents an integral part of their engineering discipline. Proximity of engineering and ethics in engineering education is key. Ethics is integral to engineering education and engineering practices because engineers co-create society, the constructed environment, and reality. When engineering ethics course planners and teachers incorporate content from specific engineering disciplines and practices, it facilitates students' integration of engineering and ethics concepts.

Several chapters across this book assert that EEE must include thick descriptions of the specific psychological, social, cultural, and organizational context in which engineering is conducted. Thus, engineering ethics needs to be linked to specific engineering disciplines and also to the non-technical spaces surrounding engineering work and decisions. Different disciplines from the social sciences and the humanities can contribute meaningful insights into the non-technical content that is key to engineering ethics. One can ask why engineering ethics is not called something else since it is not only engineering and ethics content that is important to teach engineering students. 'Responsible engineering' might be another way to label the type of content we are proposing: engineers must be taught to take responsibility for the implications of their work. Yet, responsibility requires knowledge of implications as well as possibilities to act (see, e.g., Doorn and Van de Poel (2011) for an exploration of the issues involved in engineering responsibility, as well as Chapter 11 in this handbook). Thus, knowledge of the concrete circumstances – including power relations (Foucault, 2001), legislation, organizational structures, and psychological factors – is imperative to include as content in engineering ethics education.

Ethics

One of the contributions to the content of EEE highlighted in the first section of this handbook, 'Foundations of engineering ethics education,' involves ethical and normative frameworks. This section (comprising Chapters 1–7) overviews a selection of normative frameworks that can help underpin ethical reflections, assessments, and decision-making in and beyond the classroom and into engineering practice. The existence of normative frameworks in ethics provides criteria for individuals to reflect upon what is right and wrong in a given situation. A central point in this handbook is that there is not only one (or even a few) normative framework(s); there are many, and

they originate from different traditions. Some are rooted in engineering, such as the many ethical codes of conduct provided by engineering societies around the globe. Some are rooted in Western philosophy, for example, virtue ethics, consequentialism, deontology, contractualism, discourse ethics, and the ethics of care. Others are rooted in sustainability science, for example, circular and ecological economy, deep ecology, land and material ethics, future ethics, precaution, energy justice, energy democracy, and sustainability. Ethical frameworks are not necessarily occidental. Many normative frameworks originate from non-Western knowledge systems/traditions, such as *Ubuntu* from sub-Saharan Africa, *Buen Vivir* from indigenous Latin America, Confucianism from China, and Buddhism from different Asian countries. Normative frameworks are referred to in ethical and political discussions of engineering and technological innovation and serve as assessment criteria for what counts as 'good' engineering or technological solutions. Many people involved in the construction of this handbook seek to identify and cultivate rich, multi-dimensional understandings of these other traditions, particularly in light of the rapidly standardizing nature of engineering processes, products, and education systems – a standardization process hastened by capitalist production systems and by engineering accreditation processes. Accreditation of engineering education is the focus of Section 6 of this handbook; benefits and drawbacks of the system are discussed and critiques and criticisms raised.

A central assumption underpinning most contributions in this handbook is that applying normative frameworks is not an individual or solitary endeavor. Normative frameworks operate in or underpin the socio-techno-ecological configurations in which engineering students and engineers are located. Even when they are not openly discussed or reflected upon, they influence backstage or behind-the-scenes decisions, conventions, habits, practices, and engineering solutions. Thus, an argument put forward in this handbook is that EEE must address a broad palette of ethical frameworks so that engineering students, as future engineers, become acquainted with some existing normative frameworks *and* a broad section of engineering processes, practices, and solutions for enacting these frameworks. The frameworks can additionally inform and qualify individual and collective ethical decision-making.

The handbook's chapters reveal a lack of consensus within the EEE community regarding the status of these normative frameworks: Are they universal, objective truths? Do people construct them? Or are they somehow in between? Engineering education provides fertile in-between ground, given that some phenomena (like gravity, heat transfer, or solubility) are taken as given/objective/fact, whereas other phenomena are more readily recognized as being socially constructed (e.g., design briefs and quality standards).

An additional point where consensus is lacking regards whether insights from different normative frameworks can be combined or whether one must adhere to just one framework at a time in ethical work. In some cases, ways of weighing alternative solutions within one normative framework cannot be mixed with the rationale underpinning a different framework because the basic assumptions are at odds. These discussions emerge in various chapters of the first section; the argument is latent in many chapters and explicit in Chapter 2 on ethical theories and Chapter 8 on philosophical contributions. Moreover, the plurality is manifested in Chapter 7 on the ethics of artificial intelligence (AI) and appears explicitly in the editor's introduction to the first section of the handbook.

