Chapter 10
Governing Engineering

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Abstract Most people agree that our world faces daunting problems, and, correctly or not, technological solutions are seen as an integral part of an overall solution. But what exactly are the problems and how does the engineering "mindset" frame these problems? This chapter sets out to unravel dominant perspectives in challenge perception in engineering in the USA and Denmark. Challenge perception and response strategies are closely linked through discursive practices. Challenge perceptions within the engineering community and the surrounding society are thus critical for the shaping of engineering education and the engineering profession. Through an analysis of influential reports and position papers on engineering and engineering education, this chapter aims to identify how engineering is problematized and eventually governed. Drawing on insights from *governmentality studies,* this chapter strives to elicit the bodies of knowledge, belief, and opinions in which engineering is immersed. Thus, the overall objective is explorative. By investigating the language, practices, and techniques by which engineering is governed, this chapter points to the presumptions, stipulations, and "limits" of the dominant discourses that shape our thinking about engineering and engineering education. Thereby, the analysis adds a critical input to the ongoing debates on "the future of engineering."

Keywords Engineering challenges • Challenge perception • Response strategies • Governing engineering

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Introduction

Technology is an integral part of the modern world – both in regard to solutions and problems. Engineering – understood as the profession that deals with bringing about and implementing technological change – has thus become an endeavor of the utmost significance to modern society. Correctly or not, technological solutions are seen as the answer to most of the problems we face today, and ingenious engineers are struggling to solve the problems. But what are the problems and how does the engineering "mindset" frame these problems? Is engineering education – as practiced within engineering schools and universities – capable of providing the right kind of knowledge and the relevant skills for engineers to deal effectively with the problems? Thus, does engineering education face the challenges of our times? When engaging in these vital questions, it is worth dwelling on the specific character of the challenges, how they are perceived, from which perspectives, and how they are interwoven with the response strategies.

So, what are the challenges to engineering and engineering education? Is it to invent and develop new solutions to the most pressing problems we face in society today? Certainly, but what are these problems and who defines them? Recently the National Academy of Engineering put together a list of 14 challenges ranging from making solar energy economical to providing access to clean water (www.engineeringchallenges.org). Likewise, concerned engineers are reflecting on their roles and responsibilities in dealing with challenges like security and privacy concerns, corporate social responsibility, and sustainability (Douglas et al. 2010). Numerous reports, position papers, and academic articles from governmental bodies, engineering societies, concerned engineers, and reflective scholars in the USA and Europe have described the challenges facing engineering (e.g., ATV 1997, 2000, Duderstadt 2008, 2004, 2005; The Ministry for Science and Technology and Innovation 2005; Sheppard et al. 2008; Williams 2003). Should they be taken for granted as they are stated? What is the status of the challenges and the accounts? Are they inevitable in the sense that the categories reflect essential – or even objective – features about the position of engineering within society? It is certainly clear that the challenges described have a reified status. It is not up to the individual to define the challenges otherwise.

The categories of challenges represent socially established facts that are widely taken for granted in the sense that people adhere to their existences and act according to their realities. To adopt a terminology of John Searle (1995), it could be said that the "challenges to engineering" are *objects* in the sense that they are in the world. They are ontologically subjective but epistemologically objective items. Thus, "challenges to engineering" is a socially constructed category that is established through people's actions and beliefs about the role that engineering is playing – or ought to be playing – in society. It is clear that the challenges would not be there if people did not subscribe to their relevance. Likewise, it is also clear that the challenges are real in the sense that people abide to the existence of the challenges.

Where does this leave us as researchers? One way of approaching the study of engineering challenges would be to accept the objective status of the challenges at

face value and without further ado. The task would then be to investigate how the challenges could or should be met in engineering education through, e.g., pedagogic and didactic measures, redefinitions of core curricula, specification of learning outcomes, dealing with congestion problems within engineering curricula, and optimizing teaching. This approach is surely tenable, but there is risk of contradiction if it is not accompanied by further reflections on the status of the challenges. The challenges point to different problems and vindicate different approaches to engineering education.

