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EDITORIAL

Editorial: It's the End, but the Moment Has Been Prepared for

This issue of *Engineering Studies* is my last as editor-in-chief (EIC), and so this editorial is my opportunity to thank a number of people and to reflect on five wonderful years working with our authors, editors, reviewers, and readers. The journal's new editor-in-chief, Jessica Smith, will introduce herself when she takes over with volume 15. I'm incredibly hopeful for Jessica's tenure as editor. She brings a wealth of knowledge and experience and contacts but also, and more importantly, a sensitivity to who does and could contribute to (and benefit from) engineering studies and what those people might want this journal to be. Our readers and staff (including myself in both categories) are very fortunate that Jessica is taking on this role.

Inflections: personal

Let me start this farewell essay by giving some context for how my tenure began. I applied for the editor-in-chief position in 2017, two years after moving from the United States to the Netherlands. At that point, I felt well-established at my new institution, Maastricht University, but I was still winding down some projects left over from before my move and wasn't yet in a position to begin a big new research project. I'd recently joined the collective editorship of *Historical Studies in the Natural Sciences*, but when the position of EIC for *Engineering Studies* opened up, I couldn't resist applying for that as well. Engineers and engineering scientists are a red thread running through all my work and I've always been convinced that the study of engineering as a social practice is distinct from – but also connected to and overlapping with – the interdisciplinary study of science or technology. With my own research in an interim phase, it made sense to concentrate for a while on helping others to publish *their* research, especially in a journal for which I had such an affinity. Still, deciding to apply for the editorship was a big step, and I particularly want to thank Hyungsub Choi for encouraging me to take it. Also, many thanks to the members of the search committee for taking a chance on me!

Today, my own situation, the journal's, and the field's are rather different. On the personal side, the projects I was wrapping up when I applied for the EIC position – primarily two monographs (*The Long Arm of Moore's Law: Microelectronics and American Science* and *The Squares: US Physical and Engineering Scientists in the Long 1970s*) and an edited volume with Joe Martin (*Between Making and Knowing: Tools in the History of Materials Research*) – are now done and dusted. But, I now have two new major projects, to which I owe both the funders and my collaborators my full attention. One, 'Managing Scarcity' (funded by the Dutch Research Council), is a history of the oil industry's entanglements with alternative energy and global environmental governance during the 1970s (https://managingscarcity.com/). I've been heartened that the extractive industries are becoming an ever-larger focus of

engineering studies – including in Jessica's own work – and I very much look forward to Managing Scarcity's benefiting from that turn.

My other new project, 'NanoBubbles' (funded by the European Research Council Synergy program; I am one of four co-PIs), is an interdisciplinary examination of why nanobiologists sometimes make claims that are wrong or hyped, and why it is often far too difficult to correct such claims in the scientific record. Here the connection to engineering studies is more in the realm of epistemology. That is, one of the longstanding philosophical critiques of nanoscience is that it is an 'an engineering way of being in science' where scientists are expected/aim to make commercially-valuable *things* rather than knowledge.[1] And thus, nanoscience is supposedly more 'indifferent' to what is contained in the scientific record than earlier fields were. We can question whether engineers are really so indifferent, but then sometimes the most influential models are incorrect models!

In addition, the members of the NanoBubbles project talk a lot about academic journals, their history and sociology, their dysfunctions and possible reforms. Journals are, after all, the iconic form that the 'scientific record' takes. So my experiences as an editor offer some helpful insights into the practices and problems of modern journals.

In any case, I find myself once again at a turn in my career, one that makes it unsustainable to remain EIC of *Engineering Studies*. I don't have quite as many irons in the fire as my predecessor, Gary Downey, did, but I have enough going on that it would be unfair to many people, not least the readers and authors of this journal, to keep going. For me, being editor of *Engineering Studies* has been a fantastic learning experience that came at just the right time in my life, and which I'm pleased to pass along to Jessica. I just hope that you, our readers, have also been happy with the last five years of the journal. I do know with more certainty that you will be pleased with what comes next.