Education

Another way of thinking about the space of EEE is to ask what is or should be distinctive in the knowledge of those who teach engineering ethics. Throughout the twentieth century, schol-

ars sought to identify what makes expert teachers so good at teaching. Essentially, two different approaches emerged (Darling-Hammond, 2006). The dominant tradition followed a (more or less) behaviorist path in seeking to identify the observable teaching behaviors that were associated with increases in student knowledge. Once these approaches were identified, they could be simplified, codified, built into curricula, and issued as guidance or imposed as requirements for new teachers entering the field. This approach to improving teaching owed much to engineering modes of thought and was closely allied with the emerging 'scientific management' approach pioneered by the mechanical engineer F. W. Taylor (Au, 2011). It fed through the efforts to describe 'learning outcomes' (rather than learning experiences) that emerged in psychology in the 1950s and 1960s, and it remains influential today via accreditation approaches and via the Bologna reforms across the European Higher Education region (see Gleeson, 2013; the framing of engineering curricula in terms of 'learning outcomes' is a theme that emerges in the sections on assessment and accreditation in this handbook).

A second, less dominant, tradition followed the work of John Dewey (1929), who tried to identify the (less observable) knowledge of methods, learners, and subject discipline that would empower teachers to make more flexible and adaptive decisions to respond to the different and changing needs of students. Dewey's focus on the knowledge base of flexible, adaptive educators came back into focus in the early part of the twenty-first century via the work of Linda Darling-Hammond (2006). Like Dewey, Darling-Hammond sought to map the knowledge base of the expert teacher, this time informed by a further 80 years of teaching practices and educational research. The features she identified were:

- Understanding the *subject(s) being taught*
- Understanding *learners and learning*
- Understanding *teaching*

Regarding *understanding the subject(s) being taught*, Darling-Hammond (2006) described effective educators as those who recognize that the same teaching techniques cannot simply be transported from one subject or discipline to another. In engineering ethics education, this would imply that – because the epistemologies, the modes of inquiry, and the central concepts of engineering ethics education are different from those that apply in, for example, mathematics or physics – engineering ethics education may well need to take a different format from those of other subjects being studied by engineering students. To be able to flexibly choose appropriate pedagogies, educators need to understand the epistemologies, ways of working, and core ideas of engineering ethics education. This, in turn, implies needing to clarify what these things are. Given the fragmentation and disciplinary diversity we have already identified as underpinning engineering ethics education, mapping the space of the subject(s) being taught has required an inclusive approach from us as editors (this is reflected in Sections 1 and 2 of this handbook). Since most students come to our engineering ethics classes with the intention of being engineers and not ethicists, understanding the specific disciplinary epistemologies of engineering disciplines (including mechanical, electrical, computer, environmental, or biomedical) is also important in making good decisions about what it means to teach engineering ethics within that discipline (this is reflected in Section 4 of this handbook).

Related to *understanding learners and learning*, not every technical expert grasps social dimensions well. The phenomenon of extremely gifted academics who are unable to effectively teach is perhaps so well-known as to hardly require elaboration. For Darling-Hammond (2006), the key issue is that it is not enough to be an expert in a subject domain; one also needs to under-

stand the learners who must learn and the social and psychological processes through which they learn. Learners come to any ethics class with a store of prior knowledge and experiences, which effective teachers understand. These teachers also understand how to leverage and question students' prior knowledge in order to help them learn. Understanding our learners – in their rich diversity – is therefore central to the knowledge base of an effective educator. Our learners differ not only in their backgrounds but also in the identities and senses of self that they are in the process of constructing during their time in engineering education. These diverse learners build competence through cognitive, emotional, and embodied processes – and knowledge of these processes informs the pedagogies that are chosen in engineering ethics education. Learners also build their competencies in social contexts, in interaction with each other and with their teachers. This, too, influences the design and choice of teaching approaches of effective teachers. This focus on learning and learners shaped our editorial team's decisions regarding what to include in this handbook. Traditional engineering ethics textbooks would not usually dwell on the psychology of moral development (Chapter 10 within Section 2 and Chapter 28 within Section 5) or on the curriculum and accreditation models for engineering programs (Section 6). The relationship between emotion and rationality in ethics and in ethics learning is also a theme that is not widely considered in other texts but is included here (in Sections 1 and 2, particularly Chapter 4). This book reaches beyond the technical aspects of engineering, drawing from all these domains and more, because they all make important contributions to the expertise of engineering ethics educators.

Understanding teaching, the third component of Darling-Hammond's (2006) framework, corresponds to Dewey's focus on 'methods': the good teacher brings together knowledge of their subject and knowledge of learners and learning to incorporate diverse teaching strategies appropriate to both the content and the learners. In engineering ethics education, this is reflected in the use of a range of different teaching strategies, including case studies, art-based methods, reflection, role play, and challenge- and project-based learning, among other methods (covered in Section 3). Teaching also involves assessment, and crucial aspects include understanding how to evaluate whether or not students have developed the capabilities that were intended (Section 5). Our attention encompasses not only how teachers create assessments for their classes but also their utilization of research-based tools. These tools aid teachers and educational researchers in comprehending the impact of their work and how it might be further developed, as discussed within this handbook.

The three sets – engineering, ethics, and education – provide a framework for thinking about the choices the editorial team made in deciding what would go into a comprehensive handbook for engineering ethics educators and researchers.