The fact that the challenges are produced and sustained through social processes calls for a more critical and reflective approach. It is thus fruitful to investigate how and why the challenges are construed and perceived in the way they are. This kind of approach inscribes itself in the broad research tradition of "social constructionism" and post-structuralist analysis. The label of this research tradition is indeed vaguely defined and often driven to extreme positions. Therefore, it is worth pausing to define the approach in more detail. Using Ian Hacking's (1999) conceptual clarification of types of "social constructionism," the approach can be clarified further. Constructionism in relation to challenge perception can be stated in three successive steps:

1. The challenges should not be taken at face value. It should be recognized that the challenges are brought into existence and shaped by social events, forces, and history, all of which could well have been different. Thus, the contingency of the shaping of challenge perception in engineering practice should be recognized.
2. Furthermore, it should be recognized that the responses to the stated challenges are diverse and often mutually incompatible. It is thus unproductive to reform engineering education on the basis of an unreflected acceptance of (some of) the stated challenges.
3. And lastly, it is mandatory to produce a more nuanced and cogent picture of the challenges to engineering practice in order to reform engineering education.

This "social constructionist" argument is reflected in Foucault's post-structuralist research methods. According to these methods, the aim of the researcher is not to judge whether – in our case – the stated challenges are true, justified, or deserving of any other epistemic, normative, or moral privileges. The goal of the researcher is instead to describe and analyze *how* the challenges have gained their authority within specific regimes of knowledge/power. The format of this book chapter does not allow us to engage in a fully fledged historical investigation of challenge perceptions within engineering. Instead I will – inspired by approaches from social constructionism and post-structuralism – discuss challenge perception and response strategies in engineering in order to investigate how various agendas are set and how various discussions are framed. This discourse analytic approach does not aspire to do justice to all nuances and perspectives in the current discussion of challenges to engineering. The aim of our discussion is to call attention to the dominant positions taken within the debate and to illuminate the premises of these positions. The ambition is thus explorative and critical in Foucault's sense of critique (Foucault 1988). By unfolding how the challenges to

engineering are *problematized* and *articulated* according to different positions and hegemonic knowledge/power regimes, the limits, horizons, and tacit assumptions of these positions are explicated and thus exposed to critical reflection. It is clear that challenge perception and response strategies are closely linked through discursive practices that frame and interpret engineering in specific ways. Drawing on insights from *governmentality studies* (e.g., Dean 2010; Miller and Rose 2008; Burchell et al. 1991), I will elicit the bodies of knowledge, belief, and opinions in which engineering is immersed and that are mobilized in order to govern the future of engineering. Finally, I will point to formative questions that are pivotal to the debate of the future of engineering.

Challenges

In the public debate it is often claimed that engineering is challenged. Although the engineering profession has been very successful in establishing its position within modern society, various voices raise concern regarding the future of engineering. In many western countries governmental committees are established to deal with the challenges facing engineering. Likewise engineering societies and interest groups, academia and industrial federations, and private companies are voicing their concerns and developing response strategies in order to deal with the perceived challenges. But although there seems to be agreement about the fact that engineering is challenged, opinions differ when it comes to specifying the nature and characteristics of the challenges. Thus, perceptions seem to differ. It is useful to sketch some dominant claims about the challenges facing engineering.

In one line of argument, "challenges to engineering" are not really challenges in the sense that engineering is threatened or confronting a crisis. The "challenges" are in reality not specific challenges to engineering, but rather challenges to our planet, humankind, society, etc. When The US National Academy of Engineering in 2010 published a list of 14 grand challenges for engineering (www.engineeringchallenges.org), the list contained problems such as "provide energy from fusion," "manage the nitrogen cycle," and "secure cyberspace." These grand challenges are not challenges *to* engineering but rather *for* engineering. In fact they seem to be opportunities for engineering to get funding, engage in business, and raise the prestige of the engineering profession in general. It is the voices that point to challenges *to* engineering that will be of interest here.

