Philosophy of Engineering and Technology

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The Engineering-Business Nexus

Symbiosis, Tension and Co-Evolution

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Foreword by Carl Mitcham

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Foreword

Engineering and Business: Toward the Fragile Appreciation of a Fraught Relationship

This important volume contributes to a growing literature in engineering studies by advancing critical reflection on relationships between engineering and business. Within the engineering community, engineers often experience conflicts between professional obligations and the demands of corporate employers. Within the business community, engineers are sometimes thought insufficiently sensitive to economic demands—a judgment now being reflected back into engineering school efforts to incorporate economics and entrepreneurship training. But seldom has this tension been subject to the broad, interdisciplinary reflection aimed at in the present volume.

Capitalism—the core of modern business—was coeval with engineering or what some mistakenly insist was just "modern" engineering. Adam Smith's *The Wealth of Nations* (1776) appeared in the same decade as the Smeatonian Society of Civil Engineers (1771), the first such professional association. Although the US National Academy of Engineering has praised engineers for transforming the lifeworld through steam ships, railroads, airplanes, radio, television, and computers (http://www.greatachievements.org), capitalism is credited with being the wealth production machine that has raised billions of people out of poverty. The claim for the primacy of business enterprise—as it has been practiced in the forms of mercantile capitalism (since the early 1500s), industrial capitalism (since the early 1800s), and financial capitalism (since the late 1900s)—has been the central argument of liberal and neoliberal economists.

In the words of Nobel Prize-winning economist Milton Friedman in a 1979 television interview with Phil Donahue that has become a staple of neoliberal websites:

> [T]he only cases in which the masses have escaped from [grinding poverty], the only cases in recorded history, are where they have had capitalism and largely free trade. If you want to know where the masses are worse off, worst off, it's exactly in the kinds of societies that depart from that. So that the record of history is absolutely crystal clear, that there is no alternative way so far discovered of improving the lot of the ordinary people that can hold a candle to the productive activities that are unleashed by the free-enterprise system.

The reality, however, is that capitalism would not have been able to pull off this unprecedented multiplication in human wealth had it not been for engineering. The myth of capitalism alone depends, like all myths, on a careful obscuring of conditionals. Smith's "invisible hand" that leads bakers to provide bread for others would have remained quite limited to those with whom they had personal relationships had the baker not been able to capture, if not enslave, the engineering mentality. Indeed, the superimposition of self-interest over benevolence is a feature as characteristic of engineering as of capitalism. It was the engineering analysis of production into simplified functions that could be used to impose a strict division of labor, as in the famous example of pin manufacture, and the reduction of workers to laborers, together with the enslavement of steam energy to mechanical reproduction, that unleased the forces of exploitation and waste production that have engendered the Anthropocene.

The transformation of capitalism—or the investment of money not to make good products but to make a profit—through the economic captivity of engineering is dramatically illustrated in John Lee Hancock's docudrama *The Founder* (2016) of the McDonald's fast-food chain. The engineering of burger production by the brothers Maurice "Mac" and Richard "Dick" McDonald was done by careful time-and-motion studies along lines pioneered by mechanical engineer Frederick W. Taylor (1856–1915) and industrial engineers Frank (1868–1924) and Lillian Gilbreth (1878–1972). When entrepreneur Ray Kroc (played by Michael Keaton even better than his *Batman*) discovers the original McDonald's system in operation near Pasadena, California, he proposes to franchise it. The McDonald brothers resisted, because of a desire to maintain the quality of their product and a rejection of the ideal of simply increasing profit. For Dick McDonald, high-quality and rapid service were ideals to be protected rather than franchised to increase profits.

Kroc, a money hungry businessman, through repeated pressure eventually persuaded the McDonald brothers to contract with him to open his own McDonald's in Des Plains, Illinois. Over the next few years, by means of underhanded tactics and legal maneuvering, he lowered the quality of the product (by, e.g., replacing real milk shakes with synthetic ones), eventually running the brothers out of business, divorcing his wife, and swaggering onto the stage of business history with a self-promotional (but assisted) autobiography, *Grinding It Out: The Making of McDonald's* (1977). *The Founder* exchange about the milk shakes, however, remains fundamentally revealing:

> Ray: I just found a way to save … hundreds of dollars [with] powdered milk shakes.
>
> Dick: Ray, we have no interest in a milk shake that contains no milk. …
>
> Ray: You don't want to save a bundle.
>
> Dick: Not like that. … It's called a "milk shake," Ray. Real milk, now and forever.
>
> …
>
> Ray: If you don't want to make a profit, that's fine. But don't stop the rest of us [with your] cowering in the face of progress.
>
> Dick: If phony powdered milk shakes is your idea of progress, you have a profound misunderstanding of what McDonald's is about…. You will do as we say. You have a contract….
>
> Ray: You know, contracts are like hearts. They are made to be broken.
>
> …

> Mac: We came up with the … system. Not you, us. What have you ever come up with? Can you name one thing? You can't. And you never have and you never will. Because you are a leach, Ray, you are a professional leach.
>
> Ray: You know what I came up with, Mac, a concept. I came up with the concept of winning. … I want to take the future. I want to win. And you don't get there by being some aw-shucks, nice guy sap. There's no place in business for people like that. Business is war. It's dog eat dog, rat eat rat. If my competitor were drowning, I'd walk over and I'd put a hose right in his mouth. Can you say the same?
>
> Mac: I can't. Nor would I want to.

The irony here is that the original McDonald brothers as businessmen adopted the engineering mentality in order to improve their product, not simply to make money. Money making was a secondary goal. It was Kroc who, as one interested in multiplying the forces of economic growth through the free-enterprise system, captured engineering expertise and turned it to his personal advantage.

Another irony can be found in Kroc's vision of engineering-business nexus as grounded in competition. On Thomas Friedman's "Golden Arches Theory of Conflict Prevention" (from *The Lexis and the Olive Tree*, 1999)—which posits that no two countries with McDonald's in them will go to war—there is a benefit greater than either high-quality hamburgers or increasing profit. Given the challenges of climate change, to which capitalist progress is a dominant contributor, it would be useful to consider ways in which reforms in the engineering-business nexus might enhance explorations of the alternative ideal of degrowth as pioneered in, for example, Romanian American economist Nicholas Georgescu-Roegen's *The Entropy Law and the Economic Process* (1971) and French philosopher Serge Latouche's *Petit traité de la décroissance sereine* (2007; translated as *Farewell to Growth*, 2009).

The articles collected in the present volume, from a broad spectrum of authors and disciplines, cannot help but push readers further into reflection on the multiple ironic relationships between engineering and business. The need for continuing research on these issues is one on which every chapter in the book, separately and even more so together, will stimulate thinking.

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Preface

In no small part, this volume has been inspired by Robert R. Locke and J. C. Spender's 2011 book *Confronting Managerialism: How the Business Elite and Their Schools Threw Our Lives Out of Balance.* In discussing the difference between management and managerialism and the role of business schools in promoting the latter, they write:

> Managerialism…is a phenomenon associated with membership in a specific group of managers that share specific attributes – a caste. It does not reflect the culture of democratic capitalism with its commitment to collaboration; rather the caste desires to stand apart from society, to become less social and more predatory; to see both markets and businesses as opportunities to plunder, whatever the consequences; to take unforgiving advantage of the errors, misfortunes, and circumstances of others, no matter how they arose…. No aspect of that harm is more pernicious than the role business schools have played in reinforcing the caste's sense of itself and the legitimacy of its predatory instincts done in the name of good management. (Locke and Spender 2011, p. 2)

For many students in engineering and business programs, management roles will be part of their future. Our volume is motivated by the concern that they should be able to critically address such caste-like behavior and values to the extent that they occur in education and practice.

The contributors to this volume thus explore the nexus between engineering and managerialized business. This nexus is complex and multilayered, involving coevolution, tension, and symbiosis. On the one hand, we live in a world that appears to be progressively and relentlessly becoming itself an engineered artifact. More than our roads, buildings, and communications systems are engineered. How we function within our societies is affected and transformed through the activities of engineers and the companies in which they work. In such a world, *thinking about engineering* has become increasingly important and necessary, and yet is challenging and difficult. On the other hand, the majority of the world's population inhabits a world based on an economic model of continuous growth. This economic growth model—an object of critical reflection in itself—provides the historical and current context and the framework in which most engineers work. In this volume, our scope has therefore been expanded to *thinking about engineering and business*, and we locate engineers as actors within the current economic growth ideology.

In our current increasingly engineered society, one ideal of management and controls comes to the fore as the Anthropocene, i.e., the world transformed into an engineered artifact in which human existence is included as well. The human imprint has now become so pervasive and profound that it equals the forces of nature and is thereby turning the Earth into a planetary terra incognita. At the same time, the experience of climate change, which can be associated with the third phase of the Anthropocene, calls for management and control to safeguard planet Earth as a human life supporting system. The Anthropocene therefore raises the question as to how engineering and business together should be considered, given the fact that the current engineering-business *nexus* remains embedded in an economic model of continued growth, whose transformation consequently is called for. It is clear that the transformation deemed necessary to evolve from the current system did not arise as the product of a deliberative choice by individual engineers. This is because it concerns the socioeconomic system as a whole, including our embedded engineering and business practices, rather than a limited set of actors—engineers—within society. The societal and environmental challenges we face are not simple or "tamed" problems, but rather complex or "wicked" problems, and their solution will require interventions at the intersection of technology, business, and society.

With this volume, we want to pick up this thread of reflection on the mutual positioning of engineering, business, and society. Contributors have addressed the connections between engineering and business and the moments of tension between them. They have explored complex relationships between engineering and business from the ideological to the curricular. Professional value systems are identified and compared. Ways of seeing the world through the lens of these value systems are explored, with a focus on how they are embedded in engineering and business cultures. Finally, contributors have explored and posited movements to reshape, reform, and even reject the engineering-business nexus and how these are appearing in engineering education.

The present volume continues efforts in previous publications to explore ways in which scholars from the humanities, social sciences, and engineering can contribute to engineering education. This is approached partly through an appreciation of the multiple contexts within which engineers work and partly through appreciation of the challenges with which engineers, engineering institutions, and engineering education are currently confronted. We provide additional context by examining a number of engineering ideologies and looking at historical case studies that shed light on current realities. How engineers function within the workplace and the practices of those engineers are described in order to extract key attributes of workplace engineers and the tensions they face. We close by examining how the engineering-business nexus is configured within the higher education system. Throughout, we have tried to confront and challenge real developments past and present.

While systems at rest tend to remain at rest, external pressures on engineering education systems have created a movement to innovate engineering programs. Among other responses, the development of hybrid engineering programs has proliferated. In part, this is to meet corporate demands, to respond to national priorities, and thus to provide a more relevant education to engineering students. The novelty of this volume is that our approach to the engineering-business nexus does

not come from a narrow curriculum development need, but rather through examining the broader transformations affecting engineering practice, and therefore, how the splintering and hybridization occurring at a micro (i.e., course or curricular) level is caused by changes in business practice at the macro level.