The 'mapping' metaphor

The three-component description of engineering ethics education that we have used here is a useful narrative device for describing part of what is distinctive about this handbook and what distinguishes it from other excellent books and resources that exist. It is, however, a post-hoc rationalization; we did not start this project with the framework outlined above in mind. Earlier in this introduction, we described our approach as being to 'map a previously unmapped space,' and it provides a valuable way of thinking about what we intended to do when our team decided in consultation with publishers – to provide as comprehensive coverage of the overall terrain of engineering ethics education as possible. Extending the metaphor also allows us to think about some dimensions of the work that were important to us.

Mapping as a change in perspective

Because so many of us use maps so often, it is easy to forget that mapping requires the capacity to visualize a space from what seems to be an entirely unnatural angle. While we look at the world around us, we see it in a horizontal plane, but mapping requires shifting one's perspective to imagine how that world looks from above. In our world of airplane travel and satellite images, this is perhaps not such a shocking change in perspective, but the earliest known maps may date back some 27,000 years (Wolodtschenko & Forner, 2007). It is worth reflecting on what an effort it must have taken to wrench one's perspective free from the world as it was experienced and to imagine how it looked from above. Looking at maps even today can be a disorienting experience, with roads that feel parallel in experienced reality being seen to diverge in plan, while regularly traveled routes that feel short can be seen to be longer than less familiar ones.

Mapping the terrain of engineering ethics education requires a similar change in perspective. Those working in the field experience it through their interactions within the field, yet, in cultivating this handbook, we needed to present a view of the field that may feel unfamiliar to some of those who live and work in it. At the same time, we wanted to respect the different perspectives of those who 'live the world into being.' For this reason, we built on an emerging practice in engineering education to include positionality statements (see, e.g., Gani & Khan, 2024, Hampton et al., 2021; Secules et al., 2021). Since this is an emerging practice, it was not always easy for authors to know how to describe their position and perspective in engineering ethics education. Our hope is that this approach provides an appropriate counterpoint of 'horizontal' and 'vertical' views of the field and that readers will perceive the utility of seeing the field from these different perspectives.

Mapping as a colonial process

For much of the world, the process of 'being mapped' was intrinsically linked to colonialism; as Richard Phillips has written, "Imperialism went hand-in-hand with mapping, by which Europeans imaginatively and materially possessed much of the rest of the world" (1996, p. 6; see also Anderson, 1991; Gauba, 2002). Maps often served an administrative or military purpose, allowing colonial rulers to more efficiently manage populations, extract resources, and move troops. Imperial and colonial maps also shaped the way in which colonized people lived in their world: as the play *Translations* by Brian Friel (1981) explored, for example, Ordnance Surveyors anglicized and changed place names in 'their' colonies as they mapped and, in doing so, assigned places new names – often stripped of their original meaning – that are still used long after independence.

For those who, like us, want to engage in even a metaphorical mapping project, this is an important reminder. Given Europe's colonial past and postcolonial present, this reminder is perhaps even more crucial for a project like this handbook, which emerged from the European Society for Engineering Education (SEFI). We were acutely aware of the risk of a colonial or postcolonial gaze in mapping the space of engineering ethics education. Our request to all authors to include a positionality statement was one response to this danger. Another was that we tried to be as open and inclusive as possible in the perspectives and voices that contribute to this handbook. A third way in which we sought to acknowledge this risk was by asking authors to go beyond the hegemonic (Western and masculine) moral theories of consequentialism, deontology, and virtue ethics and to engage with a broader set of ethical theories that were also representative of voices previously excluded from the mainstream of engineering ethics education.

Mapping as an unfinishable process

The first attempt at modern mapping of a country is thought to be the Cassini maps of the Kingdom of France, which were developed in the period between the 1740s and the 1780s. It is perhaps interesting to note that, having spent 40 years involved in the project, Cassini died before his mapping work was completed (Brotton, 2013). Even if his work had been completed before his death, by the time it was finished, the world would certainly have changed, and his maps, once finished, would immediately have required revision.

Much changed even during the time we were working on editing this handbook. This project began in the spring of 2021, when travel was still restricted due to the Coronavirus pandemic and COVID vaccines were being distributed (and hoarded) in Western countries. The pandemic raised huge ethical questions for engineers regarding, for instance, the way the virus originated via humans' interaction with the natural world; about the way transport technology facilitated its spread; about the surveillance, monitoring, and privacy of individuals and populations as the spread of the virus was being checked; about the risks involved in rapidly developing vaccines; and about the ethics of nudging populations towards vaccination. As we were working on this book, the release of ChatGPT in November 2022 seemed a seismic moment in how people and technology interact. It also raised big ethical engineering questions about who owned the data on which it was trained, whether or not the privacy of those interacting with it was being protected, the welfare of those involved in checking toxic content, and the risks of the algorithm producing convincing but false information (see Chapter 7 on AI and Chapter 18 on software engineering).