Another type of argument can be found in reports and analyses from governmental bodies, industrial federations, and political "think tanks." To exemplify this type of argument, let me refer to reports produced in a Danish context by The Ministry of Science, Technology and Innovation (2005) and by The Danish Academy of Technical Sciences (ATV 1997, 2000). The title of the 2005 report is "More and Better Engineers." Among other things the reports claim that the Danish society will have a shortage of 13,000 qualified engineers in 2020 unless drastic measures are

taken to recruit more students in engineering education.[1] The report construes this development as a problem for the Danish society because the economic growth and welfare are highly dependent on technological innovation (supposedly delivered by engineers). Furthermore, the quantitative problem is supplemented by a qualitative problem. The reports indicate a gap between the competencies supplied by engineering education (today) and the competencies demanded by (future) employers. Because of this gap the western societies and their businesses will be left behind in the global competition. This line of argument thus states that the labor market for engineers is determined by the societal need for engineering services and products, and the engineering profession must adapt to changing needs of customers. The engineers must be aware of the dynamics of the market and have commercial insight in order to be employable. The challenge perceptions grouped in this category are mostly functionalist in the sense that they strongly emphasize the preeminence of the market system as the driver for change in engineering. Challenges are posed by society and should be met by the engineers. The engineers are the servants of society, delivering neutral technical solutions that can be put to use in accordance with the priorities and needs of the market system. For brevity, let us label claims of this type *the market challenge.*

Another set of challenges relates to the category of *social responsibility* on the part of the engineers. Here engineering is viewed as a pervasive and powerful enterprise that affects the lives of all living creatures on our planet (e.g., Douglas et al. 2010; Duderstadt et al. 2008, pp. 29 ff., Clough 2004). According to this perspective on challenges to engineering, engineers must take the responsibility upon them and work to improve living conditions for all men and the environment in general. The important challenge facing engineers nowadays is not so much grounded in the argument that engineers must meet the expectations of the market (although the proponents of this position do not see a conflict between the market challenge and the social responsibility challenge). Instead the real challenge for engineers is to change society into a better place. Ethical motives are at the root of this perspective.[2] Challenges are not primarily seen as something that should be reacted to. Instead the proactive and transformative element in engineering is stressed (e.g., Duderstadt et al. 2008, p. 71). The real challenge for engineering is to employ the engineers' skills and knowledge in ways that serve humankind and sustain the environment. In this perspective engineers must strive not to let technology deteriorate into one-dimensional technical fixes. Instead technological solutions must always take social aspects into consideration. Via socio-technical solutions and innovative design, the engineers can help to create a better world. Being a socially responsible engineer implies working with the social and technical elements as a heterogeneous assemblage. Engineers must improve their social skills and learn to frame and solve problems in ways that have the *real* problems in mind.

[1] Similar arguments are produced by, e.g., Duderstadt (2008, p. 25) about the US context.

[2] Interestingly it is rarely seen that these ethical arguments are developed into political convictions.

A third category of challenge perception sees the challenges of engineering in relation to the internal evolution of the techno-scientific complex and *engineering knowledge*. Science and technology has changed dramatically over the last decades (Hård and Jamison 2005; Jamison et al. 2011). New disciplines and areas of research such as information technology, biotechnology, media technology, and nanotechnology have proliferated and transformed engineering practice in radical ways. In this light Rosalind Williams (2002) has challenged the engineering profession by asking exactly what it is about. The traditional engineering disciplines fail to grasp the new areas of research and industrial production. The techno-scientific complex with its many new disciplines is extremely diversified and hard to comprise within the engineering curriculum. Thus, the main challenge from this internal perspective on engineering practice relates to defining the core elements and unifying features of engineering knowledge. This challenge has very profound and practical consequences for engineering education and engineering identity. What should engineers know and what should be at the core of engineering curricula? Is it mathematics, physics, and chemistry or are these traditional scientific disciplines not the essential ones? If not, what should be put in their place? This third category of challenge perceptions revolves around epistemic questions, and it is appropriate to refer to it as the *knowledge challenge*.

