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Engineering ethics studies in China: dialogue between traditionalism and modernism

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This paper maps approaches to engineering ethics in the People's Republic of China. It is addressed primarily to English-language scholars interested in learning more about one aspect of the complex historical and cultural context of technological education in a nation that now graduates more engineers than any other in the world. Although the basic terms of this mapping – i.e., traditionalism vs. modernism – will strike some non-Chinese readers as too simple, it nevertheless represents a common conceptualization within the community of discourse being presented. Engineering ethics studies in China today are constituted by a dialogue between traditional Chinese value systems concerning engineering and modernist perspectives influenced by both Marxism and more technoscientifically advanced nations as a result of global technology transfers and economic exchanges. As a preliminary exploration of this dialogue, the paper offers a historical-philosophical narrative of engineering and engineering ethics in China as reflective of traditional attitudes shaped by engineering in the premodern sense of *gong cheng* and its modern reinterpretation in the late 1800s and early 1900s. The paper then outlines some of the main research areas in contemporary Chinese engineering ethics studies. Finally, in the face of globalization, the traditionalism-modernism tension is used to characterize contemporary challenges in engineering ethics in China. The paper concludes with an argument addressed more to Chinese than to non-Chinese scholars, suggesting a need to rethink engineering ethics in order to redefine the meaning of 'made in China'.

Keywords: engineering ethics; China; traditionalism; modernism; history of engineering ethics

Introduction

The cultures of Europe and North America have for some centuries been engaged in efforts to understand and assess the worlds of those with whom they have come in contact over the course of a long imperial expansion that has led to globalization. Although European and North American scholars like to make distinctions among their different countries and cultural traditions, the experience of Chinese and other colonialized peoples is that the West is more monolithic than it is often acknowledged.

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From a different perspective, non-European cultures have for hundreds of years been making counter-efforts to appropriately integrate into their own traditions the modernity presented to them by colonialist enterprises. Engineering ethics studies in China can be seen as another phase in this effort to chart a course of subaltern appropriation based on independent assessment. Indeed, one North American scholar has noted, in a presentation at the Chinese Academy of Sciences, that a strong case can be made for China as a leader in undertaking critical discussions of the ethics of science and technology – as exemplified especially by on-going work in engineering ethics that exceeds anything taking place in, for instance, India or Africa.[1] What follows is thus a brief review of engineering ethics studies in China in a way that both calls such work to the attention of those outside China and seeks to advance it.

Current context

According to a widely cited study from the U.S. National Academy of Engineering titled *Rising Above the Gathering Storm* (2008), China is today graduating more engineers than any other country in the world. According to this report, by 2010 China will be graduating roughly twice as many engineers as the United States.[2] Although as a percentage of the population the numbers are actually below those for engineering graduates in the United States, the general tenor of the report as a whole was to suggest that the United States is falling behind in science and engineering education.

The report has, however, been subject to considerable debate. For instance, one critique is that 'the key issue in engineering education should be the quality of graduates, not just the quantity'.[3] In fact, Chinese engineering educators *have* been concerned with the quality of engineering education. Since the early 1990s, China has been trying to improve the quality of engineering education through professional program accreditation, and some civil engineering accreditations have been recognized by international engineering professional organizations such as American Council for Construction Education (ACCE).[4]

According to the data from the website of the Chinese Ministry of Education, engineering programs constitute the largest percentage of higher education programs,[5] with 320 colleges and universities specializing in 'natural science and technology'.[6] However, in the Chinese usage, science or natural science is usually combined with technology or engineering (ke ji 科技 or li gong 理工) to stress the inseparable relations among science, technology, and engineering. Therefore, it is difficult to give a clear definition of what constitutes an engineering program, since a university characterized as specializing in natural science and technology may be one in which engineering programs are centered.

[1]Mitcham, "Engineering Ethics in Global Perspective," 2009.
[2]National Academy of Engineering, *Rising Above the Gathering Storm*, 2008, p. 217.
[3]Gereffi et al., "Getting the Numbers Right," 2008, p. 13.
[4]Bi, "Guan yu zhong guo gong cheng zhuan ye ren zheng de suo jian suo si" [Observation and Speculation Concerning the Engineering Accreditation in China], 2009, p. 14.
[5]Ministry of Education, *Number of Specialties and Number of Educational Programs Established by Field of Study in Regular Higher Educational Institutions*, 2010.
[6]Ministry of Education, *Number of Regular Higher Educational Institutions*, 2010.