It is not only the world that is changing; educational research also continues to give new insights into how people learn to be ethical. In the years this book was under development, we saw a notable growth in focus on de-colonizing engineering education (Cruz, 2021; Seniuk Cicek et al., 2023); on emotion in engineering education (Lönngren et al., 2021, 2023); on arts-based and drama-based methods in engineering ethics classes (e.g., Martin et al., 2019; Hitt & Lennerfors, 2022); and on challenge- and problem-based learning in engineering ethics education (e.g., Bombaerts et al., 2021; Sukackė et al., 2023), for example.

Because technology and educational science are both changing, what we know about engineering ethics education is changing, too. And so, any attempt to map the space of engineering ethics education will only ever represent a snapshot of that territory at a given moment in time.

Our team sees mapping as an unending process and this handbook as a map of sorts. It is important to remember that 'the map is not the territory.' We render a territory – in this case, the territory of engineering ethics education – on a smaller scale. The process of transposing the territory as a map does not produce a 1:1 rendition of the territory but rather an interpretation that highlights only some features. This recognition emphasizes that our endeavor is not terminated; it can and should be complemented by further attempts at mapping, via different interpretations, all incomplete and, as such, continuously open and never-ending.

Nevertheless, we also believe a good map can still last a long time. The Cassini map number 53 of central France – mapped and engraved in the mid-1700s – maps the small mountain hamlet of four houses where one of the editors of this book spends holidays each year. Of course, there are differences; the spelling is not the same, and the mountain road to the hamlet was not paved until the 1960s, two centuries after Cassini's team passed through, so roads and bridges are undoubtedly different. Yet that map from two and a half centuries ago still shows the names and locations of places that exist today. Our aim with this handbook is to provide a snapshot of the territory that is detailed enough for researchers, teachers, and even students to find it a useful first point of reference – to help them to situate themselves in the territory of engineering ethics education, even as that territory shifts over the coming years.

Our positionality as editors and the origin of this handbook

This handbook grew out of the work of the Ethics Special Interest Group (SIG) of the European Society for Engineering Education (SEFI). The SEFI Ethics SIG Spring School in March 2021 was hosted by EPFL in Switzerland but was held online due to travel restrictions still in place amid a slow rollout of COVID-19 vaccination programs across Europe. One of the themes of the 2021 Spring School was 'collaboratively writing engineering ethics' and, to address that theme, Tom Børsen from Aalborg University presented a review titled "Lessons Learned about Engineering Ethics Education at the SEFI 2020 Conference." One of Tom's conclusions was that a substantial amount of high-quality research on engineering ethics education was being presented at SEFI and that there was a basis there to make a considerable contribution to the field's growth. A participant in the event, Shannon Chance, recommended that Tom curate a handbook or special focus issue based on the expansive terrain he had identified. Coincidentally, just before that Spring School, in winter 2020, and also inspired by the annual SEFI conference, Shannon, Diana Adela Martin, and Thomas Taro Lennerfors had met and discussed the possibility of developing a handbook of EEE.

The stars were aligning, and two weeks after the Spring School, at Tom's invitation, he and Shannon met to develop a strategy, which included inviting as editors Diana, Thomas, and Roland Tormey. Tom and Shannon credit Diana with bringing Gunter Bombaerts onto the project. Tom extended invitations, and almost immediately, the constellation of editors for this handbook (Tom, Shannon, Roland, Diana, Thomas, and Gunter) gathered to discuss how we could build on the work underway via SEFI to 'collaboratively write' engineering ethics education. The composition and characteristics of the team influenced a host of decisions made during the creation of the handbook.

The team is interdisciplinary. It includes editors with diverse backgrounds in multiple disciplines with profiles such as architecture and higher education (Shannon); chemistry, philosophy, and technology studies (Tom); philosophy, liberal arts, and engineering education (Diana); sociology, mathematics, and educational sciences (Roland); industrial engineering and humanities (Thomas); and nuclear physics and philosophy (Gunter). We all have prior experience in editorial roles for journals, books, handbooks, and/or special focus volumes. Some of us also have experience developing inclusive educational projects outside academia (Shannon, Diana, Roland, and Gunter). Through this handbook project, we generated new knowledge, extended geographic scope, and helped build additional publishing and project management skills among ourselves and our larger engineering and ethics education community.

The editorial team is gender diverse (two women and four men). Its members come from or have worked in various places, including Belgium, Denmark, Ireland, Japan, the Netherlands, Romania, Sweden, Switzerland, the United States, and the United Kingdom. We share a high level of respect and advocacy for diversity, equity, and inclusion. Alongside our gender, national, and disciplinary diversity, we also have similarities that present limitations in our endeavor to represent diverse viewpoints: we are predominantly (although not entirely) white and of European descent, and we all currently work in technical universities or engineering faculties in Europe.