The challenges to engineering developed in the literature can thus roughly be summarized in the three categories: the market challenge, the knowledge challenge, and the challenge of social responsibility. Proponents often sketch their arguments with elements derived from more than one of these categories. But it will become clear, however, when I look closer at the proposed response strategies that respective proponents align their arguments within specific discursive frameworks that give priority to one specific category of challenge perception. Let us investigate this further.

Response Strategies

The three categories of challenge perception reflect specific kinds of response strategies. Let us investigate the specific story lines of the strategies.

The *market challenge* is generally met by response strategies that focus their attention on the role of the engineers within the company. The strategy's fundamental claim is that engineers need to supplement their technological skills and competencies with commercial qualifications (e.g., ATV 1997, 2000; The Ministry of Science, Technology and Innovation 2005). The engineers still have to undergo an advanced technological education, but a proportionate part of the education has to qualify the engineers within economics, (project) management, sales, investment analysis, negotiation, etc. In this line of argument, the yardstick of relevance for engineering qualifications is the company's needs. The argument states that in order to stay competitive, the companies need practically oriented engineers that are able to develop technological products and solutions in the most cost efficient way and in accordance with the costumer's requests. The desired virtues are flexibility,

practicality, the ability to optimize, being market driven, customer focused, and agile. In short, this strategy could be called the *business strategy*. It suggests that technical universities and engineering schools collaborate with business schools or even better devote a significant part of curriculum to management studies (e.g., ATV 1997, p. 6, suggests that at least 10% of the curriculum be dedicated to management disciplines). The business strategy also recommends that engineers be trained in communication skills, collaborative skills, abilities to enter into cross-disciplinary innovation projects, etc., but there is no mention of critical reflection and other competencies typical of the liberal arts. The skills and competencies recommended by this response strategy are primarily instrumental. The engineer is thus positioned as a highly skilled practitioner with the ability to serve corporate enterprises in designing, implementing, and optimizing production for the overall motive of profit. The ideal is the corporate engineer or the "organization man" (Whyte 1956/2002). It is no surprise that the advocates of this strategy are foremost private sector companies, industry, and liberal governments that praise the free market as the ultimate regulating mechanism for designing engineering education. On these terms education should ideally be designed according to functionalist principles dictated by market needs. The business strategy has no special interest in engineering or engineering knowledge per se. It sees engineering as a convenient concept to label highly proficient people who are skilled within technology and business.

The challenge of social responsibility is met by strategies that highlight professional ideals for engineering (e.g., Duderstadt et al. 2008; Douglas et al. 2010; Clough 2004). Professional standards, codes of conduct, and ethical standings are fundamental to these strategies. Entering the engineering profession invests individuals with privileges and powers but also places responsibilities on the practitioners. The argument of these strategies holds that being educated and trained as an engineer is not just a matter of acquiring technical knowledge and skills. It is also a matter of entering a special culture that honors special values, holds scientific and technological knowledge dear, and aspires to certain virtues. In this sense, the argument claims, engineering is unique and unified. The overall focus of the engineering profession should be to serve humankind, protect our environment, improve living standards, etc. Gaining personal profits or serving the interests of industry may not be in conflict with this focus, but it must always be subordinate to the professional ideals. The strategies dealing with the social responsibility challenge are thus united in their confidence in professional ideals and practices. The professional strategy thus positions the engineer as a modern "hero" who is preoccupied with developing a better world for humankind. But the strategies have different answers regarding the character of professionalism. Thus, Duderstadt (2008, p.v) recommends that engineering is transformed into "…a true learned profession, similar in rigor, intellectual breadth, preparation, stature, and influence to law and medicine, with extensive postgraduate education and a culture more characteristic of professional guilds than corporate employees." The profession becomes the habitat and unifying point of departure for engineering practice. But what is characteristic of this practice? One answer stresses that engineering practice is about solving problems and designing and building artifacts that work. The CDIO movement