Contributions to this volume stem from networks that were established in previous collaborative projects, beginning with a 2003 precursor, *Profession, Culture, and Communication: An Interdisciplinary Challenge to Business and Engineering*, edited by Steen Hyldgaard Christensen and Bernard Delahousse and published by the Institute of Business Administration and Technology Press, Herning. This initial collaboration was continued through a series of book projects initiated and coordinated by Steen Hyldgaard Christensen and new partners at the international level, including especially Carl Mitcham, Colorado School of Mines and Renmin University of China, who acted as a key node in the network. Other publications in the series include:

- Steen Hyldgaard Christensen, Bernard Delahousse, Martin Meganck (eds.) (2007), *Philosophy in Engineering*, Academica, Aarhus
- Steen Hyldgaard Christensen, Bernard Delahousse, Martin Meganck (eds.) (2009) *Engineering in Context*, Academica, Aarhus
- Steen Hyldgaard Christensen, Carl Mitcham, Li Bocong, and Yanming An (eds.) (2012), *Engineering, Development and Philosophy: American, Chinese, and European Perspectives*, Springer Science+Business Media B.V.
- Steen Hyldgaard Christensen, Christelle Didier, Andrew Jamison, Martin Meganck, Carl Mitcham, Byron Newberry (eds.) (2015), *International Perspectives on Engineering Education; Engineering Education and Practice in Context, Volume I*, Springer Science+Business Media B.V.
- Steen Hyldgaard Christensen, Christelle Didier, Andrew Jamison, Martin Meganck, Carl Mitcham, Byron Newberry (eds.) (2015), *Engineering Identities, Epistemologies and Values*: *Engineering Education and Practice in Context. Volume II,* Springer Science+Business Media B.V.

The volume is addressed to both teachers and students in engineering and business disciplines as well as practitioners and educational policy-makers, on political and institutional levels. It is the result of a long writing and editorial process. Hopefully readers will find it worthwhile, particularly as it aims at inspiring us all to do more thinking and rethinking about the engineering-business nexus and to launch further research in this important field.

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20 September 2016

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Chapter 1
General Introduction: The Engineering-Business Nexus: Nature, History, Contexts, Tensions

Steen Hyldgaard Christensen, Bernard Delahousse, Christelle Didier, Martin Meganck, and Mike Murphy

> The vested rights of absentee ownership are still embedded in the sentiments of the underlying population, and still continue to be the Palladium of the Republic; and the assertion is still quite safe that anything like a Soviet of technicians is not a present menace to the vested interests in America. (Veblen 1921, p. 128)
>
> The engineer is both a scientist and a business man. (Layton 1971, p. 1)
>
> While the systematic monopolization of scientific knowledge by the professionals increased the autonomy of scientists, however, it had the opposite effect upon engineers, tying them to the large corporation. (Noble 1977, p. 43)

Questions about the nature, history and context of the engineering-business nexus related to specific times and countries are not new, as evidenced by the quotations given above from three American classics: Thorstein Veblen's *The Engineers and*

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the Price System (1921), Edwin Layton's *The Revolt of Engineers* (1971), and David Noble's *America by Design* (1977). What these classics have in common is that they all set out to examine the consequences related to a decisive moment in the history of business and engineering in the United States, namely the emergence of the multidivisional business corporation – a new institutional entity constituting a main feature of corporate capitalism or what Harry Braverman (1974) calls monopoly capital. Each in its own way has shown how the professional ideals and aspirations embraced by many American engineers during the Progressive Era, from the 1890s to the 1920s, were in marked tension with business imperatives and bureaucratic loyalties. Nevertheless the work of both Edwin Layton and David Noble helped to contextualize the professionalization of American engineers. They also showed how prevailing engineering values and attitudes were frequently interchangeable with a business ethos inculcated through dominant pathways in engineering education and career trajectories. At a more general level the conflicting values and commitments of professionals and managers have been substantiated in Joseph A. Realin's 1985 book *The Clash of Cultures: Managers and Professionals* in which he proposes how professionals should be managed to avoid a clash of cultures.

The engineering-business nexus has also been a persistent subtheme in engineering ethics. In their 2000 book *Introduction to Engineering Ethics* Mike W. Martin and Roland Schinzinger write:

> From its inception as a profession, as distinct from a craft, much engineering has been embedded in corporations. That is due to the nature of engineering, both in its goal of producing economical and safe products for the marketplace and in its usual complexity of large projects that requires that many individuals work together. (Martin and Schinzinger 2000, p. 19)

Though some engineers also work within government entities, or for non-profits, such as humanitarian organizations, the bulk of engineering activity occurs in the service of business and industry. In highly technological businesses, it is not uncommon for engineers to take on business management functions and often rise into the executive ranks. So, while engineering and business are generally studied as distinct entities, they are deeply symbiotic. Further, engineering and business are both quite diverse. Engineering has a wide array of disciplines, and a wide array of job functions within each discipline. And the companies that engineers work for provide a panoply of products and services, range in scale from small consultancies to giant multinationals, and vary across a spectrum of political and cultural environments. Thus there is a complex business-engineering ecology that defies any simple characterization of the engineering-business relationship. The engineering-business relationship is also complicated by tension between the two – most often a tension between the demands of the marketplace and the ideals of the profession.

Examination of the social context in which the large corporation arose, and how this new entity was regarded by society, shows that the birth of the business corporation represented more than a simple development and implementation of new technologies and adaptation to new market conditions. In itself the multidivi-

sional business corporation was an important innovation, because it professionalized the big company and set its dominant structure. In this way the business corporation became the template for "managerialism". John Micklethwait and Adrian Wooldridge in their 2003 book *The Company: A Short History of a Revolutionary Idea* put it this way: "If the archetypical figure of the Gilded Age was the robber baron, his successor was the professional manager – a more tedious character, perhaps, but one who turned out to be surprisingly controversial" (ibid., p. 103). Ultimately, as Joel Bakan unveils in his 2004 book *The Corporation. The Pathological Pursuit of Profit and Power,* the large business corporation was also linked to emerging social, intellectual and cultural conditions, or more precisely to the disruption of an entire social order. As noted by Braverman (1974, p. 260) prior to 1850 very few American firms needed the services of a full-time administrator. Neither did they require a clearly defined administrative structure as industrial enterprises were very small. Administration in such small businesses was usually a family affair. Its basic economic, administrative, operational, and entrepreneurial activities could normally be handled by two or three men responsible for the destiny of the enterprise.

As the business corporation came to replace the small traditional family firm Alfred D. Chandler in his 1977 classic *The Visible Hand: The Managerial Revolution in American Business* noted that in many sectors of the economy,

> The visible hand of management replaced what Adam Smith referred to as the invisible hand of market forces. The market remained the generator of demands for goods and services, but modern business enterprise took over the functions of coordinating flows of goods through existing processes of production and distribution, and of allocating funds and personnel for future production and distribution. As modern business enterprise acquired functions hitherto carried out by the market, it became the most powerful institution in the American economy and its managers the most influential decision makers. (Chandler 1977, p. 1)

Chandler extends and deepens insights that can be found as well in a 1932 analysis by Adolf A. Berle and Gardiner C. Means, *The Modern Corporation and Private Property,* which picked up on the significance of the divorce of ownership from the control of the business corporation, as did Veblen's 1923 *Absentee Ownership and Business Enterprise in Recent Times: The Case of America*.

From the second half of the nineteenth century, however, it was not clear whether graduates from engineering schools or graduates from emerging business schools would provide leadership in society, industry, and emergent large business corporations, and whether they should pursue higher aims of service beyond material rewards and profit. With respect to the emergence of the American business school the taken-for-granted assumption that an enormous cadre of salaried managers should manage the business corporation on behalf of absentee owners was a historical contingency. The business school was established for a growing occupation in search of legitimacy. In Rakesh Khurana's account (Khurana 2007) the emergence of the American business school in 1881 was founded on the promise of turning management into a profession for higher aims.

Consequently, at the beginning, the rhetoric of both engineers and managers implied aspirations of providing professional leadership for higher aims. However, these groups emerged as a response to social needs related to their occupational practice, and the discussion about higher aims came along later. Although at the level of early practice the question of doing good – and giving oneself some rules – was always an issue for some people, the formalization of education and the emergence of new groups – the "professionals", or the "graduates" – was the result of a whole process. First came the needs from the practice of their trade, secondly came the need for formal education, and finally the collective discussion about the other goals such as higher aims. Today, however, and perhaps more than ever before, business leaders and practicing engineers face a complex interdependence. This interdependence arguably affects all participants in the global economy, and in our increasingly interconnected world it is becoming ever more obvious that actions providing immediate advantage to some cannot be counted on to benefit all. A glaring example of such actions that provide advantage to a single group to the detriment of other stakeholders is the way business managers are incentivized:

> The tactic of "incentivizing" managers with stock options, for example, followed from a market logic – inculcated in directors and managers alike by business schools beginning in the 1970s – that assumes that managers are both purely self-interested and motivated only by the prospects of lavish material rewards. By demoting managers from professional stewards of the corporations resources to hired hands bound only by contractual requirements and relationships, business schools thus helped create the conditions and standards of behavior through which the market-based mechanism of stock options was turned into instrument of defrauding investors, jeopardizing the livelihoods of employees, and undermining public trust in managers and corporations. (Khurana 2007, p. 375)

These new times raise questions about business and engineering practices, the meaning of leadership and expertise, and, ultimately, the very purpose of business and engineering. For engineers this is all the more relevant as we live in a progressively engineered world, which raises troubling questions regarding the meaning of life and the goals of societies in this kind of world.

In light of this background, the purpose of this book is to explore the engineering business ecology in order to increase our understanding of its nuances. This includes understanding the common ground between business and engineering, as well as differences between them. Our aim is to explore perceived benefits and challenges, compatibilities and tensions, and agreements and misunderstandings within the engineering/business relationship, and consequent implications for society. In the process, we also want to highlight the importance of the engineering/business relationship in the education of engineers.

The present volume therefore interrogates multilayered relationships between engineering and business on a broad international canvas with an eye to the social transformation of business schools and the unfulfilled promise of management as a profession (Khurana 2007). Key overlapping questions that inform the volume are:

- What kinds of conflict arise for engineers in their attempt to straddle both professional and organizational commitments?

- How should professionals be managed to avoid a clash of managerial and professional cultures?
- How do engineers create value in firms and corporations?
- What kinds of tension exist between higher education and industry?
- What kinds of tension does the neoliberal entrepreneurial university pose for management, faculty, students, society, and industry?
- Should engineering graduates be ready for work, and can they possibly be?
- What kinds of business issues are reflected in engineering education curricula, and for what purpose?
- Is there a limit to the degree of business hybridization in engineering degree programs, and if so, what would be the criterion for its definition?
- Is there a place in engineering education curricula for reflective critique of assumptions related to business and economic thinking?

As regards the last bullet question, concerns have been voiced over the narrowness of business curricula and the lack of reflective critique resulting in the failure of business educators to challenge students to question assumptions, to think creatively, and to understand the place of business in larger institutional contexts. Prominent examples of scholarly work that point to the need to address this situation are Rakesh Khurana's 2007 book *From Higher Aims to Hired Hands: The Social Transformation of American Business Schools and the Unfulfilled Promise of Managements as a Profession,* Anne Colby, Thomas Ehrlich, William M. Sullivan and Jonathan R. Dolle's 2011 book *Rethinking Undergraduate Business Education: Liberal Learning for the Profession,* and Robert R. Locke and J.-C. Spender's 2011 book *Confronting Managerialism: How the Business Elite and their Schools Threw our Lives out of Balance.* In spite of dispersed initiatives the situation seems to be quite similar in engineering education curricula. All the more so is this the case since STEM fields play a crucial role in the neoliberal entrepreneurial university and managerialism and administrative bloat have been flourishing in this new corporatized entity.

In addressing the above-mentioned questions the present volume collects 21 original contributions grouped into four parts. Part I concerns engineering and business value systems, and Part II engineering and business ideologies past and present. Part III has its focus on the practices of business and engineering. Finally the focus of Part IV is on engineering and business education.

1.1 Part I: Engineering and Business Value Systems

The five chapters in the first part of the present volume examine the relationship between business and engineering through the values and ideologies as conveyed by scholars of these two occupations in various geographical areas in North America and Europe respectively and who normally speak different native languages. For the sake of precision: American English is the native language of two American

scholars, British English the native language of an Irish scholar, and French the native language of a Quebecois and a Frenchwoman. This part of the volume thus evokes the values of two occupations morally characterized in various ways according to the cultural moorings and industrial histories of each of the universes traversed in this first part. The various perspectives also depend on the chosen theoretical disciplines and frameworks, whether it is philosophy, ethics, or social science.

