# BOOK REVIEWS

**Creativity, Problem Solving and Aesthetics in Engineering: Today's Engineers Turning Dreams into Reality** by David Blockley (2019) Springer, Cham, hardback US$60, pp.xvii + 225, ISBN: 9783030382575

**Philosophy for Engineering: Practice, Context, Ethics, Models, Failure** by Priyan Dias (2019) Springer, Singapore, paperback £45, pp.xiii + 124, ISBN: 9789811512704

For more than 200 years since English-speaking engineering emerged in the late 1700s, it has mostly remained an unconscious presence in philosophy as well as in the larger culture – despite the fact that modernity is fundamentally dependent on engineering and is the first engineered lifeworld in human history. Insofar as engineering has been thought, it has mostly been subordinate to the science which it at once makes possible and puts to use in transforming its design and production of technologies; engineering has remained culturally subservient to the knowledge creation it enables and its production of ideally useful and convenient outputs. Together these two volumes by civil engineers in England and Sri Lanka are significant efforts from the engineering community to address the manifest cultural lacunae, both within and without engineering.

David Blockley is a civil engineer sensitive to philosophical issues associated with his profession. One of his expert fields is safety engineering; I have learned from personal discussions to modify some previous views of engineering in this regard. Together with his technical research and publications on engineering safety and infrastructure systems design, Blockley has authored a number of public outreach books on engineering (2012), structural engineering (2014) and bridge building (2020). The volume under review highlights Blockley the public engineering intellectual. There is no more exemplary engineer member of the contemporary 'party of humanity' (see Gay, 2013).

In nine crisp chapters, Blockley sketches an engineering self-understanding of the cultural significance of this distinctive understanding of the world (the first and second chapters) and then argues (in the third) for a grounding of engineering in five principles that he maintains are 'implicit in the best engineering of the past and missing the worst, from which we would benefit if they should become explicit in the future' (p.28). A further five chapters elaborate on the principles with stories, examples and further reflections in five key fields of human constructive design: dwelling (the engineering of structures), moving (transport engineering), communicating (information and computers), fighting (military engineering) and well-being (public health and biomedical engineering). The conclusion offers a humanistic vision of engineering-mediated flourishing.

The philosophical core of the book can be found in chapters 3 and 9. In Chapter 3, Blockley describes his five principles of good engineering as recognizing that (1) engineered parts are never independent of one or more encompassing wholes; (2) there are often unintended consequences of engineered making; (3) engineers must try to anticipate and prepare for such unintended consequences; (4) this preparation demands ingenuity; and (5) ingenuity entails learning, especially learning to learn. Blockley coins an acronym for the combination: PUPIL (Part, Unintended, Preparedness, Ingenuity and Learning). More fully stated, '*we are Part of a world of Unintended consequences for which we need to be Prepared through Ingenuity and Learning*' (p.29, his italics).

In elaborating on the fourth principle, Blockley invokes Aristotle's analysis of the virtue of *phronesis* or practical wisdom, often rendered in English as prudence. For Blockley, ingenuity is not, as it is for many today, a blind celebration of invention and innovation. It not only involves a closing of the gap between academic and vocational education, but also shifts from:

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> authoritative top-down command and control to a mature collaborative culture that focuses on enabling others to be successful. The principle will remind us of the considerable ingenuity we have shown in the past but also the danger of complacency and arrogance of 'technical triumphalism' in the face of the challenges ahead. (p.29)

Blockley concludes chapter 3 with a further reflection on practical wisdom, beginning with a quotation directly from Aristotle: 'Some people who do not possess theoretical knowledge are more effective in action (especially if they are experienced) than others who do possess it'.[1] On his interpretation, this again argues the need to bridge 'the academic/vocational distinction' and counsels against technological triumphalism, especially a 'general Western triumphalism that dominates modern "globalisation"'. While admitting that engineers are natural optimists ('they have to be to tackle [their] daunting projects'), Blockley argues their optimism needs to be tinged with realism because '"techie" triumphalism is a risk' (p.34).