Most of us are research-active in engineering ethics, having published on topics that we see as linked to engineering ethics and which appear in chapters throughout this book – like energy policy, energy justice, global responsibility, corruption, AI ethics, innovation for sustainable transitions, innovation ethics, corporate social responsibility, insecticide use, and interpersonal discrimination in teams (see, e.g., Chapters 6, 7, 11, and 13). All of us are research-active in engineering ethics education, having published on pedagogical methods in ethics education (including case studies, role play, use of film, and challenge- and problem-based learning); on global and historical perspectives in engineering ethics education; on the impact of accreditation on ethics

education; on emotions in learning ethics; and on the integration of socio-ecological responsibility into engineering study programs. We have drawn upon various epistemologies and research methodologies, including philosophical inquiry, quantitative and qualitative social research methods, and systematic literature review. These research interests and features of our epistemological positions certainly impacted our choices in framing this book.

Cultivating researcher capacity and building community were central concerns for the editors. Two of the editors (Roland and Shannon) have been involved in organizing SEFI annual conferences, and three of us (Gunter, Roland, and Diana) have been organizers or co-organizers of four SEFI Ethics Spring Schools. Many of us (Diana, Roland, Gunter, Thomas, and Tom) have also been involved in organizing the SEFI ethics webinar series, the SEFI ethics newsletter, the SIG annual conference workshops, and ethics working group meetings, among other things. At the start of this project, one of us (Shannon) was just finishing a term as chair of the global Research in Engineering Education Network (REEN), having led a transformation toward more geographically diverse representation and extending REEN's work to build the capacity of educators to use and conduct engineering education research. Our shared focus on community-building is evident in the choices we made in developing this handbook.

Different members of the editorial team played different roles during the handbook's development; however, we each took responsibility for one section: recruiting authors, supporting them, managing feedback workshops and peer reviews, and editing their chapters.

Tom was the conceptual lead for the project, and Shannon was the organizational and production lead and the point-of-contact with publishers. Together, Shannon and Tom collaboratively managed the overall effort. Shannon took the lead in crafting detailed proposals and negotiating with publishers; Tom managed our team meetings. The two mapped the overall process, timelines, and deadlines. In the final months, Shannon copy-edited all the chapters and introductory statements, ensuring a degree of coherence in linguistic style and approach across the 105 different authors and providing extensive editorial assistance in some cases. She contributed a significant amount of content for most of the overview statements (sections 1, 3, 4, and 6) and made substantial contributions to several of the chapters (including Chapters 27 and 33). Shannon has also taken the lead on publicizing and promoting the handbook, offering workshops, and facilitating panel discussions at conferences around the globe during the production phase of publication. The editorial team encourages all contributors to promote the work and to organize similar events – that present the content, engage and empower people to use it, and invite others to join our engineering ethics education efforts – whenever possible.

The whole team worked to identify gaps and ways to fill them, adding several new chapters along the way. Diana, Shannon, and Tom worked closely to identify and address ethical concerns related to author attribution and acknowledgments, aiming to achieve a high level of transparency and fairness. Nevertheless, our team recognizes the probability of inadvertently failing to acknowledge some of the invaluable contributions made, and we apologize to anyone whose contribution has not been rightfully named and attributed.

Our first step in bringing this project together was to organize a participatory workshop at the SEFI conference hosted by TU Berlin and held online in September 2021. Working with the participants at that workshop (titled 'Eager to Contribute to an Engineering Ethics Education Handbook?') helped us co-construct an outline of the six sections of the handbook and identify some content, structure, and potential authors for each section. Building on this, we, as editors, developed a plan for the handbook and an outline of what it should contain.

In March 2022, we launched an open call for authors, outlining the proposed structure and content and inviting educators and scholars to express their interest in participating in the project. We

connected with various organizations, asking them to distribute our call for authors. We posted the call on the SEFI website. We reached out to personal contacts and as wide and globally expansive an array of engineering education organizations as possible. We asked interested people to tell us about their background and motivation, what chapter topics interested them, and whether or not they already had co-authors to propose. We were delighted to receive over 100 responses from across the globe.

Using this list of interested authors, we set about building author teams. We aimed to assemble an international author team for each chapter; ideally, each team would include four people from different institutions and countries and, wherever feasible, from different continents. We identified and invited a lead author for each chapter, outlining our collaboration aims and recommending potential co-authors for the chapter team while leaving the lead authors leeway to choose collaborators.

At the end of the process, we asked each author to let us know all the places they had lived or worked for a year or more. We developed Figure 0.1 using that dataset; the map helps us see the geographic extent of the community contributing to this resource. The map helps demonstrate our diversity, but it also makes visible where our community has not yet connected. It provides us with a valuable benchmark for the future.

Although the map communicates some core ideas about our cultural roots and our mobility, there are some things we would improve for subsequent versions: we would ask authors to pin their own locations for greater accuracy, and we would select a different base map (the one we used here was available open access on Wikipedia). We recognize that 'mapping and colonialism' are themes in this introduction, yet the equirectangular distorts space and makes equatorial regions appear smaller and, implicitly, 'less important' (Africa looks 2.5 times the size of Greenland but is, in fact, 14.5 times the size). Two-dimensional depictions of the world map projection are the subject of lively debate and are heavily contested in de-colonial studies of mapping – we support the push to evolve them.