Through contrasting North America with Europe, the first part of the book highlights the influence of political and social contexts on the production of ideas and categories of analysis. In particular the boundaries between two occupational worlds, namely that of business people and that of engineers, are highlighted. Readers of Chaps. 2 and 3 will find that the demarcation approach that comes into view in these chapters is echoed in the Canadian Iron Ring ceremony as presented in Chap. 8. Moreover the critical perspective proposed in Chap. 6 which traces the construction of several professional models to the Middle Ages, will find some resonance, though less distant than the Middle Ages, in some of the chapters in Part II, especially in Chap. 7. In addition, Chap. 5 shares with Chap. 16 an approach focused on actors at work and with Chap. 13 a diachronic approach to careers, but above all a more interactionist perspective on professions and a more fluid understanding of occupational boundaries. Readers will find that the captivity argument advanced in Chap. 4 is reflected in Chap. 9 with respect to the captivity of Chinese entrepreneurs and engineers under the socialist planned economy. Furthermore readers of Chap. 4 may delve deeper into the discussion on the need to develop the critical thinking skills of engineers by considering Chaps. 17 and 18 which both address the broader outcomes of engineering education. In the following we present each chapter in Part I in its own right.

U.S. philosopher of the professions, Michael Davis in Chap. 2 analyzes the evolution of the relationship between engineering and business, two human activities he clearly distinguishes by means of the nature and moral obligations that flow from them. According to the functionalist framework he adopts – matching that of sociologist Rakesh Khurana – business management should not be considered as a profession in contrast to engineering which should be. Consistent with the author's definition of a profession as "a number of individuals in the same occupation voluntarily organized to earn a living by openly serving a moral ideal in a morally permissible way beyond what law, market, morality and public openness would otherwise require" (Davis 2009, p. 217), business management does not qualify as a profession whereas engineering clearly fulfills the criteria of being a full blown profession. Davis proposes that MBA students should study the professions in terms of their culture, values, and standards. He also defends the idea that business schools should not so much prepare their students to become "leaders" who should "manage professionals". Rather they should prepare students to know how to "manage with professionals" like engineers and other professionals. The author's view might be more meaningful for readers for whom "profession" is a stabilized legal and/or social institution and status. Still, however, an evident need for business managers and engineers – trained in different types of institution in most countries – to be

socialized to understand each other's occupation comes into view as an issue that goes beyond any cultural and geographical specificity.

In Chap. 3, Quebec ethics philosopher Luc Bégin and his colleagues analyze the tensions encountered by engineers between the ideals of their profession and the expectations of their employers. The founder in 2004, and active director of the Laval University Applied Ethics Institute (IDEA, *Institut D'Ethique Appliquée*), Bégin has regularly served as an ethics expert for the Quebec Government and for several professional orders, such as the *Ordre des ingénieurs du Québec*. The research question posed in this chapter relates to the same geographical context as Davis, North America. Although they do not belong to the same culture, Canadians – even in French-speaking Québec – share many values with Americans. If contrasted with other continents' approaches, there are also similarities in the ways Canadian and American scholars deal with occupational ethics. But there are also differences, especially for engineers. In Quebec the title of engineer is socially considered as a "privilege", and engineers are organized – as in the rest of Canada – as a "regulated profession". Moreover, and importantly the first and foremost legal obligation of the Order which controls them is to protect the public. In the context of the time and these entitlements, Bégin and his colleagues have observed an erosion of the professional ideals, which led them to focus their present study on the tension encountered by the engineers who work for very large public and private organizations. In order to counteract this erosion, they propose (a) that the state imposes an obligation on companies that they should guarantee a right for engineers to respect and fulfill their professional moral duties, (b) to develop a better mutual understanding of the respective values of the engineers and their employers, as well as (c) to ensure a better legal protection for whistleblowers. Although their contexts differ, Davis and Bégin share the view that engineers and business managers (Davis) or their employers (Bégin et al.) need a better understanding of each other's value framework.

Irish scholar Edward Conlon, in Chap. 4, takes a Marxist approach to engineering ethics. Despite the fact that in this theoretical approach and geographical context there are occupational groups socially defined as "professions" – and sometimes legally defined as regulated/chartered professions – the notion does not match Davis' definition. Moreover in the Irish social context the engineering title is not regarded as a privilege. In point of fact the notion of profession does not need to be defined here because Conlon does not base his research on the nature or status of engineering as a group whether its denomination is occupation or profession. He studies the concrete engineers' decisions and actions in their work context using the sociological distinction between structure and agency. Rather than discussing the relationships between engineers and their managers seen as interdependent equals or the engineers' dual obligations toward their employers and their order, the author puts forward the concept of the captivity of engineering by the capitalist machine to develop his points regarding critical issues in engineering ethics. From this perspective, the efforts of engineers to address the critical issues of safety and sustainability are seen as prevented or hindered by structural constraints that weigh heavily on their professional practice. By mobilizing Margaret Archer's theory of critical realism which is neither determinist nor relativist, the author proposes to develop an

ethical training strategy capable of contributing to the emancipation of engineers by strengthening their capacity to analyze the context in terms of the structure of their practice as a way to develop new means of action.

Glen Miller, U.S. philosopher, analyzes in Chap. 5 the ethics of engineering from an individual and Western perspective which is both realistic and sensitive to the weight of contingencies. By way of addressing the business-engineering nexus more implicitly, the approach differs considerably from the previous ones. In a micro-subjective approach the author focuses on the way individual engineers might "navigate" the engineering-business space in terms of how they deal with the ethical issues within their actual work and how they make career choices. He also questions the relationship between professional ethics and ethics taken in a broader sense. According to the author, the ethics codes produced by engineering organizations "in some countries" or by program accreditation bodies like ABET in the U.S. and EUR-ACE in Europe are good resources for an ethical career at the beginning of a professional trajectory, thereby enabling engineers to become rule-following employees. However, he also notes that they are insufficient beyond that. Miller proposes to go beyond the preventive/prohibitive approach of the codes by founding his approach on W. D. Ross' ethics of obligations, which he considers compatible with the moral stipulations of ABET and EUR-ACE. According to Miller, the development of individual dispositions to virtue can accompany, better than codes, the ability of engineers to navigate the engineering-business space over a life-long career path.

Finally in Chap. 6, French sociologist Christelle Didier proposes to stage the debates on professional values differently, by enlarging the perspective to a broader historical context without taking *the higher aims* of the profession for granted in the way of scholars such as Davis and Khurana associated with the North American tradition. She revisits the medieval European context, with its Catholic bodies and Saxon brotherhoods, as well as the Puritan conceptions of vocations which served as a framework for many academic studies of the professions and their ethics. Many of these studies have been carried out by British scholars but in the main by scholars from North America. In fact the concept of "profession" – without the adjective "regulated" – as distinct from the notion of "occupation", whatever its definition, developed in the English-speaking world, does not have an exact equivalent in the majority of other languages, such as the author's native French language as well as in Japanese to mention two recognizable examples, because it belongs to a certain type of social stratification. The author proposes to clear up a few misunderstandings in this respect as well as misunderstandings related to cultural, linguistic and theoretical aspects that accompany most university discussions on the ethics of engineering and business, and the role the concept of profession plays in these endeavors. The author emphasizes the need to question some of the basic assumptions, if the aim is intercultural exchanges, to maintain a fruitful debate.

1.2 Part II: Engineering and Business Ideologies Past and Present

The six chapters in the second part offer historical reflections on engineering and business ideologies past and present as well as reflections on reform efforts in higher education that have been informed by the dominant economic discourse of neoliberalism originating in the 1970s and the associated discourses of "new public management" from the 1980s. Geographically the chapters span past and present developments in the United States, Canada, the United Kingdom, Ireland, and China. However as Chap. 10 is focused on how the key composite engineering competence "acting as an engineer in an organization" can best be learned, it could just as well have been located in Part IV as a complement to Chap. 22 as both these chapters relate to bullet 6 under the key overlapping questions mentioned earlier. Yet the Chaps. 10, 11, and 12 may be read as a triptych as their common theme, in spite of considerable variation in subthemes, is the expansion of higher education systems in the United Kingdom, the United States, and Ireland from the post-WWII period to the present. Readers of Chaps. 7 and 8 should also consider Chap. 2 in which Veblen's 1921 book *The Engineers and the Price System* is given a lengthy treatment from a historical perspective. Here the author points out that Veblen's use of the notion of engineer, industrialist, and technologist is somewhat arbitrary but that he did identify important issues of a perennial nature between engineers and business management. These chapters have Veblen either wholly or partially in common, but they differ considerably in approach; yet some common conclusions can be taken from them. Finally using the story of McDonald's as a case in point and without making explicit reference to Veblen, the Foreword nevertheless provides an exemplification of his engineering-business dichotomy.

Drawing on Veblen's early, mid-career, and later work on "technicians", in the opening Chap. 7 the Danish and French academics Steen Hyldgaard Christensen and Bernard Delahousse respectively set out to reinterpret Veblen's 1921 book *The Engineers and the Price System* as regards the theoretical status of his projected *Soviet of Technicians.* Their reinterpretation is undertaken in light of his deconstruction of the engineering-business nexus which reflects Veblen's epistemological, ontological, and axiological commitments. Moreover their reinterpretation is founded on two methodical premises reflected in the structure of the chapter: (1) it should be based on a close-reading of the text, and (2) it should locate the text both within the theoretical context of Veblen's theory of corporate capitalism and in his Darwin-informed evolutionary theory. They advance from the recognition that Veblen explored the cultural contradictions of capitalism in terms of a contradiction between industry and business, whereby he enabled an understanding of why factories rarely worked at full capacity and in addition pointed to the business corporation as a key development in finance capitalism. They show that from an anthropological perspective Veblen traced this contradiction to the residual habits of primitive societies in terms of two clusters of instincts – group-regarding versus self-regarding instincts – and thereby identified the persistent presence of residual habits of primitive societies in modern American life. By juxtaposing engineers to

the "pecuniary class" Veblen, as part of his research program on social movements, aimed to explore a possible candidate movement such as the one led by progressive engineers with the potential to delegitimize the prevailing business ideology for a final socialist overturn. They emphasize that during the course of their study they have observed a tendency among engineering education researchers and historiographers of engineering to reduce the complexity of Veblen's thought to a number of his provocative statements. This means that the theoretical system behind such statements has been neglected, with the result that a more balanced assessment of the critical potential of Veblen's theoretical system, and his key insights regarding the inherent contradictions of capitalism, have been lacking. They conclude by establishing a trial balance of strengths and weaknesses in Veblen's work on technicians.

In Chap. 8 Canadian historiographer of science and technology, Janis Langins, picks up on the historiography of engineering and the conflicting ideologies of engineering and business in the United States during the Progressive Era and their reflection in a later industrializing Canada. He notes that in both countries the influence of modern business as well as academic engineering education became increasingly important and central to the ethos of engineers. His narrative is focused on the Canadian "Iron Ring" ceremony instituted by Herbert E. T. Haultain (1869–1961), a Toronto professor of mining engineering. He clarifies form and content of the ceremonial ritual created by Rudyard Kipling to initiate engineering graduates into their profession. The ritual commemorates an age of masculine engineering heroism, self-denial, and sense of duty in which great engineering works were not yet so common as to be taken for granted by the general populace. Kipling's poem *The Sons of Martha* served as the core of the ceremony. The author makes it clear that Kipling employed the analogy between Martha and engineers in the biblical allegory of Mary and Martha (Luke 10:38–42) and that he portrays engineers as the people who make it possible for the rest of society to "choose the better Part". In contextualizing the poem and the response it elicited in 1919 in the form of a new poem titled *The Sons of Mary* advocating the values of a distinctly pro-business ideology, he clarifies the changing relationship between engineering and business ideologies and traces the way engineering developed in the United States and Canada. In so doing he relates the two poems to themes in Veblen's work and seeks to identify the contradictions in both of these conflicting ideologies. He concludes that both these ideologies contributed to forming the uneasy nexus between business and engineering that continued to evolve during the twentieth century.