While I'm in strong agreement with much of Blockley's argument – and he is the exceptional engineer who openly calls attention to the dangers of engineering hubris – his appeal to *phronesis* and Aristotle raises questions for me that are difficult to articulate clearly. Let me make a clumsy effort. Aristotle and the Greek tradition generally distinguished between making (*poiesis*) and doing (*praxis*)[2] and placed *phronesis* in the realm of *praxis* or human affairs, social relationships, politics, and ultimately the establishment and governing of a city. In Plato, *phronesis* is closely allied with *sophia* (wisdom understood as both self-knowledge and vision of the good) while implicating the virtue of *sophrosyne* (moderation). In the idealistic *Republic*, *sophrosyne* (Latin *temperantia*) is the defining virtue of artisans or makers of things, *sophia* (wisdom) of rulers and *andreia* (courage) of warriors, with *dikaiosyne* (justice) being a *symphonia* (harmony) among the three at levels large and small. In the more realistic *Laws*, *sophia* in rulers becomes *phronesis* or concern with particulars as well as ideas. Plato places *sophia* higher than *phronesis* only in the relative sense that one has to have some vision of the good in order to seek to enact it. One can have vision of the good without being able to enact it, but one cannot enact it without having the vision. It is possible to possess *sophia* without *phronesis* but not *phronesis* without *sophia*, a simple logical superiority.

In his conceptualizations of *phronesis* and *sophia*, Aristotle[3] develops Plato's distinction, but continues to keep *phronesis* firmly situated in political doings and separated from technical makings. A quotation from the short treatise 'On virtues and vices' (traditionally attributed to Aristotle) describes *phronesis* as:

> wisdom to take counsel, to judge the goods and evils and all the things in life that are desirable and to be avoided, to use all the available goods finely, to behave rightly in society, to observe due occasions, to employ both speech and action with sagacity, to have expert knowledge of all things that are useful. (Aristotle (tr. Rackman, 1989), 1250a30–5)

By drawing the political virtue of *phronesis* into the realm of engineering, a distinctly modern form of *poiesis*, Blockley may assume a too easy transformation in the classical virtue that reveals something unique about engineering while overlooking another potentially relevant analysis in Aristotelian discourse, namely his philosophical analysis of making in the *Poetics*.

As for the first point, to argue the need for *phronesis* in engineering both marginalizes *sophrosyne* or moderation in human making (even while Blockley explicitly suggests a need for it) and highlights the extent to which engineering has become politics by other means. As Hannah Arendt (1958) argues, human action, which formerly took place in a web of human affairs, has

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[1]*Nicomachean Ethics,* VI, 7, 1141b16–18.
[2]See *Nicomachean Ethics,* VI, 4.
[3]*Nicomachean Ethics,* VI, 5–6.

enlarged itself so as to become action into nature, with all the attendant problematics of politics less any ability to legislate for such a transformed techno-social order (see also Cooper, 1991). The regulatory or administrative state is demanded by the world that engineering has created, but is a state in which it is increasingly difficult for citizens to participate. One simple example is air quality. It used to be that people could rely on clear, odourless air as signalling safe to breathe. But in an engineered world where air can be contaminated by any number of toxic chemicals imperceptible to the unmediated senses, people are dependent on engineers whose work itself cannot easily be understood. In the world of classical *phronesis*, citizens could elect their leaders; engineers control membership in their profession (that is, elect themselves), but as a group are commonly under the control of non-rational forces from both above (economic elites) and below (mass consumers).

As for the second point, Aristotle, having argued that '*techne* carries things farther than or imitates *phusis* (nature)',[4] presents *poiesis* as a *mimetika techne* (imitative skill) and argues for the importance of unity in poetic construction (e.g., in tragedy: of time, place and action).[5] In the case of *poiesis* in the emphatic form of engineering, might Blockley's five principles not also be further illuminated by such an ideal? Indeed, in calling attention to the absence of adequate attention to 'the aesthetic of living that is so often lacking in modern life', Blockley suggests that engineers especially 'need to be much more aware of the quality of beauty, style and taste that lifts our spirits' (p.7), but offers only cursory ideas about engineered beauty.

More speculatively still, Aristotle describes how in the presence of a beautiful tragic drama there can be an emotional audience response of what he calls (without much definition) *katharsis* (interpreted variously as purification or clarification)[6] in the presence of a staged imitation of the all too natural suffering of misfortune of a hero who is neither exceptionally virtuous and just, nor vicious and depraved, as a result of some unintended *hamartia* (unintended mistake or failure to hit a mark of moderation). Is there not something analogous that takes place in the presence of engineering failures great and small within the profession and among a utilizing public when it is conscious of what has happened? Or is such a *katharsis* not often replaced within our engineering world by a renewed determination to engineer, a renewed determination that runs the danger of producing an even greater tragedy? In this regard, it would be important to compare the interpretations of two other public intellectual engineers: Samuel Florman (especially 1980, 1987 and 1996) and Henry Petroski (1985).