Among all Chinese engineering schools, Tsinghua University in Beijing is generally ranked number one. According to the 2010 rankings of *US News and World Report*, among the top 100 engineering and information technology universities in the world, there are 12 from China, with Tsinghua at the top. Summarizing the *US News and World Report* rankings in relation to China gives five from mainland China, five from Hong Kong China, and two from Taiwan China, as represented in Table 1.[7]

The Chinese Academy of Engineering (CAE) is the national academy of the People's Republic of China for engineering. Established in 1994, it is an institution of the State Council of China, the highest administrative authority of the government.[8] Through 2009, the CAE had elected 753 members distributed in nine divisions: (1) mechanical and vehicle engineering; (2) information and electronic engineering; (3) chemical, metallurgical, and materials engineering; (4) energy and mining engineering; (5) civil, hydraulic, and architecture engineering; (6) environment and light-textile industries engineering; (7) agriculture; (8) medical and health; and (9) engineering management. It is within CAE that discussions concerning engineering quality began, including references to engineering ethics studies. In 2004, for instance, the CAE joined the Japanese and South Korean academies of engineering to issue a 'Declaration on Engineering Ethics', as will be referenced again later in the present paper.[9]

Table 1. Chinese universities within top 100 world universities in engineering and IT.

Rank	University	Location
13	Tsinghua University	Mainland China
26	Hong Kong University of Science and Technology	Hong Kong
31	Peking University	Mainland China
47	National Taiwan University	Taiwan
53	Shanghai Jiao Tong University	Mainland China
59	University of Science and Technology of China	Mainland China
63	University of Hong Kong	Hong Kong
78	Chinese University of Hong Kong	Hong Kong
84	National Tsinghua University	Taiwan
86	Fudan University	Mainland China
91	Hong Kong Polytechnic University	Hong Kong
92	City University of Hong Kong	Hong Kong

Source: U.S. News and World Report, *World's Best Universities: Engineering and IT*, 2010.

[7]U.S. News and World Report, *World's Best Universities: Engineering and IT*, 2010.
[8]As part of the State Council of China, CAE functions as consulting institution for carrying out strategic research on developing engineering science and technology, helping the State Council to convert the macro-economic mandates to the specific policies and processes by means of socio-engineered constructions, and promoting the public understanding of engineering.
[9]Such a declaration was led by the inception of the Round Table Meeting on November 12, 1997 in Osaka, Japan and subsequent annual meeting with the objective of discussing regional, common, technological issues and providing impartial, balanced advice for continuous progress on engineering technology in East Asia.

In Chinese engineering schools, engineering ethics is approached from two different perspectives: ideological and professional. Ideological engineering ethics is integrated into and functions as part of the obligatory graduate courses in ideology – such as 'Dialectics of Nature' and 'Modern Scientific Revolutions and Marxism' – which aim to assure that engineering students are aware of their socialist obligations. Professional engineering ethics deals more with the challenge of going beyond ideology to create a more independent engineering profession. On the basis of the number of authors contributing to scholarly publications in this area, it is estimated that there are some 20 scholars who currently make professional engineering ethics their primary research focus.

Though most Chinese engineering schools currently adopt the ideological approach to engineering ethics teaching and research, with a significantly larger number of scholars active in this area, there is an emergent shift from the ideological to the professional in engineering schools as diverse as Tsinghua, the Graduate University of Chinese Academy of Science, Zhejiang University, Dalian University of Technology (DUT), Huazhong University of Science and Technology, and Southwest Jiaotong University. In 2007, as a result of efforts by scholars from these schools, the Chinese Society for Ethics of Science, Technology, and Engineering (CSESTE) – the first Chinese academic organization on engineering ethics – was established at DUT and Wang Qian (from the Department of Philosophy at DUT) was elected its first president. The following more extended analysis grows out of personal involvement in CSESTE and work with Professor Wang Qian.

Traditional background

The contemporary, modern Chinese context cannot be fully understood without some appreciation, however, simplified, of the traditional background. In Chinese, as in English, there is an important but loose distinction between 'technology' or *jì shù* (技术) and 'engineering' or *gong cheng* (工程). Chinese attitudes toward technology in relation to machines, alchemy, and agriculture have been examined at length by Mitsukuni Yoshida,[10] but no similar analysis exists for engineering. The components of *gong cheng* appear in the Chinese classics[11] with somewhat different meanings than in the contemporary compound. The point here was recognized even by Joseph Needham, the first European scholar to pay serious and sustained attention to the history of science and technology in China. In his influential but controversial *Science and Civilisation in China*, Needham acknowledges an etymological complication in the following passage:

> A few words many not be out of place here regarding the origins of the terms used for engineers in Western languages and in Chinese. To our minds, the word 'engine' has come to have so vivid and precise a meaning that it is hard at first to remember that it derives from that quality of cleverness or ingenuity which is (or was thought to be) inborn in certain people – 'ingenium', indwelling genius, innerly generated. Since derivatives of these roots were already in common Roman use for expressing qualities of wit, craft and skill, it is not surprising that 'ingeniarius', as a term in the more restricted

[10]Mitukuni, "The Chinese Concept of Technology," 1979.