The entrepreneur as a social character as well as a class of people smacks too much of unfettered private initiative and business not to constitute a precariat when this character emerges in a socialist plan economy. The narrative of Chap. 9 by the Chinese philosophers of engineering and technology, Wang Nan and Li Bocong, addresses this situation in China during the period of "opening up" from 1978 to 1992 under the leadership of Deng Xiaoping. By first exploring various meanings of the notion of entrepreneur they go on to discuss historical periodization. As the "opening up" period constitutes a whole in itself following European antecedents in historical periodization, they argue that it would be meaningful to term it "the

Long 1980s". They articulate that the outcome of Deng's leadership was a nation that underwent huge social transformations, but remained subject to the rule of the communist party, even though it lost its strong ideological moorings. Having defined the engineering community they explore the consequences for the engineering community of Mao Zedong's (1893–1976) harsh leadership from the 1950s to the 1970s, whereby an anomaly in the engineering community was created as entrepreneurs were lacking and engineers like other intellectuals were restricted. If entrepreneurs had disappeared under Mao they reemerged under Deng, and engineers who had been restricted in their work evolved into a special kind of engineers, Sunday Engineers. They finally explore a number of cases in which the extra money Sunday Engineers were able to earn by working on Sundays, helping factories in the countryside to become more effective, became a subject of ideological controversy and law suit for bribery before official ideological acclaim was in place.

The English engineering educator and researcher John Heywood, resorting to the history of higher technical education in the United Kingdom, starts in Chap. 10 from the general observation that there is a perennial conflict between education and industry in terms of the different perceptions educators and industrialists have regarding the purposes of higher education. He makes it clear that presently there is a pressure on the higher education sector that it should prepare new graduates immediately for work in industry. He sets off from the recognition that educating and training graduates to act confidently as engineers or technologists in an organization solely through academic study is impossible. In support he points to a growing body of literature providing evidence to the fact that the key engineering competence "acting as an engineer in an organization" can only be learned on site. He then goes on to examine an exemplary case regarding the education and training of engineers and technologists in England and Wales in the 1950s and 1960s, and thereby provides an understanding of how the new post-WWII system of higher technological education in the United Kingdom came about and how its expansion was projected to respond to the need for technical manpower obeying the *gold standard* of academic degrees in technical diploma (dip. tech). During this period of time the combination of academic study and industrial work – the sandwich principle – came close to forming an ideal national curriculum for higher technological education and training, but in the end it did not become as successful as it could have been due to the fact that the responsibility of industry and academia was not appropriately shared.

Taking a job creation perspective, the Irish and North American academics, Mike Murphy and Michael Dyrenfurth respectively, in Chap. 11 examine the role of neoliberal entrepreneurial universities as job creators and as engines of economic growth in the increasingly knowledge-led global economy. They first look into how the role of the university has expanded from traditional first and second mission activities, in terms of teaching and research, to encompass third mission activities that include industry engagement and how this engagement supports job creation and economic development. Next they examine how new jobs are created within a geographic region or country, and the role the university can play in support of this. Finally, they examine the role of government and policy related to sustainable job

creation. They start from the premise that if the regional or national goal is job growth, then the focus should be on how largest job growth occurs. They argue that maximum job creation is best achieved through the attraction of large companies, support for growth of small and medium-sized companies, and the nurturing of start-up companies. In Ireland, the government has taken the approach of consistently attracting foreign direct investment, investing heavily in higher education, and providing a favourable business environment, including making the tax system purposefully pro-business and fine-tuned to ensure it is internationally competitive. Enumerating third mission activities, they provide the following grouping of activities: (a) Technology Transfer & Innovation activities; (b) Continuing Education activities, and (c) Social Engagement activities. They explore how the activities within the grouping of Technology Transfer & Innovation are those most directly associated with economic development.

Completing this part in Chap. 12 with a focus on the restructuring of higher education in the United States, Steen Hyldgaard Christensen examines how the corporatized public research university came about, its distinctive features, and considers the costs and benefits to the public good of commercializing teaching, research, and service. He explores how the dominant economic discourse of neoliberalism originating in the 1970s and the associated discourses of "new public management" from the 1980s have created a tension between two dominant institutional logics of higher education in university restructuring, namely those of the university as a social institution and the university as an industry. He identifies how the relationship between the two institutional logics or models of higher education can be conceptualized in terms of a *social charter* between higher education and society. *The communitarian philosophy of the public good* is reflected in a social and public charter associated with the traditional model of higher education. *The neoliberal philosophy of the public good* promotes an individual and economic charter, resulting in the industrial model of higher education. Finally *the utilitarian model of the public good* advocates a changing and contested charter that is a blending of both the traditional and the industrial models of higher education. He concludes that a precondition for the alternative utilitarian charter to succeed is that students and faculty will have to develop ideas with respect to the funding of the envisioned alternative and to build broad public support for this vision, as simply expecting the state to supply more money is unrealistic.

1.3 Part III: The Practices of Business and Engineering

Approaching the engineering business relationship empirically the four chapters of Part III interrogate a number of practices related to business and engineering respectively. Even though these occupations are often inseparable, yet questions may be raised as to whether they are distinguishable, how engineers and business managers are perceived by outsiders, and how they perceive themselves. In a paradoxical way, the omnipresence of engineering makes it almost invisible to the public. If

engineering and business have a lot of commonality within industry, the main issue remains whether they are dealing with the same questions. For instance what responses do they offer to important, yet often neglected issues like the value aspect of work in industry. The practices of business and engineering and the interplay between them can also be studied by exploring their boundaries, particularly the issues of gender equality in the workplace and the predicament of newly hired engineers beginning new jobs. Exploring these issues constitutes the red thread of contributions to this part. Before presenting the four chapters of Part III in their own rights, it is to be noted that a number of issues raised under this section are unsurprisingly echoed in other parts of the book. Readers of Chap. 13, for instance, should consider Chap. 5 in which the relationship between business/engineering practices and society is treated from an ethical standpoint. Likewise readers of Chap. 14 will find some resonance on the need to broaden the scope of entrepreneurial education across different chapters, particularly in Chaps. 17 and 18. From a different perspective, Chap. 15 which deals with the ideals of social justice and human rights through the theme of gender inequality should be related to the broader concept of social charter developed in Chap. 12. And readers of Chap. 16 on the problematic of newly hired engineers beginning new jobs will find further interest in the conclusions of Chap. 22 regarding the employability of engineering graduates.

In the opening Chap. 13 the Australian academic and philosopher of engineering Erik W. Aslaksen sets out to investigate the questions of how engineering and business practices appear to the public and to analyze their complex association in relation to the economy and society at large. His point of departure is that the relationship between these two activities is characterized by two features, namely the need for business to provide the conditions for generating a return on investment, and the fact that engineering, while applying technology to meet expressed needs, generates new technology, thus providing business with new opportunities. After defining a number of significant concepts, Aslaksen explores the relationship between four functional entities: engineering, industry, business, market, and he argues that what appears to society as being *technology* is largely determined by business. He also highlights the difference between science and engineering in the way they are perceived by the public: while science ranks high, engineers are paradoxically almost "invisible". Then he focuses on how engineering and business are interlocked in a strong economic relationship in which technology is the interface, and he observes that the twentieth century tendency to isolate business from engineering not only proved to be inefficient, but also ignored many non-economic issues. He then goes on to introduce the concept of *engineering paradigm* relating to the external conditions under which engineering is practiced, particularly in the interaction with the business process. Due to increasing legal, technological and statutory constraints, he notes that the engineering paradigm is currently undergoing crucial and rapid changes. Finally he concludes that these transformations to the engineering paradigm call for changes to the engineering profession namely through *hybridization*, whereby technology mediates our relationship to our environment. Acknowledging

that this raises a number of major questions, the author calls for a restructuring of the engineering profession and its place in the workforce.

The investigation presented in Chap. 14 by the Australian and Irish academics and engineering educators James Trevelyan and Bill Williams respectively, originates in their observation that the engineers seldom perceive the *value creation* of their work even though their contributions create value for their enterprises and their clients. This has led them to review the scarce literature addressing value creation by engineering and business enterprises. First they explore various definitions of value creation from the perspectives of business research, wealth creation, engineering design and engineering education, focusing on the role of technological innovation for the creation of value, and referring to the concept of *creative destruction* put forward by Schumpeter in the early twentieth century. They note that value creation is perceived in an abstract way and is marginal to the engineering discourse. Then, drawing on empirical studies on engineering practice they set out to identify how engineers create and protect value regarding the reduction of investment risk, due commitment and maintenance work. They argue that engineering activities also aim at value protection, avoiding economic value destruction and showing how destruction can occur. Their research reveals that very few engineers are involved in technological innovation and that most of them perform more "ordinary" tasks. The authors stress the need for human interpretation of documents as well as the necessity for engineering and business people to appropriate information in order to make decisions. Finally, from the qualitative analysis of interviews and field observations, they examine areas of research into engineering practice that could lead to considerable financial savings in major enterprises. In so doing they put forward a model of value creation and protection within an engineering enterprise. They conclude that in the absence of awareness on engineering practice there is an urgent need for engineering faculties to broaden the scope of entrepreneurship education to help their students understand how they can create and protect value in different settings.

After noting the shortage of engineers in most countries, the two Irish academics Jane Grimson and William Grimson – both former presidents of Engineers Ireland – open Chap. 15 by asking if there is sufficient diversity in the engineering community to ensure efficient and sustainable solutions to meet the needs of everyone in society. The diversity they have in focus here is gender: they outline that not only women are significantly under-represented in senior positions in organizations but also that the pay gap with men is still a reality today, despite the fact that a number of major sectors like industry, commerce, engineering and academia, have made or are making real efforts to eliminate gender inequality. They also examine why it is essential to address the gender issue and distinguish three reasons for this: the first is based on the principle that social justice and human rights are or should be guaranteed by the work environment, the principle that all careers should be equally open to both men and women being a prerequisite. The second is a matter of parsimony whereby talent should not be wasted by the failure to attract and retain women in the engineering profession especially in a period of shortage of engineers. The third reason is precisely relating to the diversity argument whereby the wide range of different skills, perspectives and experiences can better respond to whatever challenge is to be faced.

Then they set out to identify a number of measures which organizations are taking to tackle the complex task of promoting gender equality. In so doing they consider four key themes: committed, determined and sustained leadership from the top of the organization, working arrangements to ensure better work-life balance, facilitating initiatives to develop future women leaders, and tackling unconscious bias. After analyzing two characteristic case studies they conclude that gender balance will not be attained automatically without such positive interventions as it is rooted in our culture, and that the engineering profession has to take sustained action now in order to be able to meet the needs of society today and tomorrow.