Inflections: journal

The journal, too, is at an inflection point, as perhaps can be seen in the outcomes of some of my attempted editorial innovations. First, and least successfully, when I started, I hoped to draw on the collective editorship model of *Historical Studies in the Natural Sciences*, where each member of the editorial board takes the lead on manuscripts that are closest to their expertise but where all of the members sign off (and often give valuable input) on every manuscript. As I soon figured out, though, that model works much better for a more monodisciplinary journal than for a highly interdisciplinary one such as *Engineering Studies*. Our authors draw on so many different methods and address such disparate regions, topics, and fields of engineering that it's extraordinarily difficult to have meaningful things to say about all of our manuscripts. That makes the editor-in-chief's job pretty challenging! And it means that it's neither fair nor productive to ask the Associate Editors to weigh in on everything – much better, as I found out, to ask them to oversee reviewing of manuscripts where they have some relevant knowledge and contacts and leave decisions about the totality of manuscripts to the EIC in consultation with our Managing Editor, Kacey Beddoes. Kacey, many many thanks – the journal, and I and everyone else associated with it, have benefited enormously from your careful oversight and wise counsel.

My second editorial innovation – rethinking the composition and purpose of our masthead – was, I think more fruitful. Gary's Advisory Editors were largely people with the presence in the field to bring some heft and legitimacy to the journal, and his Associate

Editors were people who were already deeply committed to the idea of engineering studies – exactly the right strategy for a new and up-and-coming journal. Indeed, it was a strategy that worked so well that I could afford to try something different when I took over. So instead, I tried to use the Associate and Advisory Editor roles as both a lure – to draw new people into a relationship with the journal and thereby into participation in the field – and as a pathway for the growth of individual careers. I, therefore, asked Gary's Advisory Editors to step down and to act as emissaries for the journal while making space for a (mostly) more junior group of people whose careers would, I hope, be boosted by association with the journal. Over time, as new people have shown themselves to be reliable reviewers, authors, or guest editors, I've invited them to join the slate of Advisory Editors, and I've asked Advisory Editors to move into the more active role of Associate Editor. Thus, I tried to create a natural progression of growing involvement *within* the journal.

But I've also had in mind a natural progression of growth *beyond* the journal, particularly for the Associate Editors. Being an Associate Editor at *Engineering Studies* is now an established stepping-stone to other editorial work: for example, Amy Slaton to *History + Technology*, Emily York and Aalok Khandekhar to *Engaging Science, Technology, and Society*, and Matt Wisnioski to join Gary in running the Engineering Studies book series at MIT Press. It's made me really happy to see people move on to new ventures. It's always a challenge to replace talented, dedicated Associate Editors, but helping people get where they want to go is ultimately a good thing for the field and for the journal (not least because these people remain reliable reviewers for and supporters of *Engineering Studies*).

A third innovation was to ask several of Gary's Associate Editors to reconvene as the journal's new board, with the chair of the International Network for Engineering Studies (INES) as an *ex officio* member. That extra layer of governance offers an important source of advice and oversight and gives the journal a more focused channel with which to communicate with both INES and our publisher, Taylor & Francis. That's going to come in handy in the next few years because the journal publishing industry is changing rapidly. Like most publishers, Taylor & Francis is moving to an Open Access model where articles will be free for all to download. That means *someone* will have to pay the publishing costs (or Article Processing Charges, APCs) that are currently borne by individual and institutional subscriptions to the journal. But who? At other journals and publishers, we are already seeing that funding for APCs will come from some mix of individual authors and their employers, national and supranational funding agencies, and professional associations such as INES, with publishers dispensing a few 'free' APCs per year to be used at the editor's discretion.