[11]Broadly speaking, the Chinese classics refer to the texts written in vernacular Chinese or in classical Chinese which existed before 1912 when the last imperial Chinese dynasty, the Qing dynasty (1616 CE-1912 CE), fell.

> sense, is found in Europe with increasing frequency from the + 12th century onwards. Not till the + 18th was it freed from its primary military connotation. The course of events in China was not quite parallel with this.[12]

Of the two *han* zi (Chinese characters) that compose the Chinese term, the first (*gong*) originally indicated technical or craft work as opposed to agricultural work, the second (*cheng*) meant measurement, quantity, rule, and related notions. By contrast, the first of *han zi* of *jì shù* refers to 'skill' of any kind, including agricultural work; the second simply means 'method'; and the combination is quite ancient. In the case of *gong cheng*, however, the combination of these two *han zi* occurs no earlier than the Song dynasty (c. 1060 CE),[13] and at first only in a kind of metaphorical abstraction to mean something like the degree to which a technical project has been completed, especially in reference to such structures as religious temples, government offices, canals, ramparts, bridges, and houses.[14] The path from this early meaning to the modern sense of engineering as involving a scientific control of nature is long, complex, and difficult to describe in English, because the kinds of transitions typical of Chinese thought are not the same as those common in the West. One influential factor, for instance, has been the strong poetic tendency in Chinese to let an individual name stand for the species, as when the words *jī* (loom) and *dian* (lightning) come to indicate all mechanical and electrical devices, respectively. Another factor has been visual, as when the traditional term for artisan, *jiang*, was written as the technical work character, which also looks like a tool, placed inside what appears to be a carpenter's square (匠).

Another significant aspect of *gong cheng* is, as Needham suggests, the absence of any military associations. In European languages (both Romance and Germanic) the various cognates of 'engineer' up through the 1600s named special kinds of soldiers. So much was this the case that 'civil engineering' had to be created as a term that could reference engineering practice outside the military context, and histories of modern engineering regularly begin with examinations of the military manifestations of engineering in the design and operation of fortifications and 'engines of war' such as battering rams and artillery, before turning to non-military expressions.[15] By contrast, Needhman's study deals first and at length with civil engineering, and when it turns to practices in a military context (in volume 5, part 6) even uses a different term, 'military technology'. The civilian orientation of all technology is, in fact, an ethical principle articulated as early as the fifth century BCE when Mozi, the founder of Mohism,[16] 'opposed the use of technology to wage unjust wars and to produce curios for the court'.[17]

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[12]Needham and Wang, *Science and Civilization in China*, 1965, p. 9.

[13]CE stands for Common Era, as is a non-sectarian replacement for AD (Anno Domini, In the Year of Our Lord) that is standard in Western as well as Chinese scholarship. It is, for instance, recommended by the *Chicago Manual of Style*.

[14]Yang and Xu, "Gong cheng fan chou yan bian kao lue" [Evolution of the Concept of Engineering], 2002.

[15]Mitcham, *Thinking through Technology*, 1994.

[16]Mohism was one of the four main philosophic schools (the other three were Confucianism, Daoism, and Legalism) during the Spring and Autumn Period (770 BCE to 480 BCE) and the Warring States Period (479 BCE to 221 BCE). It was considered as the early premodern form of science and engineering society and a major rival to Confucianism with its emphasis on the principle of "inclusive love."

[17]Yin and Li, "Chinese Perspective," 2005.

Given its civilian foundations and orientations, *gong cheng* implicitly incorporates civilian values and the promotion of public benefit. Such values and benefit will, of course, be conceived from distinctly traditional Chinese perspectives such as those associated with Daoism, Confucianism, and Buddhism, in which *dao* (sometimes translated as 'way' or 'nature') and *he* (harmony) play central roles. Traditional values are not those of modern efficiency and power so much as living in harmony with the way or nature of reality. The British scholar Angus C. Graham, for example, calls ancient philosophers 'the Disputers of Dao' or the meaning of the natural way.[18] The concepts of *dao* and *he* are especially important in Chinese thinking about engineering ethics, as will be discussed further below.

Using the term *gong cheng* to reference engineering in the distinctly modern Chinese sense – involving the scientific control of nature – was strongly influenced by the work of Christian missionaries and associates in their translations of western texts as part of their efforts to modernize China.[19] As a result of the modernist movement – as it also developed among Chinese literati in the late 1800s and early 1900s – *gong cheng* came to be understood as engineering in distinctly contemporary senses. In current parlance it is now possible even to refer to 'social *gong cheng*', which means something like 'social engineering' or the management of human affairs.[20]

Thus premodern or traditional *gong cheng* engaged ethics in two important respects. First, as already suggested, *gong cheng* is easily assessed not only in regard to its power to transform the physical world but also in terms of its social and human influences. According to Confucians, technical projects should not only advance social welfare at the material level, but promote moral education. Traditional *gong cheng* artisans also possessed a pre-professional ethics, such as *wu le gong ming* (engrave artisan name products), which obligated them to carve their names on artifacts and thus take a kind of personal responsibility for them.