Closing this part with Chap. 16, the American academic Russel Korte explores the relationship between engineering and business from the viewpoint of newly hired engineers beginning new jobs in a business organization, as this complex transition experienced by graduates illuminates the differences they encounter between engineering as they learned it in school and as they practice it in an organization. The author's perspective is that business and engineering are both occupational communities embedded in an organizational context where engineers have to go through a socialization process with business people to learn how to practice and where, as a result, boundaries are more or less blurred while they work together. The chapter reports the findings of a qualitative, inductive case study carried out by the author on a sample of newly hired engineers and Human Resources managers. One of the first results that Korte relates here is that new engineers are more discomforted by the socio-cultural aspects of organizational work than by the technical aspects of "real" engineering work. He then points out to the complexity and ambiguity of engineering practice which depends on the quality of social interactions within the enterprise: social interaction goes beyond pure communication, and is essentially about building relationships and making sense of things, which form the major part of the new engineers' work. Analyzing Korte's surveys a distinction emerges between three types of communities, engineering, business and organizational communities, each of which depends on and comprises the interactions of the other two. He also stresses that, with the rise of innovation and entrepreneurship, traditional forms of organizations have been evolving to more dynamic models based on communities and collaborative networks. He then concludes that the distinctions between business and engineering communities are mainly disconnected abstractions and tend to disappear in the intricacy of organizational work.

1.4 Part IV: Engineering and Business Education

The six chapters in this section explore, analyze, and provide insights and recommendations on the education of the engineer, not simply from a narrow technical disciplinary perspective, but from the more complex perspective of its purposes within a wider business context. Like the other sections in this volume, the thirteen authors who have contributed to these six chapters come from four countries on two continents. Four are Danes, four are Irish, three are Americans and two are

Canadians. Each chapter has focused on engineering education issues evident within their national footprint. Yet each chapter throws up some common messages or findings: that the nature of societal challenges requires a more reflective engineer, that the education of such engineers requires a systemic approach, and that the employability of engineers demands more complex approaches to their education.

Before presenting the six chapters of Part IV individually, there are links worth noting between the chapters in Part IV and those in the earlier sections. Chapter 2, in its discussion of engineering and business management, provides interesting contrasts to Chaps. 17 and 18 regarding the mechanisms by which engineering curricula are broadened with business subjects. Chapters 18 and 19 examine ethics and sustainable development in engineering and technological education; while Readers might also look at Chap. 3 for an alternative perspective in that it argues that the economic imperative for profitable production is a cause of work place accidents. Chapter 22 which examines employability and whether engineering graduates are ready for work can usefully be read in conjunction with Chap. 5 which notes that engineering graduates are largely left to their own devices after graduation with the competences described through ABET and EUR-ACE criteria. For Readers of the evolution of engineering education, and the current trend towards introducing entrepreneurial subjects, Chap. 9 provides an interesting historical Chinese counterpoint to the western examples provided in Chap. 18, and both are worth reading. In examining the arguments set out for broadening the engineering curriculum in Chap. 17, there is value in a review of Chap. 10 in which John Heywood provides an excellent UK historical example of when industry and education shared responsibility for the development of engineering graduates. Erik Aslaksen in Chap. 13 argues that engineering, as a profession, has not responded adequately to changes over the last 50 years, and the Reader might find echoes of this in the pace of change in engineering curricula described in Chaps. 17 and 18. Readers interested in how engineering graduates assimilate in their early careers should compare a Danish study described in Chap. 22 with an American study described in Chap. 16.

In Chap. 17, three Irish academics – Mike Murphy and Pat O'Donnell from engineering education and John Jameson from business education – examine the evidence of whether and how undergraduate engineering students in Irish universities and institutes of technology are exposed to a broadening curriculum from subjects in liberal arts or social sciences. They do this in response to the assertion set out by philosopher Carl Mitcham that the greatest engineering challenge is to cultivate "deeper and more critical thinking … about the ways engineering is transforming how and why we live". In line with Mitcham's critique, the authors construct a hierarchy called the "Mitcham Classification of Engineering Program Enlightenment" and then use this instrument to examine every undergraduate engineering program in Ireland to determine what evidence there is of a systemic approach to broadening through the inclusion of liberal arts or social science courses, including business courses. The evidence would indicate that the academic engineering community in Ireland generally attaches a low priority to the development of a broader context and perspective within engineering students, beyond technical and disciplinary content, and that there is no systemic attention to a broadening

agenda. Often the same few courses within a program are used as evidence across a number of accreditation criteria. Business school leaders also point to a low level of collaboration between engineering and business schools, and the underlying rationale appears to be the "engineer identity" that pushes back against inclusion of non-engineering content. The authors note that an argument might now be made that the narrow technical focus of engineering programs may contribute to the general diminution in the role of the engineer from "an expert astride the wheel to a cog on it". There are resonances here with the conclusions set out strongly by Kolmos and Holgaard in Chap. 22 with regard to employability of engineering graduates.

While written independently by Michael Dyrenfurth and the American academic Gary Bertoline respectively, Chap. 18 takes a similar approach to Murphy, O'Donnell and Jameson by examining the educational curricula of BE&T (business, engineering and technology) students within U.S. universities. Dyrenfurth and Bertoline use the terms "pragmatic capabilities" for employer-demanded skills, and "larger outcomes" for the needs of society, to describe the overall set of competences that BE&T students should acquire. The authors first conduct a review of undergraduate programs in the United States in order to confirm that "significant proportions of university undergraduate enrolment are directed towards pragmatic purposes such as engineering, business and technology"; and they subsequently examine the implications of that focus. They next set out to examine the extent to which ethics, corporate social responsibility and "conscientious capitalism" are reflected in plans of study of a selected number of high profile public and private universities. This is comparable in intent to the examination carried out by Murphy, O'Donnell and Jameson in Chap. 17 to determine broadening content within Irish programs of study, including holding interviews with selected deans and leaders. The results found by Dyrenfurth and Bertoline indicate that ethics is covered widely, but there is less evidence found for corporate social responsibility (CSR) and conscientious capitalism. Interestingly, within the U.S. it would appear that programs are more responsive to accreditation-driven requirements than the Irish authors found. Chapter 18 describes in considerable detail two exemplars of systemic change. These are Olin College, which perhaps provides a unique example of designing a university including its curricula from a student-oriented set of requirements, and the Purdue Polytechnic Institute, which provides an example of transformative change within an established college of technology. The authors conclude by noting that 'bolt-on' approaches to broadening the curriculum will not work and systemic transformation is required.

In Chap. 19, Canadian scholars Lovasoa Ramboarisata and Corinne Gendron also address ethics education, CSR and sustainable development (SD) education at the taught postgraduate level in Canada. They examine business schools and their role in educating engineer-managers via MBA and MS programs. This again can be seen as extending the examination undertaken by the authors in Chaps. 17 and 18. Here in Chap. 19 the authors provide a review of the development of ethics education and the growing debate about its sufficiency arising in recent years from incidents such as bridge and building collapses, water contamination, and chemical leaks. Despite professional codes of ethics and the acceptance that engineers should

put the public interest above self-interest, business interest and professional interest, the authors point out that ethical training provided to engineers still stresses their duties to their profession. The authors explore whether education has made the necessary change of direction, or turn, to accommodate the demanding concepts of CSR and SD. What they report finding, however, is that this critical turn has not yet been made to go beyond instrumental ethics, loyalty to businesses, and moral righteousness towards the profession. Ramboarisata and Gendron report that the "business-case" approach remains dominant and broadening teaching beyond this approach is largely still absent. They further report data that show integration of these topics into curricula as non-significant, and that stand-alone courses cannot meet the "ensemble of objectives identified". The authors provide an exemplar course that they designed and teach for an MBA and Technology Management program in Montreal. Through the authors' pedagogical choices, their students have become reflective practitioners.

Chapter 20 focuses on experiences with changes in both the conception and the curriculum of engineering education: the "Design & Innovation Program" implemented at the Technical University of Denmark (DTU) in 2002. The Danish academics Joakim Juhl and Anders Buch draw a historical framing: how, after World War II, public investment in fundamental research first was seen as necessary to protect the special status and independence of research, but gradually the emphasis shifted seeing science as a political instrument, with economic growth as a key performance indicator. Almost simultaneously, views on the internal functioning of science were changing too: instead of focusing on the demarcation of a proper ethos of science (in the line of e.g. Robert Merton and Karl Popper), science came to be seen as a more socially embedded activity: trans-disciplinary, context-aware, and more reflexive ("Mode 2-science"). A final impulse for the development of the Design & Innovation Program was constituted by legislative measures in Denmark. Although officially framed as an "opening up" of universities "outwards to society", and an improvement of universities' "decision-making competence", the changes seemed to have financial self-sustainability of universities as their leading idea. The Design & Innovation Program was developed as a response to that. It combines creative, synthesis-oriented competences, innovative, socio-technical competences and reflective technological engineering competences. The unique and rather atypical profile of this program was attractive to incoming students, and at first the program appeared very successful. In the long run however, it was difficult to maintain the program at its original pace. Juhl and Buch end their chapter by drawing some lessons concerning the entanglement of engineering and business, the normative shifts that occur when marketability is introduced as a quality criterion both for engineering and for academia, and the contingencies and situated nature of how innovations are implemented and evaluated.

In Chap. 21, the American engineering educationalist and philosopher of engineering Alan Cheville and English academic John Heywood take a more analytic and contemplative stance on reforms of engineering education. First, they challenge the traditional view of engineers as "problem solvers". The term "problem" is far too static and one-dimensional to describe the situations engineers have to deal

with. They prefer talking about "tensions": this is a better rendering of the multidimensional, dynamic and dialectic nature of engineering work. In an organization, tensions often arise as the result of differences in "credo" of the members, a credo being a set of beliefs, attitudes and values that may or may not be directly in line with the official policy of the organization. Engineers, like many other collaborators, have to operate within the tension of these different credos. But they are seldom well prepared for this ill-defined situation that seems to require continuous negotiation. The authors argue in favour of an engineering education combining the traditional, linear problem-solving competences with the more subtle, context- and communication-aware competences that would prepare young engineers for their work in real organizations. They use the metaphor of the "real" and "imaginary" components of complex numbers, well known to engineers; both components are necessary to allow the possibilities of complex mathematics to be fully deployed. The hitherto "hidden curriculum" of engineering education should therefore at the same time be adapted and be made more transparent, in order to incorporate and combine both components. And even in the very act of reforming their curricula, educators and their leaders should combine the pragmatic straightforward problem solving approach, with the awareness of the never completely solved set of tensions within which they operate. In this way, the proper professional value of engineering can be protected against the mono-dimensional finance-driven approach that is present in many policy issues, in education as well as in the rest of society.

With the search for employment, young engineers are immediately in the very middle of the engineering-business nexus. In the final chapter of this book, the Danish academics and engineering educators Anette Kolmos and Jette Egelund Holgaard report on the results of an extensive survey (taken in Denmark between 2010 and 2015) on how young graduates perceive the way their education prepared them for the labor market. First of all, the authors are well aware of the conceptual discussions about the components and the idea of "employability", especially when terms like "generic skills", "transferable skills", "core skills", "soft skills", etc. are used. Equally, they are aware of methodological issues in the set-up of surveys, and of the difficulty of interpretation of the answers, often also depending on how the questions were framed or formulated. Finally, it also appears that what students or young graduates expect to be important for their first employment, may very well differ from what employers (and educators, and other stakeholders) expect. Kolmos and Holgaard comment *inter alia* on how the students' self-perception of their competences and their future employability changes when they move through their study career, and on the role of prolonged internships.

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Part I
Engineering and Business Value Systems

Chapter 2
Engineering and Business Management: The Odd Couple

Michael Davis

Managers think in quarters; engineers, in decades.
—Anonymous

What is in opposition is in concert, and from what differs comes the most beautiful harmony.
—Heraclitus

Abstract This chapter has four main parts: the first sketches the changing relationship between engineering and business management; the second describes some differences between the response of business schools to this relationship and the response of engineering schools, especially the difference in their respective courses in "ethics"; the third part draws from the first two a statement of a major problem in relations between engineers and business managers, that is, combining business-management-as-a-mercenary-calling with engineering-as-a-profession; the fourth part proposes a response for business schools to that problem, especially the introduction of the concept of "managing *with* professionals". Engineers and business managers work together best when they understand the value of the ways in which they differ.

