Ethics and Engineering

The world population is growing, yet we continue to pursue higher levels of well-being, and as a result, increasing energy demands and the destructive effects of climate change are just two of many major threats that we face. Engineers play an indispensable role in addressing these challenges, and whether they recognize it or not, in doing so they will inevitably encounter a whole range of ethical choices and dilemmas. This book examines and explains the ethical issues in engineering, showing how they affect assessment, design, sustainability, and globalization, and explores many recent examples including the Fukushima Daiichi nuclear disaster, Dieselgate, "naked scanners" at airports, and biofuel production. Detailed but accessible, the book will enable advanced engineering students and professional engineers to better identify and address the ethical problems in their practice.

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An Introduction

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For my parents, Simin and Rusbeh

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Preface

Tell an engineer that you teach *engineering ethics* and it will not be long before you hear one of the biases about engineering, about ethics, or about how the two fields relate to each other. Ironically, one persistent bias is the view that engineering is an *unbiased* and *objective* practice, because "engineers deal with facts and figures, so there is no place for opinions or ethics in the practice of engineering." Another bias, fueled by much thought and discussion about ethics in relation to malpractices, is that an engineer "must be honest." Sometimes you hear other affirmative responses that are no less upsetting: "Of course it is very important that engineers follow the law." Unfortunately, these oversimplifications of the respective fields of engineering and ethics (and their relation to each other) have given rise to some dismissiveness of ethics from engineers. This is disconcerting because engineers and prospective engineers have an essential role to play in meeting the grand challenges of the twenty-first century and in shaping our future societies. The world population is growing, yet we continue to pursue higher levels of well-being. Increasing energy demands and the problems resulting from climate change are only two of the many major challenges that humanity is facing in this century. Whether engineers recognize it or not, in addressing these challenges, they will encounter a whole range of ethical choices and dilemmas that they will have to deal with. This certainly applies to various existing technologies and engineering practices, but more and more it applies to innovative and emerging technologies, such as technologies that employ artificial intelligence (AI).

With technological developments in general, and with innovations more specifically, ethics is sometimes seen merely as a moral brake giving a green or red light to development. This is why some engineers shun ethics in practice, because they often consider ethics to be the red light in terms of what they could develop through innovation. In this book, I aim to consider

ethics in a nonbinary way, which could help ethics to steer technological developments at an early stage. This kind of nonbinary moral analysis is already the focus of current "ethics and engineering" studies, and it definitely requires an interdisciplinary approach, demanding the involvement of applied ethicists, but it is equally important to take engineers on board with such analyses. In other words, engineers should have a certain degree of knowledge and awareness of these ethical problems. I aim to contribute to that awareness through this book by introducing the concept of *ethics up front*. Rather than dwelling on ethical reflections in retrospect, this approach aims to facilitate the proactive involvement of engineers in addressing ethics in engineering practice and design. Immersing engineers in real-world ethical issues of engineering should enable them to identify the ethical problems at hand, and to choose different tools and frameworks to proactively address those problems in their practice of engineering.

Let me briefly mention what I mean by the *practice of engineering* and how that is reflected in the set-up of the book. In their normal practice, engineers employ and engage in a variety of activities including the assessment and evaluation of risks, costs and benefits, and the design and development of new artifacts and systems, for instance, energy systems. In those activities, ethical values are expressed either explicitly or implicitly, and other ethically laden choices are being made, whether they are recognized or not.[1] It is my intention to help engineers to become more sensitive to these ethical issues in their practice and to think more intentionally about them. After the introductory chapter (Chapter 1), in which I set the scene for the ethics-up-front approach, the book is arranged into three parts, each containing two chapters.

Part I is about the assessment method used in the engineering practice. In the first chapter here (Chapter 2), assessments of risk are discussed, along with questions about societal and ethical aspects of risk. The second chapter (Chapter 3) discusses the Cost–Benefit Analysis (CBA) as a crucial assessment method for engineering projects, along with critiques of the method in terms of ethics. This chapter also discusses alternative methods for balancing costs, benefits, and environmental impacts of engineering projects. While both chapters detail critiques of the proposed assessment methods, it is not my

[1] I thank an anonymous reviewer for helping me to better pinpoint what I mean by "practice" in this book.

intention to dismiss any of these methods; that would be throwing the baby out with the bathwater. Instead, I have tried to highlight the possible shortcomings of these methods in order to help engineers to apply the methods in a more vigilant manner. Moreover, I have tried to present the adjustments, amendments, and so on, that the literature suggests in order to deal with the ethical problems of each of these methods. In this part, I also briefly discuss ethical theories in relation to the engineering examples discussed.

The focus of Part II is on engineering design as a crucial aspect of engineering practice. The first chapter in this part (Chapter 4) covers methods for including ethical values in design, especially when conflicting values are encountered. At the same time, the text presents a broad notion of design – including, for instance, the design of an energy system – in such a way that it endorses important values. The second chapter (Chapter 5) addresses a specific type of design that has recently become very important, namely the question of designing morality into the machine. New applications based on AI present a host of unprecedented ethical issues.