In the concluding chapter on engineering-mediated flourishing, Blockley once again invokes Aristotle by noting that the concept of 'flourishing' derives from the Stagirite and reiterates the centrality of practical wisdom. This is a challenging chapter in more than one sense. In the most obvious sense, Blockley reviews and assesses programs of grand challenges for engineering developed by the United Nations, the American National Academy of Engineering and a series of globalized summits of collaboration among the American, Chinese and British engineering academies (beginning in 2017). The list of challenges – which, it should be noted, engineers have largely given to themselves – run the gamut from making solar energy economical and creating energy from fusion through reverse engineering the brain and enhancing virtual reality to advancing personalized learning and enhancing the tools of scientific research. In this review, he notes both the technical challenges and, even more significantly, the engineering, educational, public policy and political challenges.

Regarding education, Blockley's chapter 9 opening case study is of an Australian bridge disaster which, because of a personal relationship with one engineer involved, led him for the first time to recognize the crucial factor of 'political and commercial pressures surrounding' engineering projects. Yet in the whole of his engineering education up to that moment, he admits, 'I had never been asked to even think about human and organizational factors [because of their] narrow technical

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[4]Aristotle, *Physics*, II, 8, 199a,16–17.
[5]Aristotle, *Poetics*, 1447, a15 ff.
[6]Aristotle, *Poetics*, 1453, a1 ff.

focus' (p.187). This realization stimulated an interest in systems engineering, which he further admits remains a minor component of engineering education. Additionally, it is not clear to me whether systems engineering ever reaches very far outside engineering.

Issues of policy and politics further highlight the challenge of how the need for government reliance on technical experts in formulating policies tends toward technocracy. Blockley notes the need and the tendency – and how 'many engineers find the kind of decision making of politicians and civil servants rather baffling', so that once again, 'if engineers are to be at the heart of public decision making there will have to be a change in the current culture of engineering education and professional development' (p.201). Blockley goes back and forth, appealing to the truth of his ideal (*sophia*) and implicitly admitting the difficulty of realizing it (absence of *phronesis*); the theory/practice divide stubbornly persists.

I might note in passing that at this point Blockley also makes favourable reference to a related article of mine, which I now find even more inadequate than I do his analysis. I think the political philosophy of engineering is more deeply fraught than either of us has yet fully appreciated.

Priyan Dias, however, largely eschews issues of politics and policy and begins by crediting Blockley as a seminal influence. (Blockley provides a foreword to his book.) As an engineering student at Imperial College London, Dias attended a lecture by Blockley and later spent a sabbatical year with his Bristol University systems engineering research group, where the two developed a common interest in philosophy. During a second sabbatical at the Institute for Complex Systems Engineering at Carnegie Mellon University, where he was able to sit in on seminars at the nearby University of Pittsburgh Centre for Philosophy of Science, Dias began work on *Philosophy for Engineering*, which is more philosophy-focused than Blockley's book. Drawing particularly on the thinking of Karl Popper, Thomas Kuhn, Michael Polanyi and Martin Heidegger, Dias examines ethical issues arising from the social role of engineers, ontological questions of the engineering profession and epistemological concerns of engineering knowledge in a process of repeatedly engaging what he identifies as five key themes for engineering: (1) practice, (2) context, (3) ethics, (4) models and (5) failure. (It is not too difficult to detect synergies with Blockley's five principles.)

The book, as Dias himself says, is 'engineered' into nine chapters, seven of which are revised versions of articles published between 2006 and 2013 (four in philosophical and three in engineering serials), bracketed with an introduction and a conclusion. Telegraphing his philosophical interests, all core chapter titles are questions, with many chapter sections also being questions. But reaffirming his engineering approach, each is provided with a bullet point summary.