Keywords Engineer · Manager · Ethics · Standards · Profession

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2.1 The Changing Relation

The Odd Couple is a play (and movie) about a cohabitation that seemed in prospect certain to fail. When fussy Felix became suicidal over his impending divorce, his best friend, disorderly Oscar, took him in. Within days, Felix and Oscar were finding each other hard to live with. *The Odd Couple* is a serious comedy about the benefits and costs of that "marriage of convenience".

There are at least three reasons *The Odd Couple* seems to me a useful metaphor for the long cohabitation between engineering and business management. The first reason, and least important, is that Felix seems to have the engineer's typical urge toward order and material improvement; Oscar, the manager's typical tolerance of changes of plan and imperfection. Felix is shy and socially awkward; Oscar, talkative and socially adept. The metaphor has a visceral appeal. Second, their cohabitation depended on mutual interest. Oscar lived alone in a large apartment that divorce had emptied of wife and child and his housekeeping had turned into a health hazard. The cohabitation would not have lasted for as long as it did had Felix not needed Oscar's company and housekeeping as much as Oscar needed a place to live and someone to listen to him try to understand why his marriage had fallen apart. Third, and most important, both Oscar and Felix changed over time as a result of living together. Both were better people when they ended their cohabitation than when they began it. Each benefitted from the compromises, experiments, and revelations that their cohabitation forced on them.

The last reason I gave for taking *The Odd Couple* as a useful metaphor for the relationship between engineering and business management was that the odd couple's relationship changed over time, benefiting both. I counted that reason as the most important because scholars tend to overlook how much the relationship between engineering and business management has changed in the two centuries since engineers first entered business in significant numbers—and that change tells us something important about both engineers and business, especially about the ways in which they benefit from the relationship.

Two centuries ago engineers were as likely to be independent consultants hired for a job as long-term employees. Like the Roeblings, those early engineers would have had a post-secondary degree in engineering. Business managers, in contrast, were then typically proprietors ("capitalists") educated in the "school of hard knocks". So, for example, Cornelius Vanderbilt (1794–1877), the railway magnate and one of the century's richest men, ended his formal education at age 11. Most of what he knew of business he learned from running his own, starting with a ferry service he began at age 16. Such too were the managers that Thorstein Veblen seems to have had in mind in *The Engineers and the Price System* when he described the "business man" of the nineteenth century as one who "came more and more obtrusively to the front and came in for a more and more generous portion of the country's yearly income which was taken to argue that he also contributed increasingly to the yearly production of goods" (Veblen 1921, p. 28). Veblen contrasted these businesspeople with the new breed of "financial manager" who "under the limitations

to which all human capacity is subject" were—because of the "increasingly exacting discipline of business administration"—"increasingly out of touch with that manner of thinking and those elements of knowledge that go to make up the logic and relevant facts of mechanical technology" (ibid. pp. 39–40). The "entrepreneur" of old was evolving into a mere "chief of bureau", an employee knowledgeable about finance but ignorant of technology in a way the older entrepreneurs were not (ibid. p. 41). The new business managers were bureaucrats much like their counterparts in the civil service.

A close reading of *The Engineers and the Price System* will, I think, reveal that Veblen knew little about engineers as such. Indeed, what he sometimes calls "production engineers" (ibid. p. 53), he also calls "technologists" (ibid. p. 61). The list of "technologists" varies a good deal. For example, in one place (ibid. p. 44), it is "industrial experts, engineers, chemists, mineralogists, technicians of all kinds"; in another (ibid. pp. 60–61), it is "inventors, designers, chemists, mineralogists, soil experts, crop specialists, production managers and engineers of many kinds and denominations". For Veblen, the important contrast was between "financial managers" whose focus is on making a profit and "technologists", including technically trained managers, whose focus is on increasing the quantity and quality of goods, reducing waste, and otherwise adding to society's wealth.

Nonetheless, Veblen did identify an important problem in the relationship between engineers, by then already mostly employees, and business management, by then also mostly employees, an increasing difference between their respective skills, knowledge, and aspirations. The financial manager's focus on profit might often "sabotage" (Veblen's word) the efficient production of useful goods that engineers typically seek. No doubt, it was at least in part this difference between financial managers and engineers, even engineers ranking high in a large corporation, that contributed to what Edwin Layton called "the revolt of the engineers" (Layton 1971).

The story of the business-engineering nexus does not end with that revolt, of course. In the century since 1921, the number of engineers working in business has grown into the millions while the other "technologists" Veblen mentioned now number only in the tens of thousands. Engineers (along with computer scientists) are now central to most large businesses to a degree most other technologists are not. What gave engineers this preeminence? The answer is obvious: the ways in which engineers differ from both business managers and other technologists.

Over the last century, business management became a popular field of study in universities. Indeed, many managers today have an advanced degree, typically a Masters of Business Administration (MBA), while their engineers typically have only a bachelor's. Business management has itself become a science-based technology, though one resting on economics rather than (as engineering does) on physics and chemistry.

Yet, the division that Veblen remarked has not gone away, merely changed. In the 1920s, management ("business administration") seemed destined to join architecture, engineering, law, medicine, nursing, social work, and the like as a profession. Schools of business management taught students that business should seek to serve

society, not simply make a profit (Abend 2013). But, by the 1960s, it was already clear that business management was *not* going to be a profession (in the sense it had once aspired to). Business managers were happy to declare that their primary loyalty was to their employer; their primary goal, to maximize their employer's profit. Indeed, some scandals of the 1950s, such as price-fixing in the electrical industry, suggested that managers might believe that loyalty to employer overrode even legal and moral obligations. Senior managers not only broke anti-trust laws for their employers but also lied about it to the press, Congress, or the courts (Herling 1962).

The introduction of "business ethics" into the curriculum of business schools a decade later was in fact a re-introduction. Courses under that name (or near synonyms) had existed in many elite business schools as early as the second decade of the twentieth century, though most seem to have vanished by 1950 (Abend 2013). Yet, the new business ethics differed from the old in at least two notable ways. First, the new business ethics developed as a field of research as well as a course of study. There were soon several academic journals (as well as several textbooks and monographs) (DeGeorge 1987). Second, almost from the beginning, philosophers seem to have had an important part in both the research and teaching of the new business ethics.[1] These philosophers seem to have drawn on philosophy's recent experience with medical ethics, especially its emphasis on resolving ethical problems case by case rather than restating old reasons to accept a predetermined answer. The new business ethics was analytical rather than homiletic. But, like the old business ethics, the new did not seem to be a "revolt of the managers" so much as a revolt of their employers, the public, and the government, a response to scandals in which educated managers thought they had done all they should when they sought (more or less successfully) to maximize short-term return on investment (as they had been taught).

According to some common sociological definitions of "profession" (advanced education, high income, and so on), business management was a profession well before 1960. Yet, by the definition that the professions themselves implicitly accept, business management had long since ceased even to aspire to be a profession (Khurana 2007). Management was definitely not a number of individuals in the same occupation voluntarily organized to earn a living by openly serving a moral ideal in a morally-permissible way (a discipline) beyond what law, market, morality, and public opinion would otherwise require (Davis 2009). Maximizing return on the capital of one's employer is not a moral ideal (an objective all rational persons recognize as good); indeed, maximizing return on investment may not even be the objective of the manager's actual employer. If we take corporate "vision statements" seriously, many employers seek only a reasonable return on their investment so that they can continue to provide a useful product or service.

Rather than becoming a profession, business management had devolved into a mere "money-making calling" in at least two respects. First, of course, managers understood themselves as competing with each other to make as much money as

[1] The only philosopher I have come across in the old business (and professional) ethics is Carl F. Taeusch 1926.

legally possible for their respective employers. Profit was the chief measure of their success. The good of society was no longer understood as even among their objectives (though they might point to the social good they happened to do as a reason to be allowed to go on seeking profit). Second, each manager typically understood herself as a mercenary rather than a professional, that is, as a mere individual seeking to make as much money as possible herself, not as a member of a group seeking to improve the skills, conditions of work, reputation, or the like of their group's common discipline. To have the loyalty of such a manager, an employer had to offer the proper "incentives", especially a high salary, bonuses for achievement, and opportunities to do work leading to "advancement", that is, to a position with an even higher salary and bonuses. We can measure business's increasing awareness of management as a mercenary calling not only by the increasing size of managers' individual income relative to that of other employees but also by the increasing share of that income coming from bonuses (and other incentives) rather than from base salary.

Unlike the old business ethics, the new was to be not so much an alternative to the money-making conception of management as a supplement to, or constraint on, it. Money-making management was to be bridled in certain ways (for example, by the employer's code of ethics); its energies redirected in other ways (for example, by replacing the "single bottom line" of profit with the "triple bottom line" of profit, social responsibility, and environmental responsibility).

2.2 Business Ethics Versus Engineering Ethics

In principle, business ethics could be (a) about how individual employees, including managers, should fulfil their moral obligations as employees, citizens, and human beings ("micro-ethics"), (b) about how businesses should conduct their affairs within the bounds of morality, managers understood as mere agents of their employers ("meso-ethics"), (c) about what society should expect of business and how it might go about getting it ("macro-ethics"), or (d) some combination of these. (Davis 2010) In practice (judging from the textbooks), courses in business ethics are today primarily about how businesses, especially large corporations, should conduct themselves; they are a kind of meso-ethics.

A typical course in business ethics today will have four divisions. First, there will be an introduction to the central concepts of business ethics, such as moral theories, "stakeholder analysis", law, the market, and the moral status of a corporation (and the people it employs). Second, there will be discussion of moral issues that arise within the business, such as affirmative action, conflict of interest, confidentiality, employment at will, drug testing, fair wages, insider trading, occupational health and safety, sexual harassment, and whistleblowing. The emphasis in this second division will be not on how individual managers, much less individual employees, should deal with particular situations involving such issues, but on how the business as a whole should respond to that sort of problem (the managers acting as faithful

agents of the business). Third, there will be discussion of moral issues that arise between a business and its community, competitors, customers, regulators, suppliers, or others outside. Among these issues will be truth in advertising, influencing government ("lobbying", facilitation payments, and bribery), intellectual property, spying on competitors, legally permitted pollution, mergers and acquisitions, product safety, and social responsibility (especially, treatment of neighbors, suppliers, and society at large). The fourth division will reconsider the first three divisions in the context of "globalization", especially the variety of local customs, cultural differences, and different legal systems that a business is likely to meet when it establishes sales offices, factories, or subsidiaries in another country, especially a relatively poor country. Should a business take its ethics with it wherever it goes, change its ethics to suit the customs, culture, or laws of each country in which it operates, or respond in some other way? (Compare DeGeorge 1987).

Occasionally, a course in business ethics may discuss "ethics infrastructure": ethics audits, ethics officers, ethics "hot lines", and so on. This discussion may include corporate codes of ethics, codes of ethics adopted by trade associations, or the like. But I have yet to see a text in business ethics with anything to say about *professional* ethics, much less one noting that many employees in any large business (actuaries, chemists, lawyers, and so on) will belong to a profession and therefore have moral obligations in addition to those of ordinary employees. A few social scientists specializing in business have, it is true, noted the presence of large numbers of professionals in business (See, for example, Shapero 1985; or Raelin 1986). But, to this day, courses in business ethics seem to divide the inside of a business into "management" (a collection of the employer's agents) and employees (mere individuals), with management answering to "the stockholders" (or "stakeholders") and controlling "the employees".