To be clear, I'm all in favor of Open Access when it's done well and in consultation with the relevant parties. One of the big aims of the NanoBubbles project mentioned above is to help scientists be more open in general, and Open Access is one of several routes to facilitate that. But there are weighty questions to consider in moving to Open Access. The big one is whether the mechanisms for covering APCs will overcome or reinforce the inequalities (between regions and institutions and also between independent and institutionally-affiliated authors) and incentives for exploitative or otherwise questionable publishing practices that exist in the current system. INES, Jessica, and the *Engineering Studies* board will need to work closely together to ensure that the journal enters the Open Access era in the way that best matches the evolving composition, practices, and values of our community. I have no insights into the eventual form that Open Access will take for *Engineering Studies*, but I have faith that Taylor & Francis, Jessica, INES, and the journal's

board will come to an arrangement that reflects our community's values. In the meantime, I want to thank the members of our board, especially Matt Wisnioski (chair), Vivian Lagesen (deputy chair and ombuds), and Atsushi Akera (until recently, *ex officio* member as chair of INES). It's been a pleasure working with you!

The final inflection point for the journal that I'll highlight is one I never adequately addressed but which Jessica will need to (and fortunately has the skills to): namely, time. When I started as EIC, the looming challenge was a shortage of manuscripts, and indeed in my first year, the pipeline ran dry and I had to combine two issues. For reasons I don't fully understand, that problem has *mostly* receded. Our queue isn't yet so full that we could move to thicker issues or more issues per volume, but we're no longer on such a knife-edge when it comes to filling each issue. Today, the much bigger challenge is that *everyone* is overstretched and no one has time to donate their labor for journal work. Thus, it's getting ever more difficult for the Associate Editors to find enough people who *say* they are willing to review a manuscript; and even many people who say they'll review manuscripts delay submitting those reviews significantly, sometimes even indefinitely.

I am very much tempted to complain about some of the things I've seen when it comes to peer review. I have enormous admiration for some of our reviewers, who send us detailed, well-reasoned commentary and suggestions along with comprehensive citations that are incredibly helpful to our authors. But more and more of the burden falls on those people because we turn to them to fill the gap when other people can't or won't review. But complaining isn't going to help the situation much. So instead I'll offer my deepest gratitude to the reviewers and Associate Editors who've given so much of their time and knowledge and solidarity on behalf of our authors. And for those who haven't: well, I'm trying to understand where you're coming from. I really appreciate it when colleagues *explain* why they have to decline the journal's requests at a given moment, especially when that explanation is accompanied by suggestions for other people we could approach. To the rest, I can only say that obviously, my perspective is partial: many of you no doubt have good reasons for providing less-than-full support for our authors, and no doubt many of you *are* providing full support to academic (and other) communities in other ways.

More helpful than complaining is the realization that when problems are this widespread they're probably systemic in nature, and hence call for systemic change. Somehow, the journal publishing system in general, but the peer review system in particular, needs to evolve. Several recent historical studies have shown that journals have evolved a lot over the years, that peer review is not really that ancient and wasn't particularly connected to quality control when it was introduced, that it often doesn't boost quality as much as is claimed, and that there has always been a lively culture of counter-journals promoting alternatives to conventional reviewing and editing.[2] So there's no reason that we can't imagine new alternatives today, and indeed from arXiv (and its spin-offs) to PubPeer, there are lots of such alternatives on offer these days. As EIC I didn't do enough to explore those alternatives, in part because the manuscript shortage initially seemed more pressing, and because the scale of the slowdown in the reviewing process only became fully apparent with the covid-19 pandemic. Addressing the issue will require soliciting and listening to views from a broad cross-section of our community – something which, fortunately, Jessica is just the right person to undertake.

