Chapter 7
Confucianism, Marxism, and Pragmatism: The Intellectual Contexts of Engineering Education in China

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Abstract Sensitivity to cross-cultural and cross-national differences in engineering education and practice is essential for globally competent engineers. Those who fail to pay close attention to the historical-cultural contexts of engineering do so at their own peril, increasing the likelihood that their gaps in knowledge and misconceptions will lead to failed collaborations, projects, and products. This chapter aims to support this thesis by describing the historical and intellectual contexts for engineering education in contemporary China. It starts by presenting a variety of controversial issues in current global discourses on China's engineering education, e.g., distinct understandings of professionalism and accountability, and different approaches to defining core bodies of knowledge, competencies, and other learning outcomes. It argues that these controversies mainly arise from insufficient understandings of three key intellectual contexts of Chinese engineering education: Confucianism (historical), Marxism (ideological), and economic pragmatism (economic). It is then followed by analyses showing how these three intellectual contexts historically contributed to shaping China's unique developmental trajectory of engineering education. The three dimensions are not presented and judged in historical sequence, but instead framed as interwoven and coproduced, with real and present implications for the culture and character of engineering education and practice. Finally, this chapter attempts to use the three-dimensional framework as an interpretative tool to reflect on the practical issues proposed in the first part. In so doing, it highlights the relevance and implications of the intellectual contexts of global engineering education and policymaking in contemporary China. The

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chapter's main thesis is further advanced by revisiting an influential cross-national, comparative study of engineering education, which helps show how discourses originating outside of China frequently provide impoverished or oversimplified understandings of the Chinese context.

Keywords Confucianism • Marxism • Pragmatism • Intellectual history • Global engineering education • Engineering education • Educational policy • China

Introduction

Influenced by economic, social, political, cultural, and other internationalization trends, engineering is more than ever becoming a global profession (Johri and Jesiek 2014). This reality is reflected in numerous reports and commentaries, ranging from the U.S. National Academy of Engineering's influential volume on *The Engineer of 2020* (National Academy of Engineering 2004) to current ABET accreditation criteria which explicitly note the importance of engineering graduates understanding the impacts of their work in global context (ABET 2008). In response, growing numbers of educational institutions, programs, and initiatives in Australasia, Europe, Latin America, the United States, and more recently Asia (e.g. China, Japan, Malaysia, and South Korea) are grappling with the challenge of preparing their engineering graduates to function more effectively in the ever-changing global context. Thus how to characterize and educate the "globally competent engineer" is an increasingly relevant and compelling question for many engineering education practitioners and researchers.

Among various responses to this question, one of the more thoughtful and influential comes from Downey et al., who define global engineering practice as a highly interactive form of cultural engagement. Thus global engineering competency becomes "a problem of engaging people from different cultures" (Downey et al. 2006, p. 107), and the globally competent engineer is expected to acquire the "knowledge, ability, and predisposition to work effectively with people who define problems differently than they do" (Downey et al. 2006, p. 111). According to this formulation, a globally competent engineer must understand the historical and cultural contexts of engineering education and practice in other countries and regions. The authors also observe that "statements about the benefits of global learning for engineering students typically locate those benefits in encountering and coming to understand engineers and other potential co-workers who are raised, educated, and living in countries other than their own" (Downey et al. 2006, p. 108).

This chapter similarly takes the view that sensitivity to cross-cultural and cross-national differences in engineering education and practice is essentially important for globally competent engineers. Those who ignore or disregard the historical-cultural contexts of engineering increase the likelihood that their lack of knowledge and/or misconceptions will lead to failed collaborations, projects, and products. One recent example is that of Google leaving China, in part due to an inadequate understanding of Chinese ideological and political culture (e.g. human rights, negative liberty, and internet censorship policy). This chapter aims to further illustrate this thesis by describing the intellectual contexts for engineering education in contemporary China. We focus on engineering education due to its dominance as an educational pathway in China, its position as a key to professional practice, and its implicit and explicit roles in bringing individuals into the profession.

Three Controversies

In current global discourse on Chinese engineering education, a variety of controversial issues have surfaced. Many are related to distinct understandings of professionalism and accountability, and different approaches to defining core bodies of knowledge, competencies, and other learning outcomes. One such controversy centers on the status of engineering ethics in China. As Guo (2009) has argued, for example, *engineering ethics does not as such exist in China*. However, moral reflection and regulation have actually had considerable influence on Chinese engineering education and practice, with Confucianism, Marxism, and Deng Xiaoping's development thought playing especially prominent roles. These moral ideas have real and considerable influences on current engineering practice and education (Zhu 2010).

There is also historical evidence for a sort of code of engineering ethics emerging and evolving in modern China. Su and Cao (2008) argue that the Chinese Institute of Engineers, with a history going back to the early 1900s, did not originally have a clear ethical code specifying the social responsibilities of engineers. However, the organization did uphold a strong commitment to both the nation and public during a period of struggle to break free of imperialist exploitation. Today, a similar code of ethics might not explicitly exist in Chinese institutions of engineers due to the influence of a Marxist ideology, which emphasizes governmental administration of engineering societies over professional autonomy. Chinese engineers might lack a formal code of ethics but nonetheless "have an unwritten one" (Davis 2009, p. 334). Is a code of ethics really absent just because it does not exist in Western forms? We should be careful not to define engineering ethics without adequately attending to relevant considerations of historical and cultural context.