Many of the teams that crystallized were interdisciplinary, and some were composed of people who were strangers to each other at the beginning of the process. As editors, we pondered and discussed if we were making things unnecessarily difficult for ourselves and for our authors, but the author teams approached their tasks with openness, good humor, and diligence – and they began to craft rich and coherent narratives. The pairings worked in almost every case, and the rate of success across teams was even higher than we have experienced with other book projects. We are incredibly proud of the quality, coherence, and comprehensive nature of the overall compilation – and of the community spirit and collaborative nature of the undertaking.

It was not enough to build coherence based simply on the diversity of authors within each chapter. We also needed to build coherence across chapters – within and across sections. Our first step was to cultivate coherence within themes by organizing workshops where authors presented their work to others within the same section and provided each other with feedback. This allowed authors to start to see overlaps, commonalities, and tensions within their respective sections. Once draft chapters were ready, we began to scale up – to look for coherence and tensions across sections. We did this by having each chapter reviewed by at least two other authors, typically one from within the same section and one writing in a different section. In this way, those working on an individual chapter could position their work within the broader context of the handbook. We enlisted a few additional experts to fill gaps during the review process.

Tom and Shannon dedicated themselves to fostering connectivity, coherence, and comprehensiveness across the entire collection, striving to impart a sense of unity and completeness to the book. They added chapters during the development of the book to cover emerging or

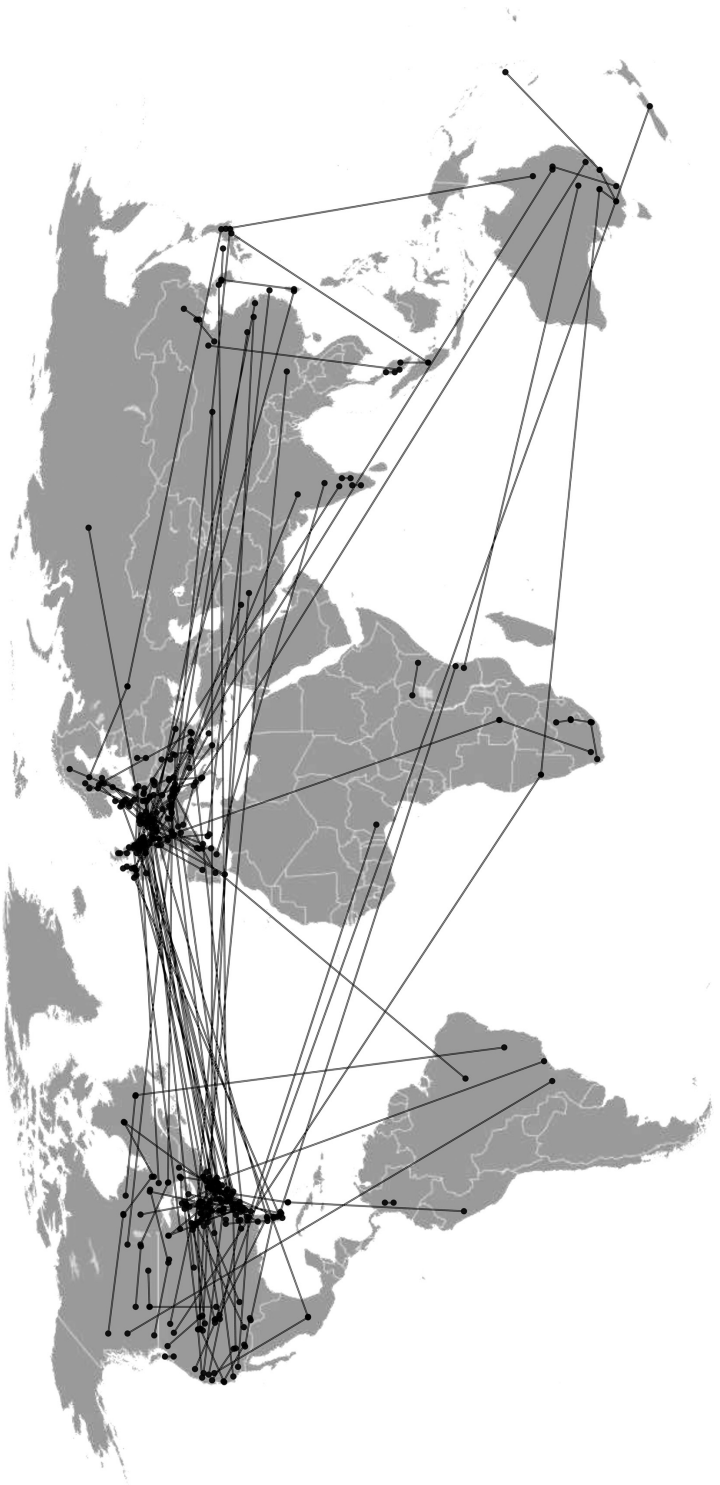

Figure 0.1 Map of authors' homelands. The circles indicate the countries where our authors have lived and/or worked for a year or more, and a line connects each contributor's countries.

under-recognized issues. Shannon edited the chapters for grammar and style, cross-referencing where possible. Tom and Shannon worked together to analyze the section overviews; they sought to ensure the overviews describe the respective themes in relation to the larger contexts of engineering, education, and the full set of manuscripts the handbook encompasses. Shannon and Tom also worked closely with Diana to ensure that individuals were adequately recognized for their contibutions.