Chapter 2 describes engineers in terms of a three-fold identity crisis. Whereas in the past engineering was treated as an unqualified (if somewhat hidden) good, it is now often charged with causing harms (an ethical concern). Internally, there are disagreements about the social role of engineers in the profession, whether engineers are best thought of as science-like producers of a distinctive type of knowledge, or problem-solving managers (an ontological question). Granting that engineering requires knowledge of some kind, what precisely are its features (an epistemological issue)? Dias proposes throwing light on these three philosophical controversies, viewing them from the perspective of his five key themes. As a provisional resolution to the identity crisis, Dias adopts the view that 'engineers should see themselves as holistic managers grounded in science' (p.19).

Chapter 3, the longest in the volume, draws heavily on Karl Popper's theories about the production and character of scientific knowledge to argue that they are both applicable to, and confirmed by, engineering design experience. In the engineering design cycle – variously conceptualized internally as from problem specification through analysis to proposed synthesis to testing and evaluation to revised problem specification; and externally as from construction according to accepted standards through historical failure to revised standards – Dias argues that engineers 'can look to Popper for philosophical underpinning of [their] processes and approaches' (p.43). The chapter further acknowledges building on a 'pioneering paper' by Blockley and Henderson (1980). Indeed, there is considerable convergence with Blockley's reflections on design in his book (pp.35ff.), although he makes no reference to Popper.

Chapter 4 utilizes Thomas Kuhn's ideas about paradigms in science to explore the functioning of models in engineering. Comparing scientific theories and engineering models, Dias argues that both are representations of the world used for making predictions, but with different 'goals (*understanding* vs *transformation*) and groundings (in *truth* vs. *safety*)' and associated 'differences in their bases, form, applicability, specification, methods of improvement and chief characteristics (*accuracy* vs *dependability*)' (italics in original, p.62).

Chapter 5 addresses questions of engineering aesthetics and ethics using the thinking of Michael Polanyi. Dias sees Polanyi's defence of passion – as opposed to 'skepticism and cold detachment' (p.65) – in the practice of science and elegance in judging scientific theory as factors in the engineering life as well. In regard to issues of aesthetics, Dias presents an original piece of collaborative empirical research (Kulasuriya *et al.*, 2002) on convergence among engineers in preferences, when options are available, for aesthetic proportions in bridge design. Finally, he sees Polanyi's distinction among three spheres of morality in science – individual, communal and societal – as applicable to engineers, and draws parallels with Joseph Herkert's (2001) distinctions between micro and macro engineering ethics. Dias rightly argues that 'the wider society is much more directly impacted by engineering than by science' so that appropriately 'the major concern of most engineering institutions worldwide is the safety of the public' (p.76).

Chapters 6, 7 and 8 all focus on the work of Martin Heidegger, in the first to examine the idea of technology as neutral, and in the second and third (with help from Polanyi) to explore ways in which engineering knowledge is practice-based. Although Heidegger obviously exercises a great attraction for Dias, these chapters are the least satisfactory philosophically. Indeed, for some philosophy readers, such reliance on Heidegger might unfortunately limit recognition of the significance of Dias's work.

Quoting Heidegger, chapter 6 criticizes the concept of technology as neutral and expands an analysis from chapter 1 (p.11) of four ways in which engineering can implicate negative outcomes: the creation of particular hazardous technologies (such as nuclear weapons); the promotion of social injustice (designing things that benefit some while harming others); introducing disruptive sociological change (as when transport infrastructure building disrupts communities); and precipitating questionable psychological influences (elevating technical efficiency over more substantive values). In response, Dias invokes Heidegger to call attention to the value of art, the possible moderating power of an ethics of care and the need for greater questioning of their work by engineers. 'The spirit of questioning is something that engineers . . . would do well to emulate' (p.88). Although Dias is correct to note (as a caveat) Heidegger's Nazi affiliation, he fails, I think, to appreciate the deeply nihilistic dynamism that Heidegger sought to reveal at the core of the engineering enterprise. This is what Hans Jonas (1984) describes as its sheer increasing large-scale (nuclear engineering) and small-scale (nano- and genetic engineering) powers that place in human hands threats (both now and for the future) out of all proportion to traditional responsibilities.

