

BOOK REVIEW

Steps Toward a Philosophy of Engineering: Historico-Philosophical and Critical Essays by Carl Mitcham (2020) 445pp., £130 (hardback) £35 (paperback) Rowman & Littlefield, London, ISBN 978-1-78661-126-0

Preliminaries

Carl Mitcham has worked for many years on bridging the gap between philosophy (his specialist discipline) and technology (the one with which he has been engaging). He is probably the most eminent and respected exponent of that relationship, having established his credentials through his seminal book *Thinking through Technology: The Path between Engineering and Philosophy* (Mitcham, 1994). The title of the book is interesting, given that it is *engineering* with which he is seeking a bridge. Twenty-five years later, with this latest compilation of essays, he feels that the bridge has yet to be built. As in his groundbreaking book of 1994, Mitcham is nothing if not comprehensive in this collection. Reviewing it is a daunting task. Although the essays are collated into three parts, the logic for doing so was not quite convincing for me. So, I shall engage with the book under the four broad themes of metaphysics and epistemology (largely drawing on the Introduction, and Essays 3, 6, 8, 14 and 19); ethics (Essays 1, 5, 7, 9, 10–13, 15–18 and 20); design (Essays 2, 4, 9, 10 and 18); and education (Essays 3, 11 and 13, and the Appendix). I should warn readers that it has been impossible for me to write this review without alluding to my own work, *Philosophy for Engineering: Practice, Context, Ethics, Models, Failure* (Dias, 2019), which I know was published too late for Mitcham to interact with – had he wanted. I shall also disclose that I am a civil engineering academic with some consulting experience (i.e., credentials in the ‘real’ world) who has been publishing on the philosophy–engineering interface for 20 years.

Metaphysics and epistemology

Mitcham says in his Preface that engineering is ‘an insufficiently thematized but deeply distinguishing feature of the present age, more powerfully definitive of modernity than science, technology or democracy’ (p.xiii). And yet, in his Introduction (and Essay 8), he bemoans the fact that engineering has largely been ignored by both philosophy (including philosophy of science) and technology (e.g., science, technology and society studies). He does, however, point to some initiatives; for example, the proceedings of workshops on philosophy and engineering (Preface), and works by Michael Davis (1998) on *Thinking like an Engineer: Studies in the Ethics of a Profession*, Walter Vincenti (1990) on *What Engineers Know and How they Know it*, and Samuel Florman (1994) on the *Existential Pleasures of Engineering*. I think it is such attempts to get into the minds of engineers, and promote reflection, that Mitcham is advocating.

Although engineering and philosophy might appear to be poles apart, Mitcham makes the interesting observation in Essay 3 that both deal with ‘everyday’ things, perhaps being less specialized than, say, science on the one hand or sociology on the other. Recall the dialogues of Socrates about such everyday things; and my own thoughts that Heidegger’s ‘average everydayness’ (and ways to transcend it) can shed light on engineering practice (Dias, 2006). Mitcham says that most of us are philosophers in some way or other, in that it is human to reflect on our actions, thoughts and existence; and also engineers, in that we seek purposeful transformations of our environments. So, a *rapprochement* between engineering and philosophy appears possible, but we are yet to see its fruition.

One very illuminating distinction Mitcham makes is that between a philosophy *for* engineering and a philosophy *of* engineering (Essay 6). Broadly speaking, he describes the former as a justification, perhaps even celebration, of the engineering approach; whereas the latter would constitute a genuine questioning of engineering from without. The efforts of the engineers he cites (such as Florman, 1994, Vincenti, 1990, and Koen, 1985) are probably examples of the former. Mitcham's own writings, including this collection, could count as an example of the latter, although since his basic disposition towards engineering is extremely positive, he could be seen as embodying both approaches. My own feeling about this is that Heidegger would be a very useful philosopher with whom to engage in developing a philosophy both for and of engineering. On the one hand, he stresses the importance of 'doing' over 'thinking', thus endorsing the value of the very pragmatic engineering profession (Dias, 2019). On the other, he was deeply suspicious of technology, mainly because of its departure from holism (as reflected in, say, craftsmanship) into reductionism; and also because it tended to conceal various realities by engulfing all other 'ways of being' (Dias, 2019).