As noted above, growing out of the work of the SEFI Ethics SIG, our starting point was the idea that we could facilitate a process to collaboratively 'write' and simultaneously 'map' engineering ethics education in a way that transgressed disciplinary borders and colonial and postcolonial (or hegemonic and oppressed) narratives; and moreover, that we could do so by involving a wide set of voices and that we could collaborate to build something that was at once rich, multi-perspectival, and coherent. We recognized the ambitious scope of the task we set ourselves and our team of authors, but with trust in each other, in the process, and in our authors, we have arrived at this handbook that charts the emergence of a coherent and vital field of study: engineering ethics education.

The structure of this handbook

This handbook is divided into six sections. The first three sections address the content and purpose of engineering ethics education, and how disciplines like engineering, environmental science, ethics, and other social sciences and humanities disciplines (and non-Western knowledge systems) feed into EEE. The subsequent three sections address processes surrounding and forming EEE: teaching methods, assessment, and accreditation.

The first section, 'Foundations of engineering ethics education,' discusses some foundational issues that underpin engineering ethics education. The issues covered in this section range from the purpose(s) of engineering ethics education to the relationship between engineering ethics education and the field of ethics, individual judgment and decision-making versus collective issues, professionalism related to engineering ethics education, how engineering ethics education relates to reason and emotion, how environmental concerns relate to EEE, and emerging issues in AI. This section contains seven chapters.

The second section, 'Interdisciplinary contributions to engineering ethics education,' makes the assumption that engineering is an interdisciplinary and applied field that draws from foundations provided by mathematics, natural sciences, computer science, management studies, social sciences, and the arts. Ethics education is equally an interdisciplinary field, drawing notably from psychology, philosophy, sociology, and social policy studies. It follows that understanding engineering ethics education requires a multidisciplinary foundation. This second section aims to provide an understanding of the foundational concepts, approaches, and problematics central to engineering ethics education. In Section 2, these concepts, approaches, and problematics are explored within the context of the disciplines from which they emerge. Six chapters comprise this section.

The third section features chapters articulating the ethical challenges of different engineering disciplines. Each of the chapters delineates which ethical issues, dilemmas, and challenges are discussed in the specific discipline and explores how the discipline's students and practitioners might address them. The ethical issues included cover both processual issues (like user involvement, codes of conduct, early warning systems, distribution of responsibility, ethical design, etc.) and the wider ambiguous implications of technology and engineering solutions (in relation to digi-

talization, energy, human rights and dignity, pollution/environmental impacts and climate change, colonization, big tech's influence on technological solutions, military technologies, technological accidents, etc.). Section 3 outlines how these issues, dilemmas, and challenges are approached and suggests solutions in engineering ethics education within various engineering disciplines. The section examines both the similarities and differences in topics suitable for inclusion in the ethics education of various engineering disciplines, as well as the diverse approaches to addressing ethical issues, dilemmas, and challenges within each discipline. Although this section encompasses only five chapters, the set provides a glimpse into the breadth of engineering work within subfields, showcasing a diverse range of concerns and approaches.

The role of the fourth section, 'Teaching methods in engineering ethics education,' is to delineate the established and emergent methods used to teach engineering ethics. Current research reflects a deep fragmentation of pedagogical approaches and confusion as to which approaches are most suitable in preparing socially responsible engineers. There are limited empirical findings to serve as guidance in the implementation and teaching of engineering ethics. However, there is a significant body of knowledge in relation to medicine, business studies, and other science, technology, engineering, and mathematics (STEM) fields that can serve as inspiration. Given that a coherent curriculum strategy requires alignment, Section 4 dialogues with the other handbook sections concerned with theoretical frameworks and assessment strategies. It is important to address the topics falling under these sections in conjunction, as a lack of clarity and alignment might lead to missed educational opportunities. This section includes seven chapters.

Section 5, 'Assessment in engineering ethics education,' deals with the difficult and challenging topic of assessment in engineering ethics education. It encompasses both the assessment of students and the evaluation of courses. Those assessing students in ethics education always have to balance measurability on one hand with aiming for the richness of topics (and developing competencies like moral reasoning or moral attitudes) on the other. Course evaluation poses a similar challenge. *What should be the aims of an ethics course, and how can the course be judged to be good (enough)?* Often, students' satisfaction is considered, but it can also be asked, *What can be reasonably said about a course's effectiveness in realizing moral sensitivity or moral attitude?* This section contains six chapters.