testifies to this down-to-earth mission (Crawley et al. 2007). Another branch of the professional strategy to the social responsibility challenge is directed by a focus on (large-scale) socio-technical systems (Williams 2003, pp. 51 ff.). In this perspective engineering is all about designing socio-technical systems and managing their complexities, dynamics, etc. Regardless of the specific interpretation given to engineering practice, the strategy holds that the profession is unified and should play a major role in dealing with the challenges humankind faces today. Thus, the profession should aspire to a higher end. Proponents of this strategy do not strive to alter engineering education by bringing in new supplementary disciplines as management or economy. Instead they propose that engineering education should be transformed into having the status of a liberal art (Duderstadt 2008, p.v) along with the natural sciences, social sciences, and humanities. It should be interdisciplinary by nature and practice-based, and engineering schools should work closely with industry to achieve this goal (e.g., Douglas et al. 2010). Furthermore, the practice of engineers should be regulated by professional licensing requirements. It should come as no surprise that the professional strategy finds its proponents in engineering professional societies and bodies, some engineering schools, and among individual engineers working in industry that stress professional standards and moral obligations in engineering.

Finally, *the knowledge challenge* to engineering also calls for a strategy. This strategy, however, is fundamentally different from the above mentioned insofar as it does not meet the challenge by trying to reinvent or reframe engineering. On the contrary, the strategy states that "Engineering is less and less a separate realm and more and more an integral part of both science and business" (Williams 2003, p. 40), and further:

> In a hybrid world, engineering can thrive only as a hybrid. Today it is most dynamic at its peripheries, where it is most engaged with science and with the marketplace. Inevitably the profession formerly known as engineering will multiply into a much wider variety of grades and types of levels, because engagement with technology has far outgrown any one occupation. The future of engineering lies in accepting rather than resisting this multiplicity.
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> (Williams 2003, pp. 80–81)

In embracing this trend Williams thus advocates what might be called a *hybrid strategy* in response to the knowledge challenge. This hybrid strategy observes that engineering is disintegrating *and* expanding its range at the same time. In accepting the disintegration and lack of autonomy of the engineering profession, she recognizes that the education of highly skilled professionals engaged with technology no longer is the privilege of technical universities and engineering schools. In recognition of the ubiquitous role of technology in society, it must also be recognized that "engineering" is expanding its domain of relevance. In consequence the proper habitat for the education of the "engineer" of the future is the university: "Engineering education must rejoin higher education in an adventurous mix that brings together information technology, the sciences, the social sciences, the humanities and the arts" (Williams 2003, p. 83).

Contrary to the business strategy and the professional strategy, the hybrid strategy does not propose that the domain of engineering be supplemented by other disciplines

(management) or transformed into a learned profession governed by licensing requirements. Instead it proposes that engineering should be reconceptualized according to changes in technology. The production of (technological) knowledge and innovation has increasingly become multidisciplinary and even transdisciplinary (Gibbons et al. 1994; Ziman 2000; Nowotny 2008), and this calls for a "hybrid imagination" (Hård and Jamison 2005; Jamison et al. 2011) of the entrepreneurs, technologists, and scientists of the future. According to the hybrid strategy, education of these innovators are situated in universities that comprise multiple disciplinary approaches and compose curricula by bringing in knowledge from different academic fields to solve problems of importance to civil society and companies. Thus, the hybrid strategy encourages dialogues with industry and civil society – although it is unclear how far this dialogue should bring the students away from the academia. The proponents of this strategy are mainly situated within academia.