Another point of departure suggested by Mitcham (Introduction) is whether the philosophy of engineering could be a sort of applied philosophy of science. This strikes a chord with my own work (Dias, 2019), where I have demonstrated the relevance of Popper, Kuhn, Polanyi and Heidegger to engineering. Note that I have strongly disputed the view that engineering itself is (merely) applied science (Dias, 2019). Blockley (2020) is another engineer who has been doing this for a while now; for example, making distinctions between the goals of science (truth, accuracy) and those of engineering (safety, dependability). Such exploration of the terms and questions that arise in engineering resonates with an approach to the philosophy of engineering classified by Mitcham as 'linguistic' (Essay 8).

One significant critique of engineering made by Mitcham is that its ends are not integral to it (see Essay 14, provocatively titled 'A philosophical inadequacy in engineering'). He argues that the ends of such disciplines as medicine and law are immediately obvious, namely health and justice respectively (hence first-order ends); whereas those of engineering, such as the public good or safety, are not readily evident and have to be socially negotiated (hence second-order ends) – thus making engineering captive to dominant social forces, whether government or business. This is a very important challenge that has implications for engineering ethics and education.

Mitcham says that engineers need philosophy in order to achieve professional maturity (Essay 8). While he gives many suggestions and challenges for engineers to pursue, engineering also needs advocates from the ranks of philosophers who endorse its intellectual stature, especially *vis-à-vis* science. He portrays William Wimsatt (2007) as arguing in effect that 'science is nothing but engineering' (Essay 19). Steven Goldman (cited in the Introduction and elsewhere) says that although socio-economic policymaking achieves its own credibility by claiming that its approaches are 'scientific', it is in fact the engineering approach of satisfying multiple objectives and making compromises that does and should guide policy. He calls this approach one of 'compromised exactness' (Goldman, 2018), and points out that it is based on contingency rather than necessity. In fact, this debate between the intellectual stature of theoretical wisdom (*theoria*), commonly understood to be science, and practical wisdom for action (*phronesis*) that characterizes engineering, goes back to Aristotle himself (2000) who, though recognizing the importance of the latter, nevertheless gives pride of place to the former. Engineering is arguably bound with such chains from Ancient Greece, and it requires philosophers (e.g., Long, 2002) to break them.

Ethics

Most excursions by philosophers into engineering involve ethics, which features strongly in this selection too. Essay 9, titled 'A spectrum of ideals in engineering ethics, simplified', is the key contribution, in my opinion. Mitcham traces how the dominant ideal started off as one of loyalty, primarily to the state, probably derived from the military roots of engineering (see Essay 1). These roots, incidentally,

may also be responsible for such engineering qualities as decisiveness in spite of uncertainty and resoluteness in the face of seemingly insurmountable odds (Dias, 2019). The above loyalty was then transferred to large corporations that employed many engineers, who perceived them as delivering large and useful public works and goods. The next ideal, which could be seen as a bridge between companies and the public, was one of efficiency. Note that Arthur Mellen Wellington, the American civil engineer who wrote *The Economic Theory of the Location of Railways* in 1887, is credited with the saying that ‘An engineer can do for a dollar what any fool can do for two’. The last ideal of holding paramount public safety, health and welfare is a relative latecomer to the stage, although this is now the stated aim in most codes of ethics published by professional engineering associations.

I think Mitcham suspects that the original ‘ethos’ (same root as ethics) of loyalty, whether to state or employer, probably subverts engineers’ capacity to be critical of their masters *vis-à-vis* the public good. Their lack of direct contact with the public does not help either, given that they are employed together in large numbers in both public and private sectors (Davis, 1998; Dias, 2019). Although professional associations are supposed to mediate in this process, they do not have a good record, and engineering ethics issues are confined largely to those internal to the profession (Herkert, 2001). Mitcham makes the very telling observation (Essay 13) that Médecins Sans Frontières (MSF) tends to pay much less attention to national sovereignty in its cross-border humanitarian ventures than Engineers without Borders (EWB). This deficiency in critiquing the powerful could be another reason for philosophy not taking deep root within engineering, given that the former is critical by definition. Recall Plato’s portrayal of Socrates as the ‘gadfly which God has attached to the state’ on behalf of the Athenian people.