Section 6, the final section, 'Accreditation and engineering ethics education,' addresses accreditation policies and practices that have driven the adoption of ethics education within engineering courses worldwide, considering that expectations (particularly regarding student performance or 'learning outcomes' related to ethics) have been difficult to define and assess. This section on accreditation, as related to engineering ethics education (EEE), considers the background history of ethics in accreditation, maps national and international accreditation values and practices, discusses the role of accreditation in licensure, and reflects critically on whether and how accreditation promotes EEE at local and global levels. Five chapters are included in this section.

The handbook is structured so that this introduction provides an overview of some of the transversal conclusions offered within the book's pages to engineering ethics education researchers and teachers, as well as to higher education management. Each section opens with an editorial introduction that identifies what the respective section editor finds most important to highlight about the section. We recommend reading both the book introduction and the introductions to the six book sections in addition to the specific chapters that align with the reader's interests. In this way, readers can gain both gain an overview of engineering ethics education as a research and teaching discipline, and an in-depth understanding of some of its many facets. Reading section introductions will also contextualize the individual chapters of the book.

Acknowledgments

The editorial team thanks each author for their invaluable contributions and commitment to this handbook endeavor; the authors' collective efforts have resulted in a comprehensive and illuminating exploration of engineering ethics, shedding light on the evolution of how ethics is perceived, defined, and practiced in engineering and engineering education as well as challenges and implications in today's globalized world. It has been a privilege to lead this project and witness the depth of knowledge and dedication demonstrated by each chapter team throughout the process. Together, the editors and authors have navigated complex topics and discussions, striving to provide readers with fresh insights and innovative perspectives on critical aspects of engineering education. From the outset, we editors sought to provide a comprehensive overview of the state-of-the-art in engineering ethics education and to push the boundaries forward collaboratively. We are proud of the collegial spirit and intellectual rigor demonstrated, and we look forward to seeing the impact of our collective work in shaping the future of engineering ethics education.

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We drew inspiration from the *Cambridge Handbook of Engineering Education Research* (Johri & Olds, 2014) and the *International Handbook of Engineering Education Research* (Johri, 2023). The second of these had similar aims regarding institutional and geographical diversity; Diana and Shannon served as Associate Editors (as well as authors and peer reviewers), supporting the handbook's Editor, Aditya Johri, in his efforts to reach farther outside North America for perspectives and contributions. Aditya helped pave the way for this new ethics-specific handbook by negotiating with Routledge the open-access purchase agreement that our present team was able to use and sharing advice and insights into the process with Shannon.

Each handbook editor facilitated a contribution to the financial costs of ensuring open access to this new *Routledge International Handbook of Engineering Ethics Education*. The open access cost was covered by Technological University Dublin (Shannon and Diana), the Department of Sustainability and Planning at Aalborg University (Tom), EPFL (Roland), the Division of Industrial Engineering and Management at Uppsala University (Thomas), Eindhoven University of Technology (Gunter and Diana), and University College London (Diana and Shannon). Providing this handbook as a free and openly available digital resource was a primary goal of Shannon and Tom from the outset; the whole editorial team embraced this vision and secured funding to support the project. We and the whole editorial team are indebted to our institutions for supporting us in our work and in purchasing open access.

We explicitly sought to ensure that newer voices could confidently contribute to the book by matching less experienced authors (i.e., those undertaking PhDs or just entering the realm of EEE research) with scholars who have more writing experience. We are thankful to the more senior researchers who welcomed newer entrants to the field onto their teams and, in many cases, provided mentorship. We recognize that those who did so provided an extra, and invaluable, service to our global EEE and engineering education research community. We hope that readers will recognize these mentoring and capacity-building characteristics in many of the projects and activities we lead, including and beyond this handbook.

We collectively thank our families and significant others who put up with us and were supportive as we spent long hours on the project. We also thank our colleagues for the conversations that pushed us to think better about the work at hand.

In conclusion, our journey in crafting this handbook on engineering ethics education has been one of joyful co-creation, mutual respect, and collective endeavor. With a diverse array of voices contributing to the discourse, our editing process aimed to maintain coherence within chapters, thematic sections, and the book overall, all while reflecting the dynamic landscape of engineering ethics education today, both as a research domain and a pedagogical subject. Engaging with 105 authors, we have cultivated a collaborative, multi-perspectival text that we hope will be seen as a

significant contribution to our field. The bi-weekly meetings of our editorial team, and the many breakout sessions conducted with various clusters of editors and contributors, have proven fruitful and intellectually enriching, fostering friendships and trusted collegial bonds. The overall experience has been immensely fulfilling, yielding a resource that we hope will be key to catalyzing action to further advance engineering ethics education. We welcome readers to join our community by reaching out to the editors and authors regarding topics of mutual interest and possibilities for future collaboration. Together, we want to celebrate and extend the value of this handbook and grow the community of voices contributing to our understanding of engineering ethics and engineering ethics education.

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