Governing Engineering

The three strategies outlined above do not only answer the challenges to engineering – they can also be seen as a means of governing engineering. As already mentioned the challenges and the strategies are closely linked. Thus, the strategies provide answers to the challenges to engineering. But the linkage is more profound than just answering the challenges. The strategies provide overarching interpretative frameworks for defining, discussing, and answering the challenges to engineering and *a fortiori* the future of engineering. The strategies are the medium in which governance exists rather than its instrument. To paraphrase Foucault, the strategies install an intrinsic logic of a regime of practice by framing situations and setting the limits for what is possible to think and argue (Foucault 1980). The strategies of regimes are the producers of truths, knowledge, authority, and rationality. They are embodied and represented by social institutions, logics, material-discursive practices and the intentions of individuals, but the strategies are in themselves nonsubjective assemblages of all the elements that conduce the conduct of actors. By problematizing engineering in accordance with specific and distinct challenge perceptions, the "response" strategies define, demarcate, and advance the territoriality of the engineering mission and set visions and directions for the advancement of engineering practice and engineering education. It is thus naïve to regard the strategies as plain responses to objective challenges. In fact the strategies should be seen as the producers of the challenges. Likewise it is naïve to search for response strategies that cover and encompass all the stated challenges. It would not only be impossible on a practical level to honor the recommendations to engineering education set forward by the business strategy, the professional strategy, and the hybrid strategy (due to the congestion problem of curricula) – it would also be inconsistent in regard to the visions and missions of the respective strategies.

It is important to realize that engineering is not only governed by direct legislative and economic conditions, institutional interests, and political initiatives in relation

to education and the job market. Engineering is also governed in much more subtle, discrete, and indirect ways. The strategies thus also work as disciplinary powers through our culturally mediated dispositions or dispositifs (Foucault 1972, pp. 3–17), i.e., through regimes of knowledge – relatively stable constellations of beliefs, values, knowledge, and techniques. Foucault called this conduct of conduct *governmentality* (Foucault 1991): by subjectification into specific strategies, we conduct our own actions and those of others in a wide variety of contexts. As an example the ethos of engineering expressed in what I have labeled the professional strategy has a disciplinary effect on the practices of individual engineers. This ethos is induced in subjects through technologies of education and socialization at technical universities and engineering schools and reinforced in engineering communities.

The three strategies that I have detected in the literature on challenges to engineering can thus be seen as prevailing discourses that afford the conduct of practitioners in engineering as well as other actors engaged in domains of technology, education, knowledge production, etc. The discourses afford and restrict the conduct of practitioners and actors through the development of logics, rationalities, and techniques that give guidance and orientation for future actions, judgments, decision making, framing, ways of seeing and perceiving, etc. The discourses, however, do not determine future action in accordance with a prespecifiable *telos*; the continuation of practice is contingent and the product of conflicts, negotiations, and reproductive actions that needs closer historical investigation. Alas, the format of this chapter does not allow us to indulge in genealogical investigations of engineering practice. Thus, it must suffice to gesture to the three strategies found by examining influential Danish and American texts on challenges to engineering. In the table below I have tried to capture some essential features of the three response strategies detected in the texts (Table 10.1).

Conclusion

Through the analysis, I have documented the prevalence of three distinct strategies in influential contemporary Danish and American texts on challenges to engineering: the business strategy, the professional strategy, and the hybrid strategy. In applying the analytical tools of governmentality studies, it is possible to see these discursive strategies as a means of governing the territory of engineering by developing visions and missions for the domain. Our constructionist and post-structuralist approach to challenge perception in engineering has thus enabled us to penetrate the texts in ways that do not take their accounts at face value; instead the texts are read as "voicing" different discursive narratives that strategize the future of engineering. Secondly, it can be recognized that the strategies – in accentuating and propagating different narratives – cannot be aligned or unified. Although some of the analyzed texts do contain arguments borrowed from more than one of the three strategies, it is clear – on a general analytical level – that the strategies are distinct insofar as their foci and goals vary. The strategies are thus incompatible in the sense that they promote