Inflections: field

So much for myself and the journal. How has the field of engineering studies changed in the past five years, and what might that mean for *Engineering Studies*, the journal? Well, there haven't been radical changes in either the field or the journal in that time, but both have gradually become *more* of what they were already. Our interdisciplinary engagement, for instance, continues to become richer. One illustration of that is our previous issue, a special issue on engineering epistemology. In my very first editorial in 2018, I called for a revitalization of philosophers' contributions to engineering studies, one that would go beyond engineering ethics; so it was especially satisfying to see that special issue to publication (for which I should thank the guest editor, Sjoerd Zwart, and the responsible Associate Editor, Julia Bursten).[3]

Similarly, the leadership of both the journal and our parent association, the International Network for Engineering Studies, is now much more tilted toward anthropology (especially thanks to Jessica as well as Beth Reddy) than it has ever been. *Engineering Studies* and INES are still deeply rooted in the fields and professional societies that have been there from the start – especially science and technology studies (Society for Social Studies of Science), history of technology (Society for the History of Technology), and engineering education (American Society for Engineering Education, among others) – but it's wonderful to see our membership/readership more active than ever at the American Anthropological Association, the Society for Literature, Science & the Arts, and elsewhere. Engineers and engineering are so multi-faceted that we can only understand them – and promote more responsible engineering practice – by drawing on multiple disciplines and professional societies. There's still plenty of room to go, though. Again, if you look back at my introductory editorial, I was hopeful that we would by now have more contributions from people in business schools and societies such as the Industry Studies Association or the Academy of Management, but we haven't made significant progress there. I was also hopeful that the Responsible Research and Innovation community would embrace engineering studies – which has happened, to some extent, but still isn't a regular locus of exchange.[4]

The journal has also crept forward in its aspiration to be a truly global forum for research on engineers. I don't want to get into an accounting game, but suffice it to say that I've tried to build on Gary's efforts, with perhaps some successes, particularly with respect to the West Asia (or 'Middle East')/North Africa region.[5] I also think it's been somewhat helpful to European engineering studies – including post-socialist regions of Europe; see our recent special section on post-Soviet Russian engineering – that the journal's EIC has been based on that continent for five years.[6] Again, there's still lots to do, though. We've also become a reasonably hospitable place for manuscripts from/about East and South Asia, thanks in part to Associate and Advisory Editors based in those regions; and the same is *very* slowly happening for Sub-Saharan Africa and Oceania, though more slowly than I would've liked.[7] One region that I hoped we would be more engaged with by now is Latin America; but there we at least have the excuse that there is now a peer journal, *Tapuya* (also published by Taylor & Francis), dedicated to Latin American STS. For the moment, people who might in the past have sent manuscripts to *Engineering Studies* are sending them to *Tapuya* – as well as they should. Hopefully over time, the institutional infrastructure provided by *Tapuya* and similar organizations will help grow the Latin American engineering studies community to the point where it makes sense for some of those people to send manuscripts to

Engineering Studies as well. Certainly, there is plenty of exciting work being done right now on engineering in Latin American contexts.[8]

One obstacle to disciplinary, methodological, and regional diversification is the difficulty our current editorial staff have in overseeing the review of manuscripts that are well outside their areas of expertise. One small remedy that I've tried is the non-peer-reviewed 'Report' format. These are shorter contributions that expose our readership to perspectives that otherwise we don't see very often in *Engineering Studies*. Often these studies are more quantitative and their authors are based in disciplines such as psychology or management and/or regions such as the Balkans that aren't well-represented in our other offerings. I'm unsure how well this strategy has worked, but I think it's handy for Jessica and her successors to have it as an option.

Another strategy – one that failed for, perhaps, enlightening reasons – was to develop a Book Reviews section. Qin Zhu agreed to serve as the Associate Editor with responsibility for book reviews, and he tried for a time to recruit reviewers, especially of books in fields related but not central to the journal's primary content. In the end, though, it proved impossible to find reviewers and we agreed that Qin should move to a regular Associate Editor position. There are, I think, two main reasons why regular Book Reviews didn't work. First, publishers are no longer willing to give print books to reviewers, and most reviewers would – by far – prefer a print copy to a digital one. Second, book reviews don't carry much weight with tenure and promotion committees, so people are less and less willing to write them (also, see again the shortage of time described above). It's a pity because I learn a lot from book reviews, both about the books themselves and about the perspective of the reviewers.