A second controversy concerns whether *engineering in China is a profession*. In fact, Guo's argument that Chinese engineers do not have explicit ethical codes might suggest that Chinese engineering lacks some critical features of a modern profession, at least from a Western point of view. By contrast, Davis (2009) maintains that engineering is a global profession. And to the extent that engineering has distinct elements and features that Chinese engineers share with their colleagues elsewhere, they work well with engineers from other countries and regions. Davis encourages researchers to take history and culture into account and "explain" what engineering is when they want to define it. Nevertheless, Davis himself does not explore the Chinese intellectual context. In fact, and as discussed below, Confucian and Marxist approaches to communitarian thought resist some core ideas in Western definitions of professionalism (e.g., individualism and autonomy).

A third controversy concerns *who Chinese engineers were and are*. Addressing this question first requires acknowledgment of the complex historical and cultural context of engineering practice and education in China. One view is that ancient Chinese artisans and craftsmen can be viewed as engineers. For instance, Rae and Volti (1993) argue that governmental officials and bureaucrats took on roles that in part resemble modern engineering practice. Yet they do not offer convincing arguments regarding the extent to which these officials and bureaucrats were truly comparable to contemporary engineers. With artisans also, the extent to which they were operating like modern engineers is unclear.

More recently, Wadhwa and colleagues have argued that what is considered engineering and who is considered an engineer in China is not consistent with prevailing American views. For example, some auto mechanics and technicians in China are called "engineers". Further, the majority of engineers do not take engineering jobs, but become bureaucrats or factory workers (technicians or production line managers). The average level of skill and knowledge among Chinese engineers appears to be lower than in the West (Wadhwa et al. 2007; Gereffi et al. 2008). As Wadhwa and colleagues argue, a number of "technology" programs – such as "information technology" – should not be viewed as engineering programs (Wadhwa et al. 2007; Gereffi et al. 2008). However, these authors fail to link the concept of "technology" to both its linguistic origins and the pragmatic context developed since Deng Xiaoping's reform and opening-up. Technology, as a pragmatic term, has a diversity of meanings in Chinese and can in some cases include engineering, as is also the case with Western institutes of technology such as MIT. *Gongcheng jishu* (工程技术) should not be simply and literally translated into "engineering technology," but might be better (if not best) understood as "engineering **and** technology" or even "engineering (skills)".

In order to better understand and contextualize such controversies – as well as engineering and technology education in China more generally – calls for appreciation of three key intellectual contexts: Confucianism (historical), Marxism (ideological), and pragmatism (economic). These three philosophies are among the most fundamental intellectual contexts of modern engineering education in China. It is thus appropriate to begin with a sketch of each of these intellectual traditions:

- Confucianism (historical): In comparison with other philosophies (e.g. Daoism, Buddhism, and Moism) in traditional China, Confucianism is the single most influential Chinese school of thought (Shun and Wong 2004). Even today, as a sociopolitical philosophy, it shapes people's understandings of relations among humans, nature, and society, with technology playing a mediating role. As a philosophy of education, Confucianism continues to shape the values of Chinese people and cultivation of "ideal men" in society. Hence Confucianism has fundamental implications for both engineering and education, including in relation to questions like: What is the role of engineering and technology in society? What is *good* engineering? What does an "ideal person (engineer)" look like? How should people be educated?

- Marxism (ideological): Marxism is the official *zhidao sixiang* (guiding ideology) for nearly all social activities and national strategies in the People's Republic of China. As a social enterprise, engineering cannot escape the influence of Marxism. Marxism is also embedded in Chinese (postsecondary) education. College students are taught to incorporate Marxist ideologies into their future careers. At the national level, engineering students (both undergraduate and graduate) are required to take courses on Marxism. Since the 1950s, the CPC has conducted many rounds of ideological curricular reforms in colleges and universities (Andreas 2009). And for Master's degree programs, engineering students must take one Marxist course on "dialectics of nature" which provides a kind of Marxist philosophy of engineering.
- Pragmatism (economic): In contrast to Mao Zedong's "revolutionary Romanticism" guided by a radical ideology and often largely impervious to practical concerns, Deng Xiaoping's thinking was dominated by what MacFarquhar (1997) calls "pragmatism," as evident throughout the course of his political career (Joseph 2010; Wong and Zheng 2001). Since the reform and opening-up, a pragmatic economic approach initially proposed by Deng has exerted a strong influence on economic and social policymaking. Because of the interwoven relations between economic development and engineering, pragmatism is thus deeply embedded in engineering practice and education in contemporary China, and engineering education is often proposed and promoted with explicitly pragmatic goals.

These three aspects of the contemporary Chinese context are not just historically sequential phenomena; they are interwoven and coproduced, with real and present implications for the culture and character of current engineering education and practice. Further, these are not the only relevant features of Chinese intellectual life today. Another relevant theme is the ideological concept of "good life." Proposed by Xi Jinping, the new General Secretary of the Communist Party of China, this concept has its intellectual roots in both Confucianism and pragmatism. Xi's idea of promoting the "good life" as part of his national project for building a "beautiful China", which is now being integrated into China's engineering practice and education policy. As suggested by the preceding overview of controversial questions related to "engineering ethics", "engineering", and "engineers", it is clear that multiple intellectual dimensions are frequently and deeply interwoven.