Part III of the book covers issues pertaining to sustainability and globalization in engineering ethics. The first chapter (Chapter 6) focuses on the questions of sustainability in energy discussions, presenting a method of using sustainability as an ethical framework rather than as a yardstick to pass a judgment on an energy technology, as, say, sustainable or unsustainable. Building on this nonbinary thinking, the book considers the broader questions of energy ethics, including important considerations of justice that may be involved in engineering practice.

The second chapter of Part III, and the last chapter of the book (Chapter 7), focuses on being more inclusive in engineering ethics. While the literature already fully acknowledges the importance of thinking about the globalization of engineering and engineering ethics, the current focus in the literature is predominantly on the ethical implications of technology transfer, or the conflicts that a Western engineer might come across when working in non-Western countries. Consequently, in this chapter I argue that the ethical issues that engineering raises in different parts of the world, especially in emerging economies that are industrializing at a fast pace, are definitely worthy of consideration. Those issues extend far beyond the problems of technology transfer or problems that a Western engineer might encounter when working in a country with different ethical standards. I review several reasons why we need to incentivize international approaches in thinking

about and teaching engineering ethics. In addition, I focus on two main approaches for the latter, namely globalizing and diversifying engineering ethics.

Let me make three remarks about the set-up of the book. First, there may seem to be a topical asymmetry between different chapters in each part and also between different parts of the book. For example, one might argue that "morality and the machine" (Chapter 5) is itself a specific kind of designing for values (Chapter 4) – so why keep them separate? In selecting the themes of this book, I have taken several important ethical issues that emerge as a result of engineering practice to be very broadly conceived. Sometimes certain issues have received additional attention. For instance, while Chapter 5, in a sense, extends Chapter 4, a specific focus on "morality and the machine" enabled me to discuss the broader ethical issues associated with AI more explicitly, including questions of agency and control. Another argument might be that sustainability and globalization do not necessarily relate to engineering practice. While sustainability is indeed not an engineering practice per se (as design is), thinking about sustainability in evaluating different energy technologies does come up in many engineering discussions and decisions. We could call these the "macro-ethical issues" in the practice of engineering.

This brings me to the second remark. In this book, I have reviewed two approaches to discussing engineering ethics, namely, (a) ethics and the engineer and (b) ethics and the practice of engineering. While there are some discussions about the former, particularly about the responsibilities of an engineer in Chapters 1 and 7, this book predominantly discusses the latter approach. This is by no means a normative judgment about one approach being more important than the other but merely a pragmatic attempt to fill a gap in the engineering ethics literature (especially in textbooks). Indeed, many engineering ethics books currently on the market already focus on the former approach and discuss in detail the "micro-ethical" issues that individual scientists and engineers will have to deal with on a daily basis.[2]

[2] The interested reader might wish to consider another book in the same Cambridge Applied Ethics series, *Ethics and Science* by Briggle and Mitcham on the broader issues of science and engineering (including research ethics), and also Van de Poel and Royakkers' *Ethics, Technology and Engineering*, *Engineering Ethics* by Harris et al., Davis' "Thinking Like an Engineer," and Johnson's "Engineering Ethics" for elaborate discussions of engineers' responsibilities and codes of conduct and other relevant issues in professional ethics.

The current book aims to focus on the macro-ethical issues, by expounding on the second approach pertaining to ethics and the practice of engineering, in which the proactive approaches to ethics in design and other engineering practices will be reviewed and expanded.

Third, my ambition with this book is to reach out to both advanced engineering students and professional engineers. While the book has not been specifically designed as a textbook (with assignments at the end of each chapter), I hope that its thematic breadth and accessibility of discussing ethics will make it appealing for advanced graduate (PhD) students in engineering who wish to know more about ethics. I also hope that the book can reach practicing engineers with an interest in ethics. I have further tried to keep the book interesting for a broad international readership both in the developing world and emerging economies and in the industrialized countries.

In the process of writing this book, there have been many groups and individuals that I wish to thank for their support, for helpful feedback, and for encouragements. First, I wish to thank the Section of Ethics and Philosophy of Technology at Delft University of Technology, and in particular Ibo van de Poel and Sabine Roeser, for their helpful feedback and support in finishing this project. Part of this book was written during a research visit to Politecnico di Milano in 2019, where I was hosted by the META group, which is an interdisciplinary network of scholars from engineering, architecture, and design departments. I wish particularly to thank Viola Schiaffonati, Daniele Chiffi, and Paolo Volonté, not only for their hospitality but also for allowing me to teach the contents of some of these chapters in their ethics classes. I owe special thanks to Hilary Gaskin of Cambridge University Press for inviting me to contribute to this Cambridge Applied Ethics series, and also for being patient with me over the many deadline extensions I had to request for various personal and professional reasons. I wish also to thank four anonymous reviewers for their careful reading of the manuscript and their helpful feedback.

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While different parts of this book have been read and commented on by different colleagues from both engineering and philosophy perspectives, the usual disclaimer applies: Any remaining mistakes are my own.