Yet another strategy for bringing attention to the journal was to raise awareness via new media. Here we're talking about not just about disciplinary, methodological, and regional diversification but also, to some extent, generational. It took a while to find someone willing to run the *Engineering Studies* twitter account (@EngrStudies – after starting and halfheartedly running the account myself for a while), but fortunately Jongheon Kim eventually offered to do so. Jongheon has been great at getting the word out on academic twitter – which has been an important space for scholarship over the past few years. Unfortunately, as I'm writing this, Elon Musk is burning twitter down to the ground and much of academic twitter is moving to Mastodon. Musk's antics are rather over-the-top, but it's likely that even without him, we would need to change social media platforms every few years. So while it's important for us to pursue this strategy, it demands a degree of flexibility and platform-savvy that's difficult to find.

Perhaps the most productive strategy for bringing new perspectives in the journal isn't to tinker with our formats or communications or even our masthead, and instead simply to be present wherever engineering studies is happening and to show that the journal is listening to the conversations going on in the field. Gary used to do this by hosting an engineering studies discussion at the annual Society for Social Studies of Science meeting. I've occasionally done something similar, both at 4S and the Society for the History of Technology meeting. More importantly, members of our community regularly organize engineering studies sessions at a variety of professional society meetings, particularly those meetings with an active INES liaison. No EIC can go to every conference where engineering studies comes up, but thanks to the INES model lots of conferences can learn about the journal and can see how their members can contribute to the study of engineers and engineering as a social practice.

There are also now more institutions outside of INES that facilitate the journal's connection to the community. There is, for instance, a consortium of editors of engineering education journals with which *Engineering Studies* is associated. The relationship between engineering studies and engineering education is complicated, of course; Jessica will have to figure out how to satisfy our readers' interest in engineering education without risking capture by that much much larger field. But, clearly, there is *some* relationship and thus it's good for the journal to be part of that conversation.

Similarly, there is now an engineering studies working group under the auspices of the Consortium for the History of Science, Technology, and Medicine (founded by Matt Wisnioski, Ross Bassett, and Ryan Hearty and currently run by Ryan and Ellan Spero). Again, engineering studies isn't at all reducible to the history of engineering, but in practice, the working group often features research by non-historians and its monthly online meetings are open to all. So far, they're proving to be a great place for the journal's actual and potential readers and authors to discuss where the field is and where it's going – with the journal simply participating in that conversation rather than trying to get out ahead of it. There will be times when the journal, through INES, does try to stimulate interest in engineering studies; but the field is mature enough that that conversation will flow naturally through a variety of institutions where the journal's staff can serve the field simply by showing up and listening without having to bang the drum.

Open questions

That's my overview of my own journey, the journal's, and the field's over the past five years. Next, I'd like to outline a few open questions, especially ones that came up during my tenure but for which I don't have good answers. What are the most important things we still don't know enough about regarding engineers and engineering as a social practice? This isn't meant to impose any agenda on my successor; it's just my personal view – informed by discussions with the journal's stakeholders over the past five years – about some topics worth exploring further.

First, every time I ask people what they want more of in *Engineering Studies*, they say they would love to read about national cultures of engineering: how does engineering vary across nations, regions, cultures, etc.? How are those variations made, maintained, and overcome? Of course, to this, I would add that we need to know more about the cosmopolitanism of engineers and the (constructed) placelessness of engineering knowledge.

Second, I would very much like to know more about engineers' spectrum of political possibilities. We know a bit about conservative engineers, such as Robert Mercer or Pieter Schelte Heerema; somewhat less about left engineers, such as Charles Steinmetz or Peter Palchinsky or technocratic ones like Howard Scott. But what about those in between? In some sense, we know a great deal about engineers who have constructed engineering as an apolitical profession, but that's not to say that we understand how engineers navigate the *totality* of the political landscape, nor how engineers imbue their practice with (a)political meaning.