Confucianism: Sociopolitical Practicality and Communitarian Ethics

It is worth stepping back to more deeply probe each intellectual tradition, beginning with Confucianism. As the most influential school of thought in Chinese culture and philosophy, it originated as a kind of "ethical-sociopolitical teaching" during the Spring and Autumn Period (770 BCE–476 BCE). As a sociopolitical philosophy, Confucianism always examines engineering and technology through ethical and political lenses. An overarching Confucian philosophy of technical projects embraces a “sociopolitical practicality”, which posits that technical projects should contribute to the social welfare of the state and its people. Late in the Ming dynasty (1368–1644), this idea was systematically developed as a national philosophy or *jingshi zhiyong*. This idea has been translated as “engaging in efforts of practical use in governing the world” (De Bary and Bloom 1999, p. 765).

A story from *Zhuangzi* (a Daoist book) helps illustrate this pursuit of practical efficacy valued in Confucianism. According to the story, on his way back to the state of Jin after his travel to the state of Chu, a disciple of Confucius named Zigong saw an old man working very hard to get water from a well, putting it in a jug to irrigate his garden. Zigong felt puzzled and asked the old man, “There is a machine now that can water a hundred gardens in one day. You would get a big reward for easy work. Would you not like one?” The old man asked the Zigong to further explain how the machine worked. Zigong told the old man the machine was called a *shadoof* (counterpoise-lift) that consisted of a lever rotating on a pole with a bucket suspended at the shorter length. Because of mechanical advantage the user saved labor. The old man hesitated before responding,

> I heard from my teacher that where there are mechanical contraptions there will be mechanical business, and where there is mechanical business there are mechanical minds. With mechanical mind, you cannot preserve your simplicity. When you cannot preserve your simplicity, your spiritual life is unsettled, and the *dao* will not support an unsettled spiritual life. I am not ignorant of your contraption but would be embarrassed to use it (Ivanhoe and Van Norden 2001, p. 243).

Zigong was impressed by the moral integrity of the old man. However, when Zigong retold this story to his master Confucius, Confucius was not so inspired. Confucius argued that “for those who merely pursue their inner life and inner truth”, the old man’s criticism of the shadoof may “seem reasonable”. But besides their inner lives, human beings also have their outer lives and they must live and “have a relationship with the outer world”. In this sense, Confucius stressed, the old man “only knows one side of the truth” (Zhu 2010, p. 91). Hence from the Confucian perspective, good application of technology is able to generate practical efficacy and social prosperity (nation’s economy and people’s livelihood).

Further insight can be gleaned from the well-known Confucian classic *Shangshu* (The Book of Documents), which includes three doctrines that could serve as fundamental principles for a Confucian ethics of engineering: *zhengde* (rectification of virtues), *liyong* (appropriate use of resources), and *housheng* (strong protection of life). Conversely, the historical record also reveals some technical projects that were constructed with the purpose of fulfilling the emperors’ personal pleasures, leading to accusations of *laomin shangcai* (wasting labor and money) or *qiji yinqiao* (magical skills and improper cleverness).

In ancient China, Confucian principles had major influences on individuals, collectives, and society, especially in terms of social hierarchy. In general, the Confucian society consisted of four major “occupations,” in decreasing order or status: *shi* (gentry scholars), *nong* (peasant farmers), *gong* (artisans), and *shang* (merchants and traders). Were any of these the early predecessors of engineers? And how might they have been educated? Technical projects (e.g. structures, metalwares, mechanical devices, and weapons) were mainly conducted in family workshops or large-scale labor activities organized by the government (Li 2006). Artisans participated in both, but in comparison with gentry scholars and peasant farmers their social status was relatively low. In Confucianism, *laoxinzhe* (those who labor with the mind) have higher status than *laolizhe* (those who engage in physical labor) (Song 2002).

Hence, histories of Chinese technology commonly see artisans as the predecessors of engineers. But this is questionable. Only high-level artisans were more literate than farmers, yet much less so than scholars. According to Barbieri-Low (2007), the literacy of ancient artisans mainly involved inscribing characters on artifacts, a practice called *wule gongming*, or "engraving artisan names on products." This could be seen as an early code of ethics among artisans who took responsibility for the quality of the artifacts they produced. With years of hard work, only a small portion of high-level artisans could move into supervisory roles. Since such supervisory artisans were involved in planning and implementing whole projects and coordinating labor relations, they could be seen as early predecessors of engineers.

Yet it is arguably even more appropriate to see some scholar-officials and technical bureaucrats as predecessors of the modern engineer, especially in light of their social roles and functions. This phenomenon represents a central idea in the Confucian history of education – "practical statesmanship" – or, to adopt a more gender neutral term, "practical leadership." Hatmaker (2012), for instance, identifies a number of different roles played by engineers in contemporary society: (a) technician; (b) administrator; (c) coordinator; (d) communicator; (e) relater; and (f) caretaker. In ancient China, large technical projects frequently involved scholar-officials who assumed roles as "administrators", "coordinators", and "communicators," covering a good part of Hatmaker's characterization. The planning and building of the Dujiang Dam serves as a relevant historical example. The project was administered by Li Bing, a Confucian scholar serving as a principle governor of Shu during the Warring States period (475 BCE–221 BCE). This early scholar-official attempted to incorporate some basic management principles in administrating and coordinating the construction of Dujiang Dam (Wang et al. 2008). Such competencies distinguish official scholars managing technical projects from common artisans, as well as other scholar-officials assuming other kind of roles.