Second, there is a moral tension between traditional *gong cheng* and other cultural ideals. A story from the *Zhuang zi* (during the Warring States period, c. 300s BCE) dramatically illustrates such a tension. According to this story, a disciple of Confucius was returning home after some travels when he saw an old man performing the hard labor of taking water from a well and carrying it in a jug to irrigate his garden. The disciple said to 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 disciple to describe the machine and was told about the shadoof, which consists of a lever rotating on a pole with a bucket suspended at the shorter length, while a user operates from the longer length, thus employing mechanical advantage. The old man responded,

> I heard from my teacher that where there are mechanical (*ji*) 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

[18] Yu, *The Ethics of Confucius and Aristotle*, 2007, p. 28.
[19] For useful references to this work, see Elman, *On Their Own Terms*, 2005.
[20] As an aside, it is interesting to note that in China it is more common to talk about the "management" of human affairs and social institutions, as well as technology and engineering, than their "governance."

unsetttled spiritual life. I am not ignorant of your contraption but would be embarrassed to use it.[21]

The disciple was impressed with the moral rectitude of the old man, but when he described the encounter to Confucius, the master was less edified. According to *Zhuang zi*, Confucius observed that 'for those who pursue only their inner life and inner truth' the old man's response to the shadoof may 'seem reasonable'. But along with their inner lives, human beings must live and 'have a relationship with the outer world'. In this sense, Confucius emphasized, the old man 'knows only one side of the truth'.[22] This story illustrates a moderately qualified moral skepticism in 'feudal'[23] Chinese culture regarding the use of technology, a skepticism well summarized in an encyclopedia entry on 'Science and Technology' by Robin Yates.[24] This skepticism is similar to one that Mitcham finds in premodern European philosophy.[25] At the same time, unlike the West, Chinese culture has been relatively tolerant of science and technology. In Chinese history, there is nothing like the trial of Galileo Galilei, the rejection of evolution, or protests against artificial contraception, except during the aberration of the Culture Revolution.[26]

To summarize, the traditional background of Chinese culture and ethical attitudes toward engineering and technology emphasizes civilian values more than power and control. Primary among these civilian values are the ideals of harmony and the *dao* or natural way of things. Traditional *gong cheng* is similar to handicraft technology that aims to reflect or cultivate nature more than dominate it.

Modernizing transformation

For something like 2000 years (roughly from 900 BCE to 1920 CE), China exhibited a significant level of cultural stability – much more so than was the case in Europe or North America. Although individuals would naturally have experienced some dislocations, if someone who had grown up in Beijing during the late Han were suddenly transported to Beijing in 1900, that person would not have felt wholly disoriented. The language, both spoken and written, would have been the same; the architecture would have been familiar; and the imperial form of government would still be in place. By contrast, any time traveler from 100 CE London to 1900 London would have found him or herself wholly lost. The language would not be understandable, the architecture wholly different, and the form of government incomprehensible. Indeed, it is because of this cultural stability and resistance to change that China in 1900 could still have been described as 'feudal' in a cultural sense and that the project of modernization was experienced by those who undertook it as working both within and against literally thousands of years of tradition. The jump from Confucius to Sun Yat-Sen is nowhere nearly analogous to a leap from the

[21]My adapted translation, *Zhuang zi*, chapter 12.
[22]My adapted translation, *Zhuang zi*, chapter 12.
[23]The word "feudal" here is a technical term in Marxist historiography, referring to a pre-capitalist economic system and its associated cultural formations in which the ruling class, through its control of arable land, dominates a majority of peasant farmers.
[24]Yates, "Science and Technology," 2003.
[25]Mitcham, *Thinking through Technology*, 1994.
[26]Yin and Li, "Chinese Perspective," 2005, p. 320.

pre-Christian thought dominated early Roman England to that of Edwardian England.