Third, we need something like a phenomenology of engineering, i.e., studies that get at the embodied lifeworld that engineers create and inhabit. This would, I would hope, connect to the growing literature on engineering and gender, sexuality, disability, race, class, and other intersectional categories. We know that engineers are not rational minds in

vats – bodies matter, but in what ways, and in how far do differences among bodies matter? Crucially, how do different engineering bodies interact and get made and recognized as different?

Fourth, we need to keep drawing out the skein of engineers' careers. Engineering studies sits adjacent to an enormous, well-resourced field of engineering education, which researches engineers-in-the-making at a very particular snapshot in their careers. Recently, an exciting intersection of engineering education and engineering studies has emerged around research on early-career engineers – see the articles in our recent special issue on 'The Early Career Years of Engineering'.[9] But why stop there? Mid-career, late-career, and retired engineers aren't simply what's left over after engineers stop being young learners – older engineers are still learning and still maturing. And what of those who *leave* engineering – they represent a huge pool of engineering values, knowledge, and practice that gets carried into many other domains.

Fifth, what do engineers do all day? This journal has published many wonderful studies of different facets of engineering work – the quotidian practices that engineers take for granted but that non-engineers know little about. At their best, the authors in this journal can take even the tiniest morsel of engineering – a single term, a type of project, a method of calculation – and tease out what it says about engineering and the larger context in which engineers operate. We need more, and more, and more of that.

Sixth, what are the stories that engineers tell about themselves and that others tell about them? What are the literary devices – the metaphors, the rhetorical turns, the pragmatics that allow the ostensibly calculative and rational parts of engineering to make sense? Recent issues of this journal have featured quite a few studies of imaginaries, narratives, and metaphors, but mostly in a piecemeal sense – we need a more synthetic view of storytelling and imagination as integral and indispensable to engineering.

Seventh, this journal presents a stage for reflection about methods in engineering studies. We are, largely, a qualitative journal, and we do occasionally publish programmatic calls for both engineering and studies of engineering to value the qualitative and the 'small N'.[10] And I'm all for that – that's the kind of work I do and cherish. But we can't only be that. I'm sure, for instance, that the winds of digital humanities and social sciences will be reaching us before long. Likewise, more-than-human ethnographies have been commonplace in some of our neighboring fields for quite a while now but have yet to figure much in engineering studies. And so on – there are lots of ways that we *could* learn more about engineers and engineering, and we should reflect on why we favor some methods over others, and on how, when, and why we might want to add to our toolkit.

And, eighth, this journal *is* for turning! I give a lecture every year to some of the research master's students in my faculty on the 'turns' – the slow turn toward STS from the 1920s to the 1970s, and then the turns within STS after that. I end with the argument that STS has become too big for the whole field to turn in any given direction, but that STS stays lively because there are constantly people proposing new pseudopods from the STS amoeba, new outshoots that stand some chance of getting the ball rolling in a slightly different direction. Well, engineering studies is itself one of those pseudopods, and a pretty successful one at that. But now that we have engineering studies, we can have turns within it. This journal should be one of the places where people can step forward to declare – or, better yet, to *show* – that this direction or that one might be exciting, might hold our interest long

enough to reveal something of note about engineers and the worlds they make. *All* of engineering studies aren't going to turn one way or another, but it's the proposal of new turns that keeps us moving.

And now for our featured attractions

Finally, while this editorial is my last as EIC and therefore is different (i.e., more self-indulgent) than most *Engineering Studies* editorials, this *issue* is just an ordinary issue of the journal – ordinary in the sense that it features three excellent articles that critically examine engineers and engineering as a social practice. So I want to close this editorial by doing one of the parts of the job I've loved the most – namely, tying together each issue's content and highlighting aspects of the articles we publish that especially speak to me and, I hope, to you.