Influenced by Confucian thought emphasizing political centralization and agriculture, particularly since the Han dynasty (206 BCE–220 CE), the government favored *dayitong gongcheng* (great unified projects) such as irrigation systems, large structures, canals, and other inland waterways which required enormous labor resources. Early technical projects were therefore large-scale and complex, necessitating strategic activities such as planning, designing, coordinating, and implementing. This expansive view of technical projects in early Confucian thought continues to influence the Chinese understanding of engineering.

Since large-scale projects required well-organized operations, government officials with either management experience or technical knowledge played leading roles. These officials mainly saw technical projects as "political projects" aligned with the Confucian idea of sociopolitical practicality (e.g., political stability and social benefit). Hence, governmental officials brought Confucian thought to planning, designing, and coordinating. Such abilities remain central to technical professionals who we call "engineers" today. And because official scholars were recruited through imperial examinations, they had to be well versed in Confucian ideas and principles. In their careers, they intentionally or unintentionally applied their knowledge – much of it originating in Confucianism – to design and carry out technical projects. Given their educational experiences and application of theoretical knowledge (Confucian thought) into technical practice, these special scholar-officials exhibit attributes closely resembling those of modern engineers.

The "engineering-management" role taken by Confucian officials further developed as a political tradition in modern China in the spirit of "practical leadership." This tradition was particularly influential in the late Ming and Qing dynasties. In contrast to traditional "moral leadership," practical leadership was based on a belief that "the inner moral cultivation and exemplary leadership were not sufficient to solve the problems China was facing and professional statecraft and institutional approaches should be added" (Liu 2012, p. 96). During the late Qing Dynasty (1840–1911), Confucian officials such as Wei Yuan (1794–1857) and Kang Youwei (1858–1927) proposed that *xixue* (Western learning) could promote sociopolitical reforms and solve social problems in China. Some Confucian scholars (so called "westernizationists") also believed that only Western science and engineering could promote sociopolitical reforms in China.

Thus, in the late nineteenth century, a great number of Western books, and particularly those covering topics in science and engineering, were translated into Chinese through collaborations between Confucian officials and Western missionaries. Engineering concepts and theories were also later imported into China. Westernizationists like Zhang Zhidong (1837–1909) established a number of modern factories, militaries equipped with Western weapons, and technical schools. These schools represented the beginning of modern engineering education in China (Carroll 2008). And while westernizationists had seen the importance of modern science and engineering, they also had a deep grounding in Confucian ideology – *zhongxue weiti, xixue weiyong* (Chinese learning as the essence, and Western learning for use). Such an idea remained highly influenced by a traditional Confucian view of technology in terms of sociopolitical practicality, while Western science and engineering mainly served practical purposes, including to help "great China" resist Western imperialism and to enlighten people's minds, but without ever allowing Western learning to displace Confucianism. Hence, the more individualistic schools of thought and institutions characteristic of the West were not imported to China along with engineering. Engineering was introduced as a modern technical *occupation* but not *profession*.

In modern China, a resistance to engineering as an individual profession was thus based in the communitarian ethical values of Confucianism. The central virtues of *ren* (benevolence) and *li* (ritual) characterize Confucian ethics as relational, in contrast to an emphasis on individual autonomy and the freedom in Western ethics. According to Wong (2008), the value of individual autonomy usually includes three dimensions: (a) prioritizing individual interests over group or collective interests when these conflict; (b) giving moral permission to the individual to choose from a significantly wide range (within certain moral boundaries) of ways to live; and (c) emphasizing the importance of living according to one's own understanding of what is right and good even if others do not see it the same way. All three dimensions are central to Western professional ethics.

These three individualistic values are foreign to Confucianism. In engineering ethics, Wong's first dimension is important because it allows engineers to think of their own professional agency over group interests (e.g., those of their companies or firms). In contrast, Confucian ethics sees the individual as dependent on the group, with individual interests as part of the group's interests and vice-versa. Wong's second dimension grants engineers free will to take ethical action from a variety of options and according to an implicit or explicit code of ethics. Confucian ethics is less favorable toward legal coercion and instead emphasizes moral exhortation and inspiration by way of example. Wong's third dimension encourages engineers to make their own choices (e.g., whistle blowing) without interference or coercion from others. Confucianism does articulate the necessity to speak up when one believes their ruler is taking a wrong course of action. Yet in Confucianism, there is no mechanism proposed to protect the critical subordinate from being punished by the ruler. Confucian communitarian ethics can thus be contrasted with an individualistic understanding of ethics. For individuals, Confucianism also posits five basic social relationships: ruler to ruled, father to son, husband to wife, elder brother to younger brother, and friend to friend. The primacy of a network of such relationships further complicates the practice of individual-based professional ethics in the Chinese cultural context.

Marxism: Productive Force and Political Redness

As noted above, Confucian approaches to technical practice emphasize the sociopolitical implications of artifacts and large-scale technical projects. This more socially-oriented approach can also be contrasted with the economic and engineering approach of Marxism, which grows out of the utilization of technology to transform nature through engineering thinking.