It was thus within and in opposition to a deeply entrenched feudal suspicion of technology and engineering that the modernist movement in China and eventually the Communist Party of China (CPC) promoted the contemporary concept of *gong cheng*. The Xinhai Revolution and fall of the Qing dynasty in 1911 followed by establishment of the Republic of China in 1912 set the stage for the creation that same year of two professional organizations, the Chinese Engineering Society and the Engineer's Society of Beijing, which were united in 1931 as the Chinese Institute of Engineers. (In both cases *gong cheng* was used in the names.) The May Fourth (1919) movement further stressed the importance of science and technology. In the 1920s and 1930s in a semi-colonial and semi-feudal society it was common for Chinese who had received engineering educations in Europe or the United States to return to China and join the CPC, as was the case with Zhou Enlai (1898–1976), Liu Shaoqi (1898–1969), and Deng Xiaoping (1904–1997), all of whom became major figures in the People's Republic of China (PRC). With the declaration of the PRC in 1949, the government initially emphasized science, technology, and engineering as means to transform and modernize a residually feudal society and develop the country. The equivalent of engineering ethics at the time was to be *you hong you zhuan* (both red and expert), which meant that scientists and engineers were required to be not only properly ideologically minded but also professionally competent. The professional ethics of engineers was thereby identified with ideological loyalty to socialism and the practice of collectivism in their working relationships. Technical competence, in order to contribute effectively to rational goals, was an ethical ideal.

This new communist ethics of engineering – which at the same time echoed the traditional Confucian subordination of technology to the social good – is implied in a number of statements in *Quotations from Chairman Mao Zedong* (1964, known in the West as the 'Little Red Book'). For example, chapter 3, 'Socialism and Communism', includes the following quotation from Mao's 'Speech at the Supreme State Conference' (January 25, 1956):

> Socialist revolution aims at liberating the productive forces. The change-over from individual to socialist, collective ownership in agriculture and handicrafts (手工业, *shou gong ye*) and from capitalist to socialist ownership in private industry and commerce (私营工商业, *si ying gong shang ye*) is bound to bring about a tremendous liberation of the productive forces (生产力, *sheng chan li*). Thus the social conditions are being created for a tremendous expansion of industrial and agricultural production.

During this same period, studies of the development of science and engineering in China were of increasing interest in the United States, partly as a result of fear of military advances – a fear that would only become more pronounced after China exploded its first atomic bomb in 1964. At the same time western studies generally recognized the distinctive Chinese Communist science and engineering policy perspective. For instance, according to a major symposium on 'Sciences in Communist China', organized at the December 1960 Annual Meeting of the American Association for the Advancement of Science:

> [T]he leaders of Communist China until 1956 left to the scientists the responsibility for governing their own professional activities .... At the inaugural meeting [of a reorganized Academy of Sciences in 1955] Vice Premier Ch'en Yi [Chen Yi] asked the

> scientists 'to use their own labor and wisdom' to meet the needs of the State and the requirements of science. This idea had been endorsed earlier by the Party paper, *Jen Min Jih Pao* [*Ren min ri bao*], which had asked for recognition that 'scientific workers have their own mission, which is to conduct research.[27]

This perspective was confirmed by the Eighth Party Congress of September 1956, in the words of Yu Guanyuan, the head of the Science Division of the Propaganda Department of the Central Committee of the Party:

> In leading scientific work, the Party should rely on scientists to the fullest extent. Modern sciences are finely divided into various fields. Only the specialist knows the fine points of a certain field of science. When we have scientific problems, we must learn humbly from specialists.[28]

During the Great Leap Forward (1958 CE to 1961 CE) and even more during the Cultural Revolution (1966 CE to 1976 CE), this policy of respect for the autonomy of scientists and engineers was subverted. During the Great Leap Forward there existed a kind of irrationalism that promoted will over intelligence. Just working hard was supposed to lead to success; backyard furnaces would compete with heavy industrial steel mills. In fact, to meet production demands, peasants simply melted down any scrap metal they could find, including ancient casting of pots and bells.

During the Cultural Revolution, any explicit discussion of ethics was rejected, perhaps because ethics (as least in the western sense) could readily be interpreted as a form of bourgeois or capitalist counter-revolutionary tendencies. All intellectual discussions were shut down in the name of ideological purity and political action. Many intellectuals, including many engineers (even Deng Jiaxian, the 'father' of the Chinese atomic bomb) were criticized and denounced by the Red Guards (*hong wei bing*) or sent to the countryside to 'learn from the peasants'. According to one study, in 1965, prior to the outbreak of the Cultural Revolution, the PRC had 434 colleges and universities; as a result of the Cultural Revolution at least 106 of these were simply closed and enrollment in others was severely reduced. Only after the death of Mao and the 'crushing of the 'Gang of Four' in October 1976 [was] higher education [able to enter] a new period of development'.[29]

Following the rejection of the Cultural Revolution in the Eleventh Party Congress (which began in 1977) and the rehabilitation of Deng Xiaoping, who became the new leader of China, the universities were reopened and a new impetus was given to scientific and technical education. Indeed, as part of Deng's call for 'reform and opening-up' at the Third Plenary Session of the Eleventh Party Congress in late 1978, dedication to science and engineering were explicitly recognized as key contributors to economic development and declared activities to be promoted.