I speak here only of texts in (general) business ethics, texts designed to train "managers". Many business schools have programs in accounting, finance, human resources, or the like that have their own course in ethics (the ethics of the profession in question). These courses have their own texts, ones much more like texts in engineering ethics than the typical texts in business ethics.

Like much of the business school curriculum, the course in business ethics will typically be organized around in-depth study of "cases", some fictional but most actual. Some are law cases but most are a summary of facts or a collection of documents. Among cases often included are some that are quite old, such as The Ford Pinto (from the l970s) or The Space Shuttle Challenger (from the 1980s). Others are relatively new, such as the tardy 2014 recall by GM of 800,000 small cars to have their ignition fixed to resolve a safety problem, or the 2015 scandal concerning VW's modification of its diesel's software so that pollution controls worked during tests but not on the road. Like these four cases, many standard business ethics cases also appear (or at least could appear) in texts in engineering ethics. Such shared cases are, in fact, evidence for a close connection between business ethics and engineering ethics.

Nonetheless, in the US at least, the course in engineering ethics arose (or, more accurately, re-arose) more or less independently of business ethics, though at about

the same time. The same seems to be true of engineering ethics as a field of academic research. (Davis 1990) There are doubtless many reasons for that independence. Among the most obvious are these four: First, engineering schools and business schools, even when located on the same campus, have historically had little to do with each other. Second (and perhaps explaining the first), the culture of business schools is quite different from that of engineering schools (as Veblen would have expected). For example, engineering students are typically much more interested in making things work than business students are; business students, much more interested in how people work. Third, though philosophers were as involved in early work in engineering ethics as in the new business ethics, they were rarely the same philosophers. Both business ethics and engineering ethics are (what philosophers call) "applied philosophy". Applying philosophy to a practice outside philosophy means learning a good deal about the practice. Learning enough about business to be useful to businesspeople probably left little time to learn enough about engineering to be useful to engineers—and *vice versa*. The economics of applied philosophy made it likely that there would be little overlap among philosophers in fields developing at about the same time. Fourth, the two fields tended to attract different kinds of philosophers. So, for example, philosophers interested in social justice seem more likely to have become involved in business ethics; those interested in technology or professions, to have become involved in engineering ethics.

Not surprisingly, then, a course in engineering ethics typically differs in fundamental ways from a course in business ethics. Perhaps the most important of these differences is that engineering ethics typically is a course in professional ethics (a kind of meso-ethics distinct from business ethics). There is an attempt to define "profession" and explain how engineering fits that definition. There is a discussion of engineering's code of ethics and practice applying the code to particular practical decisions ("problems"). (Engineering ethics texts typically reprint at least one code of engineering ethics.) There may even be an introduction to engineering's professional associations, technical standards, and licensing bodies. The overall message is that engineers have a moral obligation to their profession at least as weighty as their obligation to their employer: engineers are *not* "mere employees".

The teaching of engineering ethics is, however, not limited to a course in that subject. Such teaching goes on both explicitly and, more often, implicitly, in engineering's "technical" courses. Though I have written a good deal about explicitly integrating professional ethics into engineering's technical courses, I believe explicit integration is still relatively uncommon. So, I shall say no more about it here (For more, see, for example: Davis 2006; Davis et al. 2016). What does seem to be a common practice is the *implicit* integration of engineering ethics in at least some of engineering's technical courses. The integration goes on using such terms as "accuracy", "documentation", "efficiency", "reliability", "safety", and "sustainability". Such terms denote technical standards in engineering, standards government, engineering associations, or independent standard-setting bodies have elaborated in considerable detail. In general, engineering's technical standards are ethical insofar as they are morally binding guides to conduct that each engineer (at her rational

best) wants every other engineer to follow even if the others following them would mean having to do the same. For engineers, their profession's ethics is (or, at least, should be) not so much a supplement or constraint on their main pursuit as a component of what they seek to accomplish. To be a good engineer is to help improve the material condition of human beings in the way engineers typically do, not to make a lot of money for self or employer (though, of course, money is always welcome). Accuracy, documentation, efficiency, reliability, safety, sustainability, and the like are part of good engineering, not a mere constraint on what engineers as such do.

Engineering is sometimes described as a "captive profession", as if engineering were once free like most other professions but now only survives in cages, the large organizations in which engineers now typically work, especially modern business corporations (Noble 1977; Goldman 1991). This description of engineering seems to be mistaken for at least five reasons.

First, much of the plausibility of claims about engineering's captivity seems to arise from confusing the function of engineers (building, designing, and so on) with the discipline of engineers (the special knowledge, skill, and judgment, largely taught in engineering school, that engineers bring to building, designing, inspection, and other work engineers typically do). While the function of engineers has been carried on in many societies, including some quite ancient, and under many names (builder, inventor, machinator, mechanic, munitor, technician, and so on), the discipline seems to be much newer, originating in the French army in the late 1600s. Engineering became a civilian profession only in the 1800s when civilian technology, beginning with railroads, became demanding enough to benefit from engineering's special discipline (Davis 1995). While some of those who have functioned as engineers in earlier times may have done so free from any large organization, those sharing the discipline of engineering have not. (A disciple is defined by certain sorts of knowledge, skill, and judgment passed by teachers to students in an unbroken line from one generation to the next.)

Second, because professions are, by definition, ways to earn a living, no profession can long survive without employers, people to pay the cost of carrying on the profession. Even the freest profession must generally do what its employers want or cease to exist. Engineering has never been free of employers—nor could it be without becoming an (expensive) avocation rather than a profession. That is as true of other professions as of engineering.

Third, engineers have never been able to do much on their own. Even in the days when a lone engineer might oversee a siege, he could do little without the large organization that determined where he employed his siege craft and provided the labor, supplies, and protection necessary to carry out his plans. Today, good engineering generally requires the resources of a large organization, including the cooperation of other engineers. An engineer alone is, and always has been, more or less useless, an engineer only in the sense of having the potential to do engineering.

Fourth, all this is as true of engineers working for government, a socialist enterprise, or a non-profit as of engineers working for a business. The word "captive" in "captive profession" sounds bad but in fact tells us nothing about engineering.

While profit is a constraint on engineers working for a business, it corresponds to the constraint of budget characteristic of government, socialist enterprise, or nonprofit. Business has not captured engineering—in any interesting sense of "capture". Engineering is, instead, a profession having a symbiotic relation with large organizations, whether for-profit or not.

Fifth, the idea that projects that are "intrinsically technically challenging and interesting but without a market" (Holt 2001, 498) would have precedence in engineering but for the profit-motive of business seems to involve at least two mistakes. One mistake is the assumption that only business constrains engineers in some such way as this. In fact, every organization for which engineers are likely to work must direct their efforts away from the merely technically challenging toward what is useful, however prosaic. Few engineers are free to do what they want even in a government laboratory. Few engineers are hired to do "pure science". The other mistake is to assume that the intrinsically technically challenging project should be the aim of engineers once freed of practical constraints. The moral ideal engineers seek to serve is (more or less) improving the material condition of human beings, not high-tech at any cost. A project without a market is unlikely to improve the material condition of human beings. It is therefore unlikely to count as good engineering. Hence, it is hard to know what the term "pure engineering" might mean.

2.3 Importance of Disagreement Between Engineers and Managers

The line between engineers and business managers is not as sharp as the discussion so far may suggest. The manager overseeing the work of any particular engineer is likely to be an engineer as well (whether or not holding a business degree in addition to an engineering degree). Indeed, even the senior management of many large businesses will include a significant number of engineers. For example, of Lockheed Martin's eight vice presidents, three are engineers[2]; of GM's twenty-four senior officers, seven are engineers.[3] Many disagreements between engineers and business management are (in part at least) disagreements among engineers.

But beside, below, or above such "engineer-managers" will be managers trained only in accounting, computer science, industrial design, law, marketing, or another

[2] See biographies of: Patrick M. Dewar, Executive VP; Dale P. Bennett, VP for Mission Systems and Training; Richard F. Ambrose, VP for Space Systems, http://www.lockheedmartin.com/us/who-we-are/leadership.html (accessed October 17, 2015).

[3] See biographies of: Mary T. Barra, Chief Executive Officer; Alan Bately, Executive Vice President and President, North America; Alicia Boler-Davis, Vice President of Global Connected Customer Experience; James B. DeLuca, Executive Vice President, Global Manufacturing; Grace Lieblein, Vice President, Global Quality; Karl-Thomas Neumann, Executive Vice President & President, Europe; Mark Reuss, Executive Vice President, Global Product Development, Purchasing and Supply Chain; Matt Tsien, Executive Vice President and President, GM China. http://www.gm.com/company/aboutGM/GM_Corporate_Officers.html (accessed October 17, 2015).

non-engineering discipline. Many of the ethical problems engineers face in practice arise (as they did in Veblen's day) as a disagreement between engineers and non-engineers. Some of these disagreements set engineering against finance (such as the constraints of budget), but some may set engineering against aesthetics (what designers think looks good), culture (what marketing thinks customers expect), or law (what lawyers think necessary to protect the employer against legal liability). Products of a modern business (like products of government) typically involve complex negotiation between many "stakeholders", some of them inside the business.

It is easy to assume (as Veblen did) that when there is disagreement between engineers and "financial managers", the financial managers must be wrong. They are wrong sometimes, of course, but certainly not always. Some engineering solutions may be both beyond an organization's resources and, while morally desirable, not morally required. Much of the time, the right answer, or even the least bad answer, about what to produce or how to produce, sell, maintain, or dispose of it may be unclear, especially at first. The work of business is increasingly carried on by interdisciplinary teams because no discipline has a monopoly on answers to the complex problems modern businesses face.

What has been called "the revolt of the engineers" may be understood as part of a larger and longer negotiation both within engineering and between engineering, its fellow professions, managers, and their common employers concerning what engineering is, what it should do, and why it should do it (Sinclair 1980). The "revolt" focused primarily on two issues: one about management (the power that engineers should exercise in corporate decisions); the other about the welfare of "bench engineers" (their salary, conditions of work, opportunities for advancement, and other reasons they should have for doing their job). Meanwhile, engineers were making themselves increasingly necessary, especially for businesses making or operating complex artifacts, everything from airplanes to skyscrapers. Engineers made themselves increasingly necessary by developing technical standards, publishing them through professional organizations such as the American Society of Civil Engineers (ASCE), and then trying to follow them. The standards were developed to reduce waste, increase safety, protect health, and so on. Insofar as the standards did what they set out to do, they served long-term business interests, tying business to engineering even as engineering seemed ever more subordinate to business. Even as the "revolt" collapsed during the 1920s, a revolution in the relationship between engineers and business management continued: The "master" became increasingly dependent on the "slave".

Consider, for example, the sealed-beam headlight. It was developed by engineers concerned to improve safety on night-time roads. It was adopted as the industry standard in 1939, a time (the Great Depression) when engineers are supposed to have been most subservient to business. The new headlight, though a technological leap, was a natural extension of standards that two engineering associations, the Illuminating Engineering Society (IES) and the Society of Automotive Engineers (SAE), had jointly been working on since 1918. The headlight was developed by engineers at General Electric (GE), especially Val Roper, the leader of an applied

research team at GE's Automotive Lighting Laboratory in Cleveland, Ohio. Technical feasibility was established in 1937.

From the perspective of the typical "financial manager", the decisive barrier to adopting the new headlight was, however, not technical but financial feasibility:

> [In] 1937, General Electric, as a diversified company, had no compelling motive to overhaul a segment of their lamp business which was already profitable, growing, and arguably producing state-of-the-art products. In fact, some in the company argued that it would be wrong to require depression-beleaguered Americans to buy and install expensive new headlights. The market would buckle to popular resistance, and G.E. would be left with sizable losses from the venture. (Meese 1982, p. 12)

Roper argued in response that failing to bring the new headlight to market was to continue tolerating the horribly high rate of nighttime automobile accidents. More importantly, Roper was soon drawing on a network of engineers—in GE itself, in American automobile manufacturers (such as GM), in state bodies regulating auto safety, and in headlight manufacturers to whom GE sold light bulbs but with whom GE might soon be competing with its new headlight—to work out a plan to overcome the legitimate worries of the financial managers while simultaneously stressing the importance that the safety of the public should have in the final decision.