As a socio-economic philosophy, Marxist historical materialism considers technical activity as the production process in which technology is a productive force when it is operated, maintained, and conserved by living human labor. Because of the significant role of technology in changing society, Deng Xiaoping further emphasized that science and technology constitute the *first* productive force. The productive forces are those by which society influences nature and changes it, while nature is the universal object of labor (Lorimer 1999). In criticism of Soviet thinking, Mao Zedong modified historical materialism by stressing the importance of human labor, and he glorified human capabilities of using technology to transform nature. Mao's ideology engendered two "philosophies" that continue to influence engineering practice and national development: (1) a *philosophy of nature* (material productivity), where engineering expertise serves as the superpower in transforming nature; and (2) a *philosophy of society* (social productivity), where engineering expertise should be employed to organize and manage social issues.

During the Great Leap Forward (1958–1961) and Cultural Revolution (1966–1976), Maoist thinking about nature played a major role in shaping engineering education and national development. Mao's voluntarist philosophy – believing any task could be accomplished through sheer will – held that through concentrated human exertion and energy, material conditions could be altered and all difficulties overcome in the struggle to achieve a socialist utopia (Shapiro 2001). Scientists and engineers were educated and encouraged to pursue "giant" achievements through exploitation of nature. Engineering projects were even considered "wars against nature" by Mao and Maoist theorists. Mass labor was employed in remarkable engineering projects to build large-scale dams and canals and create new irrigated farmlands in formerly fallow areas. In this sense, Maoist philosophy of society was applied to organize and manage the huge manpower and material resources in engineering projects and other related social issues (e.g., migration problems in constructing large dams). The Maoist philosophy of society has its intellectual roots in Marxist structuralist sociology, which also sees the state as a kind of mechanism.

Thus, the state can be viewed as a large engineering system with a national economy that can be developed and engineered (planned, designed, and implemented). Maoist philosophies of nature and society co-shaped a unique understanding of engineering which still has profound impacts today, including four major aspects. First, engineering involves the utilization and transformation of nature, with the purpose to construct a kind of "artificial nature". Like Marx, Mao himself endorsed the role of science in liberating humans from the material limitations set by natural world. As he explained, "natural science is the armed force by which people strive for liberty." He further elaborated that "if people want to gain liberty from nature, they need to use natural science to understand, overcome, and transform nature so as to be free from nature" (Mao 1940). This view still prevails in nearly all ideological education textbooks for engineering graduates students. For instance, in one of the most popular ideological books, Chen Changshu (a founding father of the philosophy of technology in China) sees the objective of technology (including engineering and production) as "transforming the objective world" (Chen 2001, p. 10).

Second, engineering is understood as a process that conquers nature. This view was early illustrated by a thematic phase, "Man must conquer nature" (*ren ding sheng tian*), spoken by Mao Zedong on September 15, 1956, at the 8th National Congress of CPC. Such a view still influences the majority of senior engineers and engineering administrators, most of whom were educated in 1970s and 1980s.

Third, engineering is a universal method applied in national strategies, initiatives, and planning. Therefore, a large number of national projects involve use of the term "engineering." For instance, consider *minsheng gongcheng* (people's livelihood engineering), *cailanzi gongcheng* (vegetable basket engineering), and *makesizhuyi lilunyanjiu yu jianshe gongcheng* (Marxist theoretical research and construction engineering). These in turn belong to what Marxist scholars call "social engineering."

Fourth and finally, engineering projects are usually large-scale. As already mentioned, social engineering projects often require the coordination and management of human power and material resources at the national level. Hence social engineering projects are large-scale. In the everyday usage of Chinese language, engineering is often understood as large-scale projects. In contrast to engineering, technology has a different meaning referring to technical activity or projects at any scale. In the Chinese context this unique view distinguishes engineering from technology.

In sum, Maoist philosophy understands engineering as a large-scale process that involves transforming natural resources to fulfill the socialist state's development needs in the construction of utopian engineering projects. As socialist laborers, engineers are required to adopt socialist core values such as collectivism and particularly proletarianism. During Mao's time, engineers did not have particularly high social status. Yet because most were better educated than laborers and farmers, they were considered intellectuals. As such, engineers often were accused of being too far removed from the realities of manual labor – whether of the factory worker or farmer. Some were criticized as bourgeois individualists and/or "right deviationists." Indeed, a significant number of scientists and engineers involved with the "Two Bombs and One Satellite Program" were accused of being bourgeois intellectuals due to their Western educational backgrounds (Harvey 2004).

As socialist laborers of the working class, engineers are still encouraged to engage in practical activities at the forefront of production. Partly for this reason, recent engineering graduates have a tradition of learning from technicians and laborers by working with them on the production line. Influenced by Maoist voluntarism, engineers are encouraged to exceed production plans, perhaps even with limited resources, potentially allowing them to be recognized as *laomo* (model workers).