Earlier that same year Deng had also encouraged some scientists and engineers to establish the Chinese Society for Dialectics of Nature (CSDN). The name was derived from an attempt by Friedrich Engels, in an incomplete and posthumously published work titled the *Dialectics of Nature* (written 1883, published 1925), to

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[27] Lindbeck, "Organization and Development of Science," 1961, pp. 23–24.
[28] Lindbeck, "Organization and Development of Science," 1961, p. 24.
[29] Chu, "Project Report," 2007, p. 3.

create a Marxist philosophy of science. CSDN and its *Journal of Dialectics of Nature* (1978-present) became the leading academic vehicles devoted to the philosophy of science and technology in China. 'One of the main purposes of the Chinese Society for Dialectics of Nature is to advance intellectual cooperation among philosophers, scientists, and engineers'.[30]

In this context 'dialectics of nature' refers less to some dialectical process in nature (Engels' theme) than to the dialectical character of discussions about nature, that is, to the way change takes place in science. In this context, Chinese scholars began to reflect on the roles of science and technology, including engineering as a technology central to economic development, and explicitly to consider some of the unintended negative consequences for human beings in the form of alienation and for nature in the form of pollution. Within this context as well, scholars began to turn their attention to the ethics of science, technology, engineering, and medicine.

In the late 1990s and early 2000s the concepts of sustainable development and social harmony also became focuses of discourse. In November 2004, for instance, the CAE, together with other two academies of engineering from Japan and South Korea, issued a 'Declaration on Engineering Ethics' that included the 'Asian Engineers' Guideline of Ethics'. This guideline emphasized 'cherishing the Asian cultural heritage of harmonious living with neighboring people and nature'.[31] At the same time it committed engineers to the very modern western ideal of making 'decisions consistent with the safety, health, and welfare of the public'. Thus it highlighted a dialogue between traditionalism and modernism in efforts to formulate principles for engineering ethics in a Chinese context.

From science, technology, and society to engineering studies

The immediate precursor to engineering ethics studies in China was the emergence of science, technology, and society (STS) studies. STS studies in turn were strongly influenced by visits to the United States by two Chinese scholars, Yin Dengxian and Li Bocong. During the Spring semester of 1990 Yin, a researcher in the Chinese Academy of Social Sciences (CASS), was a visiting scholar at Lehigh University, Pennsylvania State University, and the University of Pittsburgh, where he undertook research on STS and the philosophy of science and technology. During the Spring semester of 1995 Li, who was based in the Chinese Academy of Sciences (CAS), served as a visiting researcher at Lehigh University and also participated that Summer in the biannual meeting of the Society for Philosophy and Technology, held at Hofstra University in New York.

One result of Yin's research was to arrange for a week-long series of lectures by Stephen H. Cutcliffe and Carl Mitcham in 1992 on STS at CASS. In these lectures, Cutcliffe emphasized the role of the history of technology in STS studies and Mitcham the importance of the philosophy and ethics of technology. Collateral with their visit, the *Journal of Dialectics of Nature* devoted a special issue (supplement no.1, 1992) to STS issues. Subsequently Yin (with assistance from Cao Nanyang) translated into Chinese an introduction to the philosophy of technology by

[30]Li, "STS in China," 1995, p. 2.
[31]The Chinese Academy of Engineering et al., *Asian Engineers' Guidelines of Ethics*, Nov. 1, 2004.

Mitcham,[32] a text that included a short section on engineering ethics. Yin also edited an extended series of publications on STS to which he contributed more than one volume.

After his contacts with Chinese scholars, Cutcliffe wrote an insightful summary that called for increased attention to STS studies in China,

> At numerous Chinese universities, as well as the Graduate School of the Chinese Academy of Sciences and the Chinese Academy of Social Sciences, there are whole departments and programs devoted to STS research and education. Here one finds that the boundaries between academic research, teaching, and economic policy and planning are somewhat blurred, but it is a good example of mixing STS theory with an applied focus.[33]

To some extent, the 'blurred' character of STS in China refers to its interdisciplinary features. Due to its dynamic state and 'applied focus', Chinese STS attracts more attention to the social as well as ethical outcomes of technology rather than pursuing a more strictly descriptive approach. As Yin summarized them, the primary objectives of STS education in China are:

> (a) to unite scientists and philosophers of nature, science, and technology in approaching the ontological, epistemological, methodological, logical and ethical problems in modern science; (b) to increase awareness and knowledge among all citizens of the nature of science and technology, and of their impacts on society; (c) to increase an awareness among scientists and engineers of their work as social processes.[34]

In this way, STS in China has had a strong potential to promote ethical reflection on engineering as a particular technology. Stimulated by such an approach, Li Shixin, one of Yin's graduate students at CASS, became the first person to write a doctoral dissertation on engineering ethics in China. This dissertation was subsequently published as *Gong cheng lun li xue gai lun* (Introduction to Engineering Ethics, 2008).[35]