It appears to me that one resolution to this tension between loyalty to state versus loyalty to people proposed in these essays is through engineers’ involvement in policy and politics (Essays 16 and 17). In this we can find a commonality between both Aristotle and Confucius (Essay 16). Mitcham cites Li Bocong’s (2008) idea of an engineering ‘ethics of coordination’ as possibly being a form of engineering politics. Furthermore, since policy is based on reason, whereas politics is focused on power, a strong case can be made for engineering involvement, especially in the former (Essay 17). Note again Goldman’s (2018) view that the engineering approach is decidedly apposite for policy. Elsewhere (Essay 12) Mitcham commends the French engineering experience, where ‘state engineers’ are high-level civil servants, engineering education is the way to social and political advancement, and ‘planism’ (i.e., rational planning) was once explored by some graduates of top engineering schools as a philosophical alternative to capitalism, communism and fascism.

Three essays can be viewed as case studies of policy, namely those on energy (Essays 17 and 18) and sustainability (Essay 10), which are current global concerns in which engineers are deeply involved. Issues of unequal distribution are brought out in both essays, and some counter-cultural ideas presented; for example, that scarcity (or an economy of subsistence) could be the only really sustainable option (Essay 10), and that per capita increases in energy production lead to greater equity only up to a point (Essay 18). I cannot help pointing again to Heidegger, whose critique of energy runs much deeper, given that he bemoans the very labelling of what can be done with energy as ‘work’ (in physics). Thus, holistic distinctions between ways of generating energy and doing work are levelled down via a reductionist recourse to common units of measurement for both. This leads to alienation from the environment and devaluation of human involvement (Dias, 2019). If engineers are to pursue or even consider such radical opinions and policies that question the *status quo*, they will need much deeper formation in reflective thinking.

But how about the technologies themselves? Should engineers not assess them? On the one hand, they are portrayed as being among the most self-reflective of professionals, based on the number of documented self-assessments available (Essay 11). Mitcham, however, cautions that the future holds many challenges for what he calls the ‘techno-lifeworld’ that will be inhabited by *homo faber*, so-called not only because we make things, but also because we are made by them in both a psychological and transhumanist sense (Essay 20). He calls this the ‘ultimate grand challenge of

self-knowledge, that is, of thinking reflectively and critically about the kind of world we wish to design, construct and inhabit in and through engineering' (p.284). He refers to Karl Jaspers' (1953) 'axial age' around 2500 years ago when philosophers and ethicists the world over began to ask questions about what it means to be human. Just as much as that reflection resulted in the limitation of human action (e.g., not killing, stealing), Mitcham feels that we are at the cusp of a second axial age involving the techno-human condition. He thinks that engineers, who are at the forefront of this techno-lifeworld, need resources from the body of knowledge that has arisen from the first axial age (i.e., the humanities). Such self-examination has arisen from scientists like Oppenheimer ('physicists have known sin') and Einstein ('a problem not of physics but of ethics') regarding the use of nuclear weapons (Essay 5). But it is not clear how easily such notions of limiting themselves (i.e., an ethic of inaction) (Dias, 2019) will sit with engineers, whose general inclination is towards linear progress (Essay 10). Bill Joy (2000) is one exception (Essay 5). Also, open (or 'convivial') software (Essay 7) could be an example of a pushback against techno-commercialism.

Design

Only Essays 2 and 4 mention 'design' explicitly in their titles, perhaps because it is a pervasive concept. Essay 2 asks whether design, defined as 'systematic anticipatory analysis', is the bridge between thought (governed by logic) and action (governed by ethics). Design is clearly fundamental to engineering, whether through formal method (Dym and Little, 1999), metaphor (Coyne, 1995; Dias, 2019) or heuristics (Essay 19; Koen, 1985). Mitcham contrasts the technical objective of design (efficiency) with ethical and aesthetic ones (cf. the notion of elegance in Dias, 2019). Although he appears to be somewhat sceptical about the prospect of ethical design, goals such as sustainability (Essay 10) and energy efficiency (Essay 18) appear increasingly to shape modern design. Another aspect brought out in Essay 2 is the social stratification that has arisen with the departure from craftsmanship in the modern era, resulting in the separation of 'intending' (design) from 'making' (labour).

Essay 4 is titled 'From *dasein* to design: The problematics of turning making into thinking', and starts with a quotation from Herbert Simon (1996): 'The proper study of man is the science of design'. It continues the theme that design is the historical progression from (merely) making to (anticipatory) thinking. There is an issue here in that not all engineers are designers; more of them are involved in construction, fabrication or maintenance than in design. The experience of such engineers can range from boredom (from task repetition) to extreme pressure (from unforeseen situations and the fickleness of nature). An engineering philosophy that caters for designers alone will not be sufficient. I have made a modest attempt to deal with this myself (Dias, 2019), starting from *dasein* and 'authenticity' (i.e., accepting the routine but transcending it where possible). Here, 'thinking' can be seen as recourse to first principles, when 'breakdowns' occur in the routine of 'making'. These are all Heideggerian terms, many used by Mitcham too.