One purpose of the Cultural Revolution was to train intellectuals (including most engineers and engineering teachers) to be proletarian intellectuals of the working class. During the Maoist period, political "redness" was increasingly prioritized, and particularly so in engineering education and other technical fields. "Red and expert" became a guiding hallmark for engineering education. As observed by Zhidong Hao,

> in the Mao era, efforts at creating a professional stratum were developed along the lines of "red and expert", and intellectuals did not achieve much autonomy. Rather, they were deprofessionalized. Intellectuals had to conform to the Maoist ideology and serve the Party's political goals. Even in their own technical fields, intellectuals were constrained by the Party objectives. (Hao 2003, p. 228)

Since Mao's era, "red and expert" has become a paradigm ensuring the political quality of engineering education and practice. Even today in both engineering schools and large industrial companies, there remains a two-track supervising system: Party committee and administrative organization. Party secretaries, whether or not with a professional background, often oversee key issues and policies, making final decisions about what can and cannot be done. Meanwhile, normally the head of the administrative organization (e.g., university President) is a member of the Party committee. In this sense, the purpose of "red and expert" is to ensure that intellectuals hold the right political direction. Andreas' (2009) history of Tsinghua University powerfully illustrates how these trends manifested in the historical development of China's most prestigious engineering school.

Although professional societies of engineers did exist prior to 1949, engineering associations established since that time have taken the form of "expertise organizations" (e.g., China Civil Engineering Society) rather than true professional organizations in the Western sense. These organizations are governed by the Ministry of Civil Affairs and other governmental departments (e.g., the Ministry of Housing and Urban-rural Development) and organizations (e.g., the Chinese Association of Science and Technology). Under the direct leadership of the Party, engineers are expected to embrace the core values of socialist ethics.

The "red and expert" idea still has broad relevance to engineering curricula in China. In engineering schools, the study of Marxist ideology is required in both undergraduate and graduate curricula. Guan (2012), for instance, has comprehensively reviewed the historical and current development of ideological education in Chinese universities, including engineering schools. Her study describes how ongoing efforts in ideological curricular reform have helped consolidate the dominant role of Marxist ideology and promote the education of engineering students as "red experts."

Economic Pragmatism: Modernization and Engineering Citizenship

In contemporary China, economic pragmatism has become the dominant strain of thought guiding social construction activities in which engineering practice and education are indispensable components. In contrast to philosophical pragmatism, economic pragmatism was mainly advocated by Deng Xiaoping in the late 1970s and early 1980s. And while there is no clear evidence relating Deweyan philosophical pragmatism to Deng's economic pragmatism, Chang notes that "the pragmatic approach of Deng Xiaoping signaled a significant step toward 'concrete problems' and toward Deweyan experimentalism" (Chang 2002, p. 61).

In Deng's economic pragmatism, technology and engineering are viewed as tools of modernization. One major initiative representing such ideas centers on the "Four Modernizations" (modernizations of agriculture, industry, national defense, science and technology). Although the Four Modernizations were first explicitly promoted by Zhou Enlai in 1963, the concept came to be widely viewed as the "brainchild" of Deng Xiaoping (Englesberg 1995, p. 100). The Four Modernizations initiative was adopted as a means of rejuvenating China's economy in the post-Mao era and was one of the defining features of Deng's tenure as the Communist leader.

In contrast to a more classical Marxist understanding of technology as a productive force, Deng further emphasized that "science and technology constitute the *first* productive force." Hence science and technology took the leading role in the Four Modernizations since they themselves independently represented one modernization and also played decisive and influential roles in the other three strands of modernization (agriculture, industry, and national defense).

In comparison with philosophical pragmatism, Deng's economic pragmatism was more like instrumentalism or what might even be called entrepreneurial "innovationism," since any economic activity is always a market experiment. As in Deng's famous "cat theory": "It does not matter whether a cat is white or black, as long as it catches mice." Unlike Mao, Deng was not especially worried about whether an activity was capitalist or socialist so long as it improved the economy. As Deng also said, "Poverty is not socialism, to be rich is glorious." Such an instrumentalist view led to the experimental creation of the four "special economic zones" (SEZs) in order to pursue "socialism with Chinese characteristics." In the SEZs, as Deng also stated, "Without the high-speed development of science and technology, there is no high-speed development of national economy" (Deng 1983, p. 86). Thus, as a tool of modernization, technology (including engineering), played a prominent role, thereby distinguishing Deng's philosophy of national development from Mao's.

Deng's economic pragmatism and instrumentalist view of engineering and technology has been continued by PRC presidents Jiang Zemin (1993–2003), Hu Jintao (2003–2013), and Xi Jinping (2013–present). Economic pragmatism has become a ruling ideology with significant impacts on nearly every aspect of socialist construction, including education. Since Deng's era, engineers have been aligned with this ideology by promoting their ability to support economic development, including by directly serving the needs of industry and leading innovation. Take for example the 10-year national "excellent engineer education and training initiative" launched by the Ministry of Education and other government agencies. To begin, the first of three kinds of engineers this initiative seeks to educate is the so-called *xianchang gongchengshi* (field engineer). It also mandates that engineering schools work closely with industry to tailor engineering graduates who can "seamlessly" serve industry (Ministry of Education 2011a). Other initiatives, such as the Ministry of Education's 2006 "National University Student Innovation Program," aim to train innovative engineers who can contribute to the pragmatic goal of increasing the economic and technological competitiveness of Chinese firms on the world stage.

Since the 1980s, the aim of educating innovative and practical engineers has focused on the rejuvenation of China after the turmoil of the Cultural Revolution (1966–1976). Inspired by economic pragmatism and emphasizing technology as contributing to economic development, engineers have gained higher social status and greater autonomy and respect (Miller 1996). Nationalism has thus become a centrally important part of engineering education.