Roper credited

> the rapid introduction of the Sealed Beam headlight to the responsiveness and flexibility of General Electric management [primarily senior engineer-managers], the industry-wide cooperation regarding the exchange of technical information at the engineer-to-engineer level, the restraint of A.A.M.V.A. [American Association of Motor Vehicle Administrators] to withhold preemptive new regulation, and the persistent efforts of the S.A.E. Lighting Committee and the I.E.S. Headlighting Committee. (Meese 1982, pp. 16–17)

There is, I suggest, nothing unusual in this story of engineers leading the way in making a business decision except for the scale of the achievement. This story nonetheless has at least three lessons to teach concerning the relationship between engineering and business management (and, indeed, between engineers and managers generally).

The first lesson concerns breadth of vision. It is often said that engineers are narrowly technical while managers, being generalists, see the big picture. While some engineers may be narrowly technical, many are not. As in this story, the difference in vision may not be breadth so much as direction, with engineers looking one way and (financial) managers looking another. The safety of the public is certainly at least as broad a concern as GE's financial welfare. In another respect, however, it is the financial managers who plainly have the narrower vision. Not being professionals, their chief commitment (beyond morality's minimum) must be to their employer. They are expected to look beyond that commitment only if their employer instructs them to. Engineers, in contrast, have commitments extending well beyond their employer, commitments arising from their profession.

The second lesson concerns political skills. Engineers are often thought of as politically helpless while managers are politically astute. The story of the sealed-beam headlight is, however, the story of engineers who were politically astute—at least while working within a network of engineers. The truth is probably that

financial managers are good at working with other financial managers but not with "technical people". For dealing with senior management, especially senior managers who are not engineers, the financial managers may be better able to speak the common language—which, after all, is money. But for dealing with outside regulators, or engineers at suppliers, customers, or competitors, engineers may be better able to speak the language—which is more likely to be engineering than money.

The third lesson concerns the relative sterility of financial management. Like the older term "administration", "management" as such is primarily about overseeing, reporting, or making arrangements, not inventing. Engineering, in contrast, is about inventing, improving old artifact or creating new ones. From the perspective of engineers (and the rest of us), financial managers (whether in business, government, or non-profit) will either go along with the engineers, helping with their projects, or be impediments—"saboteurs", as Veblen would have it. Of course, labeling financial managers as saboteurs is not fair, not even in the story of the sealed-beam headlight. The sealed-beam headlight would have saved few lives had it quickly bankrupted GE (or simply not been accepted by auto manufacturers or the public). If a business is to do good in the long term, it must survive in the short term. One important function of business management, especially financial management, is to think about the short term when no one else is thinking about it.

2.4 A Proposal

The forgoing analysis seems to suggest a major change in the curriculum of business schools: Business schools should systematically teach about professions. What they should teach is, however, not best described as "managing professionals" but as "managing *with* professionals". "Managing professionals" suggests that professionals are passive and managers are in control. The addition of "with" suggests instead not only that some managers will be members of this or that profession but that managers must work with professionals, even if the professionals are not themselves managers, rather than merely control them.

Among the topics that should be stressed when teaching managing with professionals is the importance of disagreement between professionals and their managers. Professionals, though experts, are not mere experts. In addition to their special knowledge, skill, or judgment, professionals have commitments different from those of the ordinary manager. Professionals, such as engineers, are in fact hired in part because of those commitments. So, for example, one reason to hire an engineer, rather than an ordinary manager, to supervise safety testing is that engineers are committed to safety in a way ordinary managers are not—whether the business makes the hire because it values safety as such, because the law requires an engineer to supervise certain safety tests, or because the legal department urged the hire to reduce liability should some accident occur. The engineer will serve the employer by carrying out those safety tests according to engineering standards even if the

results hurt the employer in the short term. Out of a disagreement between a manager worried about that short-term harm and an engineer concerned to maintain engineering standards may come an agreement satisfying both and better than either original alternative ("the beautiful harmony" of which Heraclitus spoke).

Of course, such agreement is more likely to come out of initial disagreement if the manager has learned how to carry on the discussion necessary to reach such an agreement. A course in business ethics should, therefore, include role-play in which some students play engineers and some play managers engaged in trying to reach agreement that respects the concerns of engineers as well as management. Both business ethics and other management courses should pay more attention to the discussions out of which important decisions, as well as unimportant ones, come. Indeed, I think today's emphasis on "leadership" in business is a mistake. Leaders are typically people who know where they should go and how to get others to follow. In many situations involving engineers, especially the most important, neither managers nor engineers are in a position to lead (in this sense). Like the odd couple, they must work their way to solutions they cannot anticipate, helping each other along. Better than leadership are the compromises, partial solutions, and inventions of cohabitation.

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Chapter 3
Prisoners of the Capitalist Machine: Captivity and the Corporate Engineer

Eddie Conlon

Abstract This chapter will focus on how engineering practice is conditioned by an economic system which promotes production for profit and economic growth as an end in itself. As such it will focus on the notion of the captivity of engineering which emanates from features of the economic system. By drawing on Critical Realism and a Marxist literature, and by focusing on the issues of safety and sustainability (in particular the issue of climate change), it will examine the extent to which disasters and workplace accidents result from the economic imperative for profitable production and how efforts by engineers to address climate change are undermined by an on-going commitment to growth. It will conclude by arguing that the structural constraints on engineering practice require new approaches to teaching engineers about ethics and social responsibility. It will argue that Critical Realism offers a framework for the teaching of engineering ethics which would pay proper attention to the structural context of engineers work without eliminating the possibility of engineers working for radical change.

Keywords Capitalism · Captivity · Marxism · Critical realism · Engineering ethics

3.1 Introduction

> Capitalism as a socio-economic form of life continues to have overwhelming causal importance in shaping the geographical distribution of economic activity, the life chances of whole categories of people, the availability of policy-options for dealing with pressing economic, social and ecological problems and so on. In the wake of the neo-liberal ascendency and capitalist globalization this is even more inescapably so. (Benton and Craib 2011, p. 209)

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It seems we are all prisoners of the capitalist machine.[1] Like other categories of people capitalism matters to engineers. And engineers matter to capitalism: economic growth is dependent on a process of continual technological renewal and change. Big corporations, some with value greater than some countries' GNP, with managers, not entrepreneurs, at the centre of them, are the organizational form that has come to represent growth. Therefore, engineers and managers are central features of contemporary capitalist society.[2]

Conflicts between engineers and managers feature in many case studies that engineering students study as part of engineering ethics programs (Lynch and Kline 2000). This chapter aims to situate these conflicts between engineers and managers within the broader forces shaping the employment relationship and the operation of capitalist economies. Critical Realism offers a useful philosophical framework for doing this, given its depth ontology which forces us to focus on underlying structures which shape human practices. Marxism offers one way of understanding these underlying structures and remains the most influential account of the employment relationship within sociological theory and one that has a profound effect on all disciplines concerned with work (Browne 1998; Thompson and Mc Hugh 2002). It will be argued that the aspiration of engineers to hold paramount the welfare of the public is conditioned by an economic system which promotes production for profit and operates through hierarchical organisational forms which shape the relations between engineers and managers. This is not to say that the actions of engineers are crudely determined by the imperatives of profitable production but that, as Althusser might say (see Craib 1992), they are "determined in the last instance" by the requirement of the capitalist mode of production which "shapes behaviour not by fixing exactly what people do but by establishing boundaries and limits" (Korczynski et al. 2006, p.14). I want to emphasise the embeddedness of engineering practice arising from the totality constituted by capitalist society and the structural constraints on the engineers' role and therefore defend the conceptualisation of engineering as a captive profession (Noble 1977; Goldman 1991; Holt 2001; Conlon 2013).

I proceed by discussing some features of Critical Realism and the structure of capitalist economies derived from Marxism. The position of engineers within this structure is then explored. It is argued that although relations between engineers and

[1] My title is inspired by Mike Davis's study of the American working class, *Prisoners of the American Dream,* London and New York: Verso, 1986.

[2] Broadly managers can be seen as those with delegated power to control and coordinate the diverse functions of corporations with the aim of meeting the corporation's goals. While some are also owners, in that they may hold substantial shares in the corporations in which they manage, many do not. Over time and as corporations have become larger and more complex the management function has become more differentiated (Thompson and Mc Hugh 2002). Engineers are a diverse group of technical professionals. While most are salaried employees many are also members of management. Engineers perform diverse functions within corporations. National variations in the processes for reproducing engineering work and engineers has led Meiksins and Smith (1996) to conclude it may be "impossible to develop a definition of what an engineer is, or where the boundaries of engineering lie, which would apply to all industrial capitalist societies" (p. 3). While acknowledging this diversity the focus of this chapter is on the overarching features of capitalist economies and how they impact the work of engineers. While the main focus is on corporations who seek to make profits the analysis has implications for the engineering profession as a whole.

managers have specific characteristics in different capitalist economies they are conditioned by the dynamics of class relations, which create contradictory demands on engineers, but also place limits on engineering practice especially when it collides with corporate priorities. The limits on engineering practice are explored further by an examination of the issues of safety and engineers' roles in addressing climate change, in the context of an increasingly neo-liberal business environment. The conclusion will focus on how Critical Realism can contribute to developing an approach to engineering ethics which will enable future engineers to understand the full range of issues they will be required to address in order hold paramount the health, safety and welfare of the public. To escape captivity engineers will need to confront constraints arising from the business environment.

3.2 Critical Realism

In the social sciences Critical Realism (CR) has emerged as an alternative paradigm to positivism and interpretivism. It combines a realist ontology with an interpretive epistemology: the real world exists independently of our knowledge of it and our knowledge of the world is always fallible as it is shaped by the "social position of knowers" (Carter and New 2004, p. 2). CR argues for the primacy of ontology. In seeking to explain phenomena it offers a distinctive approach. Firstly, a depth ontology: a notion of a stratified reality which includes a distinction between the domain of the real (generative mechanisms), the actual (events) and the empirical (experiences). Structures of objects, at the level of the real, generate mechanisms that facilitate events. Realist explanations connect experience in the empirical domain with structures and processes in the real domain. We are encouraged to look "at deeper structural things that might be the cause of events" (Kotta 2011). This is potentially emancipatory in that it forces us to consider "that certain states of affairs cannot be ameliorated within existing structures" (Collier 1994, p. 10). They must be changed.

While arguing that the social can be studied scientifically critical realists also argue there are differences between the natural and social sciences. Firstly, taking the conduct of experiments as a starting point, CR argues that the kind of closure offered by laboratory experiments is not achievable in the real world. Therefore causal mechanisms must be studied as part of open systems where their effects may be blocked by the operation of other mechanisms (Danermark et al. 2002). Thus their impact is conditioned by the context in which they operate.

Secondly, social structures are maintained through the activity of people. CR offers a particular social ontology focused on the relationship between structure and agency and is committed to an explanatory model "in which the interplay between pre-existent structures, possessing causal powers…and people possessing causal powers…of their own results in contingent yet explicable outcomes" (Carter and New 2004, p. 6). This implies that any investigation can only take place "at the intersection...of agental and structural objects" (Scott 2000, p. 15). Margaret Archer (1995) argues that social theory has come up with unsatisfactory ways to understand this relationship and provides a framework for understanding different approaches