However, it was Li Bocong who was the first scholar to give engineering a specific status separating it from STS approaches to science, technology, and medicine in his book *Gong cheng zhe xue yin lun* (Introduction to engineering philosophy, 2002),[36] the first book-length attempt to draft an engineering philosophy in China. Li here argued that social problems associated with engineering should be addressed in an interdisciplinary manner denominated 'engineering studies'. In Li's mind, engineering studies not only call for diverse perspectives but require cooperative research networks involving different social and professional groups. In 2007, Li collaborated with two other academicians or research fellows of the Chinese Academy of Engineering (CAE) to edit *Gong cheng zhe xue* (Philosophy of Engineering, 2007)[37] with a publisher that supplies textbooks for engineering schools. The contributors to this book consisted of philosophers, economists, managers, engineers, and policy

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[32]Mitcham, *Ji shu zhe xue gai lun* [Introduction to Philosophy of Technology], 1999.
[33]Cutcliffe, *Ideas, Machines, and Values*, 2000, p. 84.
[34]Yin, "STS Related Education in China," 1991, p. 11.
[35]Li, *Gong cheng lun li xue gai lun* [Introduction to Engineering Ethics], 2008.
[36]Li, *Gong cheng zhe xue yin lun* [Introduction to Engineering Philosophy], 2002.
[37]Yin, Wang, and Li, *Gong cheng zhe xue* [Engineering Philosophy], 2007.

makers who developed the idea of engineering studies. Broader issues included the history, ethics, epistemology, and methodology of engineering and engineering education, as well as case studies in engineering industries and R&D implementation.

Both of Li's efforts stimulated the academic development of engineering ethics. With continuous contributions from philosophers and engineers, by the early 21st century engineering ethics had become a new theme and discipline in China. One key event was the publication of Xiao Ping's book *Gong cheng lun li xue* (Engineering Ethics, 1999).[38] In March 2007, the First National Conference on Engineering Ethics was held in Zhejiang University. In July of the same year, the previously mentioned CSESTE was established at Dalian University of Technology and now serves as an institutional symbol for the official recognition of engineering ethics studies in China.

Also worth noting is the Chinese translations that have been made of two engineering ethics textbooks from the United States. One is *Engineering, Ethics, and Environment* (Vesilind and Gunn, 1999), which was translated as *Gong cheng, lun li yu huan jing;*[39] and the other is *Engineering Ethics: Conceptions and Cases* (3rd) (Harris et al., 2004), which was translated as *Gong cheng lun li: gai nian yu an li.*[40]

Five research frontiers

Against this STS and engineering studies background one may distinguish five overlapping approaches to engineering ethics in China. First is the already mentioned STS studies approach along with that of interdisciplinary studies, both of which undertake broad reflections and attempt to create a new field called engineering studies. A second, more narrow approach focuses on professional ethics, emphasizing professional responsibility and responsible conduct among engineers and polytechnic students by means of ethical education. A third approach is one that views engineering ethics as a version of practical ethics, usually in a phenomenological sense. Fourth, there is the approach of comparative culture studies, which promotes cultural background comparisons, especially on what is distinctive about Chinese engineering in the context of globalization. Finally, there are case studies that analyze ethical conflicts in particular engineering situations.

STS and interdisciplinary studies

Representing the STS and interdisciplinary approach is the Chinese language journal *Gong cheng yan jiu* (*Journal of Engineering Studies*), founded in 2004 by Li Bocong. This journal is not to be confused with the English language *Engineering Studies*, founded in 2009 by Gary Downey and Juan Lucena. In its first issue, *Gong cheng yan jiu* included a programmatic statement by the editors indicating that the journal

> Serves as a forum to promote the study of various practical, theoretical, and historical issues related to engineering. It represents an attempt to understand engineering from diverse viewpoints and approaches, and welcomes contributions from engineers,

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[38]Xiao, *Gong cheng lun li xue* [Engineering Ethics], 1999.
[39]Vesilind and Gunn, *Gong cheng, lun li yu huan jing* [Engineering, Ethics, and Environment], 2003.
[40]Harris et al., *Gong cheng lun li* [Engineering Ethics], 2006.