Yet perhaps this is not surprising. As a growing body of scholarship reveals, engineers and engineering are often tightly linked to prevailing notions of national progress (e.g., Downey and Lucena 2004). As Downey et al. summarize, global engineers must therefore recognize how "dominant ideas of national progress… have played a key role in shaping dominant patterns of engineers and engineering" in different country contexts (Downey et al. 2006, pp. 113–114). The present account thus builds on previous discussions of engineering and national development in the Chinese context, as in Jesiek and Shen's (2012) study of engineering education in China during the Nationalist period. This "national ethic" evident in multiple historical periods in China can be viewed as a kind of "engineering citizenship," in that engineers have responded to and largely upheld an obligation to orient their professional expertise and engineering thinking toward national development goals and projects. This kind of "engineering citizenship" can be viewed in three ways.

First, engineers serve as *state leaders*. Most Chinese state leaders in the post-Mao era were originally trained as engineers. In fact, during the early twentieth century, Deng spent some of his formative years studying engineering and science in France. He was later named as the "chief engineer" of the reform and opening-up and Chinese modernization. Deng's successor, Jiang Zemin, studied electrical engineering and worked as an engineer for two decades. The third generation leaders President Hu Jintao and Premier Wen Jiabao were respectively trained in hydraulic and geomechanical engineering. And from 2007 to 2012, eight out of China's nine politburo's standing committee members were trained as engineers.

Second, engineers serve as *local government officials*, taking on administrative positions at lower levels of the Chinese government. Unlike in the United States, the responsibility of provincial governors and municipal mayors in China often includes extensive responsibility for technology-based economic development in local areas. They frequently visit technological companies (particularly state-owned) and are required to be familiar with technological and economic concepts. Hence, engineers are preferable for these positions. While few have experience as practicing engineers in industry, these engineering-trained governmental officials often go on to assume roles as "chief engineers" of cities and provinces. In 2013, 13 of 31 provincial governors had engineering degrees or engineering experience, with at least three holding Ph.D. degrees in engineering.

Finally, engineers are viewed as *major contributors in the great rejuvenation*. At the university level, the concept of "engineering citizenship" is interpreted in the way engineers are portrayed as major contributors in the great rejuvenation of China. This interpretation is well embedded in the aforementioned "excellent engineer education and training initiative." In fact, the program aims to educate:

> a large number and types of high-quality engineering and technical personnel having strong innovative abilities and fitting in with the societal development. These engineering and technical personnel are indispensable to establish the solid advantage in human resources for constructing an innovative state as well as achieving industrialization and modernization. They are also indispensable to improve the core competitiveness of the Chinese nation and comprehensive national power. (Ministry of Education 2011a)

Hence, developing "excellent engineering education" appears well justified in the larger context of helping China play an increasingly influential role in world affairs.

Three Controversies Revisited

Table 7.1 summarizes the three intellectual traditions that provide a contextual framework for understanding engineering, the engineer, and engineering ethics. This framework can now be used to revisit the three controversies introduced above.

First, how might we challenge the notion that there are *no engineering ethics in China*? Confucianism, Marxism, and economic pragmatism together offer a fundamental ethical system governing current Chinese engineering practice at both the macro- and micro-ethical levels (as distinguished by Herkert (2001)). At the macro-level, according to Confucianism, a good engineering project must be socially beneficial for the state and its people. And at the micro-level, Chinese engineers fundamentally are guided by communitarian ethical values from Confucianism, including relational virtues such as *ren* (benevolence) and *li* (ritual). In the workplace, and because of the virtue of *ren*, Chinese engineers are not likely to publicly criticize their peers or even inferiors. Because of the virtue of *li*, engineers are not encouraged to criticize their superiors. Enculturation into this ethos begins in engineering education. Further, a lack of mechanisms to protect engineers from being punished by their superiors means "whistleblowing" is even less common in the Chinese than Western context. Marxist ideology also plays a role in engineering. Political redness is no less important than professional expertise – and sometimes political redness serves as an evaluative condition for engineers and their work. Finally, according to economic pragmatism, engineers are educated with a nationalist ethic of "engineering citizenship," holding that the education of engineers should serve the ends of national development.

Second, why does *engineering as a profession have a different character in China?* The three traditions all uphold some form of communitarian ethics, thereby countering the individualistic ethics at the heart of most Western views of engineering as a profession. The three traditions also require engineers to be linked with larger communities (family/relatives, society and the world in Confucianism, the Communist Party in Marxism, and the Chinese state in economic pragmatism). Thus, engineers do have certain kinds of responsibility toward other members of their society. Although engineering in China does not look like a profession in the Western sense, commitments by engineers to more expansive values than simple bottom-line profit related to the three intellectual traditions may help Chinese engineers make "professional" judgments, and hence could be viewed as constituting an important kind of professionalism in the Chinese context.