Essay 4 focuses on analysis and synthesis. There is resonance here with Popper's cyclic methodology for scientific discovery (Dias, 2019). Such formal design elements are certainly very important in any philosophy of engineering. They have even been used as exemplars to critique legal practice (Howarth, 2013). A key ethical issue that Mitcham brings out is the challenge of ensuring safety in a future that is unknown. His prescription for this is 'duty plus *respicere*' (to take more than the technical into account). This is crucial for engineering design (i.e., the envisioning of future scenarios in the context of uncertainty). Note Petroski's (1969) aphorism that success is foreseeing failure, for which of course engineers have developed various strategies. These can involve guarding against poor fabrication and maintenance via robustness in design (Dias, 1994), and planning for change in use by flexibility in design (De Neufville and Scholtes, 2011). Mitcham also raises three issues related to engineering design *vis-à-vis* nature. The first is that, compared with the arts, engineering design is characterized by conservatism and sameness (Essay 2), constrained no

doubt by the laws of nature. The second is that the world is often resistant to design, though at times susceptible too (Essay 4), presumably because of entropy (i.e., tendency to disorder). This may be why there is so much engineering attention directed at deterioration modelling and maintenance strategy. The third is that biological evolution has been used as a model for engineering design (Essay 19; Dias, 2019).

Education

Education, too, is a permeating theme rather than one confined to discrete chapters. Essay 3 emphasizes the fact that the accreditation board for engineering and technology in the United States includes a significant amount of the humanities and social sciences in engineering curricula. Such requirements are probably a worldwide phenomenon now through the Washington Accord bringing agreement across bodies that accredit engineering degree programmes. Be that as it may, it is not clear how deeply engineering students are being formed as reflective thinkers, or whether engineering educators are really convinced about the need for this. Perhaps the most common subject taught under this provision is engineering ethics (Essay 11). What may really be needed, however, is the recognition that an engineering mindset can be fostered by the study of the humanities, which – like engineering – can accommodate multiple views and are also shaped by context. Dias (2014) argues that engineering in some ways has more in common with history than science. Science, technology and society studies can also introduce reflective thinking, perhaps through perceptive reflection on events in the history of technology (e.g., the limited contribution of the Gutenberg press to global literacy: Cook, 1995).

Humanitarian engineering (Essay 13) is an intriguing idea that could evoke interest in the humanities. While it has a very pragmatic orientation that may capture student idealism on the one hand, it can, on the other, be presented in ways that cover not only humanitarianism but also humanism and human rights. The use of socio-technical systems approaches (Essay 9) are also promising. Blockley (2010) insists that every hard engineering system is embedded in a soft social system, with all its attendant issues and challenges. Finally, the Appendix provides a fundamental challenge, particularly for engineering educators, to think about what really is engineering ‘use and convenience’. The phrase is, of course, derived from the original definition of civil engineering (covering all branches of engineering other than military engineering) in the Royal Charter of 1828 of the Institution of Civil Engineers in Britain (the world’s first professional engineering body): ‘the art of directing the great sources of power in nature for the use and convenience of man’. Mitcham argues that engineering students are well grounded in the harnessing of power, but get little or no direction on what constitutes the use and convenience of humans. His etymological exploration of the term ‘convenience’, and perceptive reflections on the distractions of convenience are fascinating.

Closure

Mitcham is comprehensive in whatever he sets out to do. This is enhanced in this book by a range of collaborators, and his academic links with China, a culture very different from America. His occasional use of figures and tables will hopefully entice engineering readers to engage with him. I read the electronic version, which was helpful in searching for keywords when I moved from reading to writing, but there is also an index. The downside of reading through a collection of essays is that there is inevitable repetition, although this could also be seen as concept reinforcement. The benefit of a collection is that individual pieces can be used for study and discussion by students and faculty – and even practitioners. My personal pick of the pieces (in no particular order) are Essays 2 and 4 on design, Essays 6 and 14 on metaphysics and epistemology, Essays 9 and 15 on ethics, and Essay 13 and the Appendix on engineering education.

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