Using Heidegger again, while also making passing reference to Polanyi and John Dewey, chapter 7 argues for the primacy of practice over theory in engineering. (Like Blockley, Dias references Aristotle's notion of *phronesis*.) Dias approaches this issue from another direction in chapter 8 by inquiring into the possibility of formalizing knowledge in engineering, this time appealing to Polanyi as well as Heidegger. At the same time, Dias is well aware that Polanyi and Heidegger

> are poles apart. Heidegger is a very nihilistic philosopher who advocated a 'hermeneutic of suspicion', while Polanyi sought to restore a fiduciary (or faith like) framework for the practice of science. . . . Both however focus on practice and it is this commonality that has resulted in their being thrown together in this chapter. (p.113)

Still, in the course of a brief discussion of artificial intelligence, Dias maintains that their compatibility is revealed by the ways that 'both of them, either implicitly (Polanyi) or explicitly (Heidegger) rejected in principle the validity of cognitive modelling' (p.114).

As is perhaps obvious, Dias is especially influenced by Polanyi and Heidegger, but he is on firmer ground in his interpretations of the former than the latter, and to some extent Popper and Kuhn as well. In general, Dias does not pay much attention to the philosophical criticisms of any of his four primary philosophers. For Polanyi, however, this is not quite so much a weakness as it is with the other three, partly because Polanyi has engendered less philosophical controversy and partly because Dias just has more natural affinity with him. Dias and Polanyi are deeply compatible, whereas compatibility with Heidegger is strained. Nevertheless, there are ways in which Dias's uses of these philosophies can occasionally contribute to thinking not only in engineering (Dias's primary purpose), but also, by reflection, in philosophy.

These are two good books on philosophy for engineers. Priyan Dias's title, *Philosophy for Engineering,* is an important specifier. Philosophy of engineering for engineers is not always equally for philosophers and vice versa. It is thus useful to distinguish between the two. Both deserve to be incorporated into philosophy of engineering for everyone; that is, for all of us who now live in an increasingly engineered and engineering world. (Had they been published a year earlier or my own book, *Steps toward a Philosophy of Engineering,* a year later, they would have occupied an important place in its review of the literature.)

In conclusion, these volumes raise engineering consciousness in two senses. They invite philosophical and more general intellectual culture to pay greater attention to engineering, and they encourage engineers to make use of philosophy to deepen their professional self-understanding. Even while noting their weaknesses, I wholeheartedly commend both and, in fact, wrote promotional blurbs for each.

## References

Arendt, H. (1958) *The Human Condition*, University of Chicago Press, Chicago.

Aristotle (tr. Rackham, H., 1989) *Athenian Constitution – Eudemian Ethics – Virtues and Vices*, L285 V 20, Harvard University Press, Cambridge MA.

Blockley, D. (2012) *Engineering: A Very Short Introduction*, Oxford University Press, Oxford.

Blockley, D. (2014) *Structural Engineering: A Very Short Introduction*, Oxford University Press, Oxford.

Blockley, D. (2020) *Building Bridges: Between Theory and Practice,* World Scientific, London.

Blockley, D. and Henderson, J. (1980) 'Structural failures and the growth of engineering knowledge', *Proceedings of the Institution of Civil Engineers*, part I, 68, November, pp.719–28.

Cooper, B. (1991) *Action into Nature: An Essay on the Meaning of Technology*, University of Notre Dame Press, Notre Dame IN.

Florman, S. (1980) 'Technology and the tragic view', *Alternative Futures*, 3, 2, pp.9–30.

Florman, S. (1987) *The Civilized Engineer*, St Martin's Press, New York.

Florman, S. (1996) *The Introspective Engineer*, St Martin's Press, New York.

Gay, P. (2013) *The Party of Humanity: Essays in the French Enlightenment*, Knopf, New York.

Herkert, J. (2001) 'Future directions in engineering ethics research: microethics, macroethics and the role of professional societies', *Science and Engineering Ethics*, 7, 3, pp.403–14.

Jonas, H. (1984) *The Imperative of Responsibility: In Search of an Ethics for the Technological Age*, University of Chicago Press, Chicago.

Kulasuriya, C., Dias, W. and Hettiarachchi, M. (2002) 'The aesthetics of proportion in structural form', *Structural Engineering*, 80, 14, pp.22–7.

Mitcham, C. (2019) *Steps toward a Philosophy of Engineering. Historico-Philosophical and Critical Essays*, Rowman & Littlefield, Lanham MD.

Petroski, H. (1985) *To Engineer is Human: The Role of Failure in Successful Design*, St Martin's Press, New York.

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