Table 7.1 Three Chinese intellectual traditions

Tradition	Engineering as	Engineer as	Engineering ethics as
Confucianism	Sociopolitical practicality	Political leader	Communitarian ethics
Marxism	Productive force	Socialist laborer	Ideological redness
Economic pragmatism	Means for modernization	Pragmatic engineer	Engineering citizenship

Third, *who are the Chinese engineers?* Historically, the predecessors of engineers were not artisans. When compared with the roles played by modern engineers, it would be more appropriate to see certain Confucian government officials or technical bureaucrats, rather than artisans, as the main predecessors of engineers. In the Marxist context, contemporary Chinese engineers can also be viewed as socialist laborers, reflecting an ideological tradition of seeing engineers as linked to the working class. Finally, influenced by economic pragmatism, engineers are encouraged to be innovative and practical in addressing issues related to national development and global competition. Indeed, Chinese engineers are to some extent comparable to the long history of "state engineers" in France, where the "best French engineering schools have traditionally sent their graduates directly into state bureaucracies" (Baumgartner and Wilsford 1994, p. 71). As in France, Chinese engineer-trained-officials may also see engineering as a way of thinking or practical instrument for administering local governments and managing issues of economic development, rather than as a technological tool for solving specific problems. However, engineering is a "technical title" in China, like university professor. Through national examinations, even technicians with enough years of practical experience and who pass examinations can be promoted as engineers.

Re-considering a Western Analysis of Engineering in China

Reacting to the large and growing influence of China in the global context, many scholars have interpreted Chinese engineering for American audiences. To further highlight the implications of our account, here our framework is used to re-examine an influential example of this type of scholarship by Wadhwa et al. (2007) which examines current trends in engineering training in the U.S., India, and China.

As these authors rightly point out, the word "engineer" has varying definitions across countries. They further argue that the engineering graduate numbers gathered from the Chinese Ministry of Education are suspect because Ministry reports include "'short-cycle' degrees typically completed in 2 or 3 years … (which are) equivalent to associate degrees in the United States" (Wadhwa et al. 2007, p. 74). However, they fail to explain that the engineering students graduating from 2- or 3-year programs might better be viewed as "potential engineers" rather than fully trained or fully qualified engineers. According to Confucian principles of egalitarianism and social mobility, anyone is able on merit to move to a higher position in society. For instance, the Chinese government allows technicians graduating from 3-year programs and accumulating more than 2 years technical experience to be promoted to the status of "assistant engineers" if they pass the governmental professional-title evaluation (National People's Congress 2000, p. 1642). This policy is also linked to continuing engineering education in China, which is considered an important part of the larger engineering education system.

Wadhwa and colleagues also argue that "the Soviet development model led Chinese administrators to attach the term 'engineering' to many institutions and programs that had science- and technology-related, but not necessarily pure engineering content" (Gereffi et al. 2008, p. 15). However the authors do not clearly indicate which institutions and programs do not teach "pure" engineering content. Conversely, they fail to note that some programs having "science and technology" in their names are actually focused on educating engineers. For instance, in the "excellent engineer education and training initiative", programs such as "electronic information science and technology", "armament science and technology", and "measuring and controlling technology" are included as engineering programs (Ministry of Education 2011b). This is due to the pragmatic and broad understanding of technology in the Chinese context which views engineering as a *particular* technology, and not because the government mistakenly treats technology programs (as they are called in the U.S.) as engineering programs. Further evidence for this can be found in the remarks of Zhang Guangdou, a former Vice President of Tsinghua University and distinguished member of the Chinese Academy of Engineering who states that "higher engineering education is a technological education" (Zhang and Wang 1995, p. 29). Zhang must clearly know the Western definition of engineering since he graduated from Harvard University. Yet in Wadhwa et al. (2007), it is also argued that the data from the Chinese Ministry of Education includes "specialized fields such as shipbuilding" as engineering programs. However, it is not clear whether there really is any problem with the translation of the program's name since "marine engineering" in Chinese literally means the art of building ships, although it is treated as a subfield of engineering.

Conclusion

In sum, this chapter argues that awareness of historical-cultural contexts is crucially important for understanding engineering in cross-national perspective. Intellectual traditions in different cultures are particularly important for engineers working in cross-cultural and cross-national settings, and awareness and sensitivity to such differences could be actively taught in engineering degree programs.

More specifically, one of the most important practical implications is that awareness of the three foundational philosophies (Confucianism, Marxism, and economic pragmatism) can improve the ability of non-Chinese engineers to work effectively with Chinese colleagues. In comparison with the other two philosophies, Confucianism is more of a historical and fundamental contextual consideration defining the everyday culture of engineering practice. It also shapes the social values and the human communications within the activities of technical coordination. Marxism serves as more of an ideological context that mainly influences the ethics, standards, and regulations, engineering practice in China. Socialist values are also embedded in many engineering and development policies. Non-Chinese engineers need to well understand these policies, especially if they want to effectively work with state-owned companies. Hence, policies and policymaking in the Chinese context cannot simply be interpreted through the "native" lenses of non-Chinese engineers. Finally, Dengist economic pragmatism has fundamental implications for understanding Chinese engineering culture, including by suggesting that Chinese engineers may define and solve technical problems in their own unique ways. It also helps non-Chinese engineers understand some of the "pragmatic parameters" in technical problems that engineers might most care about in China's fast developing economy.

In addition to the practical implications for global engineering education, this chapter has implications for global comparative studies of professions. Most such studies are mainly focused on historical events and figures. Yet to better understand the *hermeneutical meanings* of these events and figures, this chapter argues that a more fundamental *philosophical/cultural* dimension needs to complement the *historical* dimension. More specifically, regarding the comparative studies of engineering, interested scholars need to at least understand to what extent or at what level meaningful comparisons can be made among the key concepts, beliefs, and issues related to engineering practice and education in different countries. In other words, better understanding the similarities and dissimilarities of the historical events and figures across boundaries requires that one must understand what these historical events and figures mean in the contexts where they originally emerged.

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