As often happens, all three articles relate in *some* way to engineering education, but in indirect and unexpected ways that connect much better to engineering studies than to the field of engineering education, at least in its conventional form. The article that is most clearly sited in the education sector is Anders Buch, Loren Mark Ramsay, and Hanne Løje's 'Discursive Enactments of Knowledge Production in Engineering Education'. The authors look at the evolution of Universities of Applied Science (UAS) within the larger changing landscape of Danish higher education. As in many countries, Danish academia is feeling the pull of multiple 'drifts'; the authors focus on academic drift (the UAS's adoption of the standards and practices of general universities, despite their original orientation toward professional training of engineers, nurses, and teachers), applied drift (shift from production of knowledge for its own sake to production of knowledge primarily for application), and mission drift (expansion beyond the missions of research and teaching to more direct engagement with society generally and the market in particular). Or rather, the authors look at how people in the UAS system *talk* about academic, applied, and mission drift – this is a study of discourse, and specifically of discursive *positions*, rather than of practice. What the authors find is that acknowledging applied and mission drift is a legitimate position within the UAS system, but that academic drift is not as prominent because teaching, rather than research, is still identified as the primary mission of the UAS. They then go on to sketch four discursive positions that are viable and three that are logically possible but not actually held by any of their interviewees. To me, this is a really intriguing finding: while I look forward to the authors' connecting discourse and practice in future publications, for now it's quite interesting to know that some discursive positions are available and some aren't. It's as if they've constructed a periodic table of discourse about engineering and higher education and can predict the characteristics and instability of some discursive positions without directly observing them.

Next, we have 'Persuasive Communication Practices of Engineers in Cross-Boundary Decision-Making', by Alexandra Coso Strong, Tehya Stockman, Tom Heale, Steven Meyer, and Elena Meyerson. The link to engineering education here is primarily in what's *not* taught in engineering schools but *is* needed in engineering practice. Obviously, that's a large category! Businesses complain all the time that new recruits need extensive training that isn't offered in engineering programs – see again volume 13, issue 2's articles on 'The Early Career Years of Engineering'. As readers of this journal will know, many of our authors see humanistic education as a particularly big gap in engineering training. Strong *et al*. extend

that to include training in persuasive communication, as they show through a series of ethnographic vignettes gathered from three companies of varying sizes.

The need for persuasion in engineering practice is, I think, an underappreciated consequence of the challenge to technological determinism that is now orthodoxy among most sociologists and historians of technology: i.e., if there is a great deal of interpretive flexibility in how technologies should be used, what aims they are intended for, and how they ought to be designed – and if there is no inarguable technical logic guiding the engineer to a single answer to a given engineering problem – then that implies that engineers and their interlocutors must *choose* among different options. Well, if that choice cannot be grounded in technical expertise alone, then people must be *persuaded* to adopt one choice over another. As the professional group whose jurisdiction includes proposing technological choices and having a stake in the outcome of those choices, engineers must necessarily practice persuasion. And yet, it is part of the ideology of engineering – certainly of engineering education – that technological choices are self-evident and rational, and that it is, therefore, unnecessary to teach engineers how to persuade. And maybe we don't want armies of engineers who also know how to be 'hidden persuaders'.[11] But *someone* will end up doing the persuading anyway. I mentioned Elon Musk earlier in this essay; he seems to me to be someone whose skills in persuasion rather outstrip his engineering skills, often to everyone's detriment. So what I take from this article is that we do want engineers who can defend their ideas effectively; and, even more importantly, we want engineers *and managers* (as well as investors, journalists, citizens, and regulators) who can recognize when they are being persuaded and can examine persuasive practices critically. And for that, some training in communicative practices, at all levels of engineering education, would surely be helpful.