Table 10.1 Narratives and response strategies in engineering

Narrative/strategy	The business strategy	The professional strategy	The hybrid strategy
Challenge to engineering	To remain competitive on a national, organizational, and individual level	Recognition of responsibilities in relation to humankind and nature	The disintegration and proliferation of technological knowledge
Vision for engineering	More and more proficient engineers	Abidance by and elevation of the engineering profession	The engineer as the reflective knowledge worker
Mission of engineering	To optimize profit and secure economic conditions for welfare	To improve living conditions and secure welfare through technological solutions	To produce new knowledge and engage with the community
Authoritative principles of the strategies	The market system, company's demand for competencies, employability	Engineering virtues/professionalism/ solutions that work	Reflection, innovation, knowledge production
Subjectification/the ideal of engineering	"The organization man"	"The modern hero of technology"	"The hybrid imagination"
Proponents	Industry/policymakers	Professional engineering bodies/ engineering schools	Academia, social scientists
Consequences for engineering education	Collaboration between business and engineering schools, practical curriculum	Establish engineering as a distinct new liberal art/an academic discipline	The fusion/absorption of engineering curriculum in higher education

different agendas, have different groups of proponents that try to advance these agendas, and delimit the territoriality of engineering in different ways.

Where does this analysis leave us? The analysis of this chapter has been explorative and critical in the sense that the challenge perceptions of influential texts have been problematized (Foucault 1988) and scrutinized in order to explicate their implicit presumptions and related response strategies. In the public debate about the future of engineering, challenges are often seen as self-evident and inevitable and thereby establishing an authoritative departure for specific response strategies in relation to engineering education, engineering recruitment campaigns, etc. By closer inspection, however, it is clear that the challenge perceptions are not rooted in neutral observations but are part and parcel of discursive formations and narratives that enable the perspectives, ambitions, and visions of actors. In establishing the linkage between specific challenge perceptions and response strategies, the analysis has made the hegemonic projects of regimes of engineering practice explicit and thus exposed them to reflection and critique. The approach of governmentality studies enables us to conceive the governance of engineering practice as the discursive subjectification of engineering identity and thus elicit new avenues for educationalists seeking to reform engineering education.

The perspective has significant implications for the study of engineering education. It thus compromises the soundness of traditional "gap analysis" in engineering education. Our analysis shows that the conception of challenges is not an independent corrective factor that can guide educationalists in designing "adequate" educations that can produce the "necessary" competencies and thus "close the gap." Challenge perceptions and response strategies are part and parcel of discursive formations and distinct narratives. Reforms of engineering education end in deadlocks when educationalists try adjusting curricula in accordance with the "demands" of the labor market or according to "professional criteria." One obvious reason is that the various strategies that inform challenge perceptions pull curricula in engineering education in different directions by setting different standards for the "adequacy" of engineering education. Engineering education cannot be reformed by providing more information about labor market demands or making more "precise" specifications about engineering professionalism. The conversation on engineering education needs to change.

I suggest that the conversation on reforms in engineering education should pay more attention to how engineering work is practiced in different contemporary contexts and how engineers construct their engineering identities. Not because this information should yield objective correctives for reforms. But because more nuanced descriptions of diverse engineering practices could provide us with a richer picture of how engineers apply their engineering knowledge and skills in diverse contexts and settings, and what problems and challenges they face on a daily basis, and in their efforts to manage and develop their careers. It is important to have more specific knowledge of the processes of subjectification and socialization in engineering education and in various forms of engineering work in order to investigate *how* discursive practices and strategies guide and govern students and engineers. Nuanced and cogent descriptions of the subjectification processes in engineering

education and engineering practice have the potential of redescribing and thus reframing engineering in an idiom that transgresses the narratives of the dominant discursive strategies. In order to reform engineering practice and education, we must have knowledge of how engineering is actually governed. This is only a first – but necessary – step in advancing the research agenda that can provide us with new knowledge to shift the governance of engineering education and practice.

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