Or not! Because now we come to our third article, 'Engineering Intangibles: Technical Employment in the US Service Economy', by John Alic. This article is definitely *not* about engineering education. And that's the point, or at least one of the points. Alic shows that – historically, and right up to the present – much (even most, at least for long stretches of that period) of the US engineering workforce had little or no formal training in engineering at an institution of higher education. Instead, those practicing as engineers picked up the most relevant training for their jobs *on the job itself*. Even those who did have engineering degrees still largely learned on the job. Indeed, we can partly see that as the context for the drifts that Buch et al. describe; if university engineering education confers only a fraction of the total amount of relevant engineering training to which practicing engineers have been exposed, then there's relatively little incentive for university engineering educators to focus on education, and many incentives for them to get caught in the academic, applied, and mission drifts.

Alic's other big point is that engineering has – like many other professions – been tied more and more into the service economy rather than goods economy, especially over the past four decades or so of globalization. Thus, definitions of engineering that exclusively focus on design or other aspects of the production of goods are inadequate. This isn't entirely a new phenomenon, of course; engineering has been a fast-track to management – the manipulation of numbers and people – rather than the manipulation of machines and products for more than a century. But financialization, offshoring, the growing power of consultancies, and other factors all mean that these days abstract services loom much larger

in *practicing* engineers' expertise (at the expense of their expertise relating to tangible products) than they used to. Whether engineering education will catch up to that change – whether it even needs to, given the importance and perhaps even necessity of learning on the job – is yet to be seen.

Some final thanks and goodbyes

And so we have another great issue, with three insightful articles representing varied – perhaps even opposed – viewpoints and methods, but with some red threads running through them and insights aplenty. And in a few months, we'll have another such issue, and another, and another. Our community of authors, editors, reviewers, readers, and so on will keep doing the good work, now with Jessica's help and eventually someone else's, and on and on. The EIC has a role to play in sustaining this journal as a creative outlet, for sure; but in most ways, the editor is the beneficiary rather than the instigator of this community's vibrancy and intellectual ferment. I've been incredibly lucky to be that beneficiary for five years, but now it's time to enjoy our community's work from a different vantage point.

So in my last words as editor-in-chief, let me once again thank you all – a few of you by name or role, but every one of you in spirit. My deepest appreciation goes to our current and former Associate Editors and especially to Kacey – you've been an amazing group to work with on a day-to-day basis. Many thanks, too, to Matt, Vivian, Atsushi, and the other members of our board as well as our Advisory Editors – our interactions have been less frequent, but that's not the right measure of your contribution to the journal. The other INES officers and of course Gary Downey deserve all our gratitude for setting up the journal in the first place and for giving it an international network of scholars and other curious people to sustain it. Our authors and reviewers, too; I always learned from you and always enjoyed hearing what you had to say. And finally, our readers. As I said in the introduction to my latest book, we all write partly for ourselves, partly for those closest to us, but any published work is also written for people we don't know and may never know, perhaps even people who aren't born yet. Writers may think that their creativity turns lead into gold, and editors may think that only they can transmute fool's gold into the real thing, but it is readers who are the real alchemists.

Notes

1. Nordmann, "Philosophy of NanoTechnoScience"; and Galison, "The Pyramid and the Ring."
2. Baldwin, *Making Nature*; Moxham and Fyfe, "The Royal Society"; and Csiszar, "Peer Review."
3. Mody, "New Editor-in-Chief Editorial"; and Zwart, "Engineering Epistemology."
4. Foley and Gibbs, "Connecting Engineering Processes and Responsible Innovation."
5. Tunc and Tunc, "Constructing Containment"; and Günel, "The Backbone."
6. Bychkova, "Creativity vs Commercialization"; and Rudenko et al., "Gender Equality Paradise Revisited."
7. Kim, "Transfer of 'Engineer's Mind'"; Wang, "Origin and Operation of the Chinese Academy of Engineering"; and Winberg, "The Making of Engineering Technicians."
8. Chahim, "Governing beyond Capacity"; Montaño, *Electrifying Mexico*; and Johnson, "A Mexican Conquest of Space?"
9. Brunhaver et al., "The Early Career Years of Engineering."
10. Slaton and Pawley, "Power and Politics."
11. Packard, *The Hidden Persuaders*.

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