> philosophers, economists, historians, sociologists, ethicists, entrepreneurs, managers, ecologists, and engineering educational circles.[41]

Here engineering ethics is thus approached from an interdisciplinary perspective. In the first four annual volumes, engineering and ethics are analyzed from multiple perspectives, including history, policy, management, law, literature, design studies, and economics.[42] In 2009 this annual publication became a quarterly and is continuing its interdisciplinary orientation. Again, as an introduction in its first quarterly issue states, this journal continues to focus

> on the following aspects: integrating theory with practice, centering on internal and foreign engineering construction and engineering activities, featuring interdisciplinary, panoramic and advanced theoretical studies, observing the interaction between engineering and society, aiming to study and put across new ideas and developments in engineering science, technology and practice, examining public policies of engineering and innovation from various angles, investigating the complex relationships between engineering and social development, promoting the academic development of related fields, and contributing to the building of a moderately prosperous and harmonious society.[43]

Another example of the STS-interdisciplinary approach involves a Chinese adaptation of the social construction of technology (SCOT) program to engineering ethics. From the SCOT perspective, engineering ethics represents the role of culture in the social shaping of engineering. This is a view taken by Xiao Feng in a Chinese study published in the *Journal of Dialectics of Nature* on the cultural causes of the collapse of the Quebec Bridge in Canada in 1907.[44] Complementing SCOT analysis is the quantitative STS work of the Webometrics, Informetrics, Scientometrics and Econometrics (WISE) laboratory[45] at Dalian University of Technology, which has developed a methodology for literature studies of engineering ethics. This method can create an evolutionary history of various research frontiers or key terms and topics; influential publications and author relations can all be analyzed visually by network graphs.

Professional ethics

Influenced by engineering ethics studies in the United States, professional ethics takes the ethics of engineering to be a required feature of what it means to be an engineer. Additionally, professional engineering ethics is often understood as

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[41]Du and Li, "Juan shou yu" [Inaugural Statement], 2004, p. vi.
[42]In vol. 1, for instance, there is Li Sanhu's article on "Professional Responsibility or Common Values: A Holistic Explication of Engineering Ethics Issues." In vol. 2, Luo Lingling and Wang Jian introduce the methodology of "post occupancy evaluation" into civil engineering design to improve public engagement. In vol. 3, Cui Hailing analyzes the Songhua River water pollution accident mainly from the perspectives of business ethics, organizational studies, and political culture.
[43]Editors, "Fa kan ci" [Foreword], 2009, p.3.
[44]Xiao, "Cong kui bei ke da qiao dao da de wen hua cheng yin kan gong cheng wen hua de jia zhi" [Value of Engineering Culture Viewing from the Cultural Cause of Collapse of Quebec Bridge], 2006.
[45]More information at its official website: http://www.wiselab.cn.

applying general ethical principles in a particular professional context. There are debates about this 'applied ethics' interpretation of professional ethics. Also relevant, however, is a question raised by Michael Davis about whether engineering in China is a profession in the same sense as in the United States.[46] It may be that engineering in the United States is a profession in a different sense than in China, something that any professional ethics would need to take into account.

In order to consider this issue, Cao Nanyan and Su Junbin have investigated the histories of Chinese institutions of registered engineers, their constitutions, and their ethical codes.[47] The Chinese Institute of Engineers (CIE) with a history that goes back to the early 1900s did not originally have a clear ethical code stating the social responsibilities of engineers. But it did possess a strong commitment to both the nation and public in that period of struggle to break free of imperialist exploitation. Engineers saw their social responsibilities as contributing to these struggles. Cao and Su argued that this strongly supports Davis' arguments for rejecting the 'myth' that engineering ethics has developed in a series of stages (from loyalty, through technocracy, to social responsibility).

After studying 15 different institutions of Chinese registered engineers and 45 constitutions of engineering communities, Cao and Su found that engineers today stress 'doing engineering well' rather than 'doing good engineering'. That is, engineers tended to emphasize simply technical competence without serious consideration of whether the projects in which they were involved were really good projects. Most ethical guidance for engineers is assumed to derive from the public, not from within the professional engineering community. Distinctive professional codes for engineers have not yet been formulated and the professionalizing process is still ongoing. A notable exception here is the 'Declaration on Engineering Ethics' (2004).[48] But there also exist some gaps between the development of Chinese engineering and contemporary requirements for ethical consciousness and imagination. In response, several polytechnic universities are now attempting to set up engineering ethics curricula to promote responsible conduct among engineers and polytechnic students.

Practical ethics

In a subtle distinction that may be confusing to those not versed in its use, a distinction is sometimes drawn in philosophy between applied and practical ethics. Simplifying, applied ethics argues that principles are applied in a professional context in a top-down manner; practical ethics argues that ethical reflection in a professional context often requires some revision in ethical principles. There is thus a controversy about whether engineering ethics is best understood in terms of application of principles or a combined practical reinterpretation and utilization of

[46]Davis, "Zhong guo gong cheng zhi ye he yi ke neng" [How is a Profession of Engineering in China Possible], 2008.
[47]Cao and Su, "Zhong guo zhu ce gong cheng shi zhi du he gong cheng she tuan zhang cheng de lun li yi shi kao cha" [Study of Professional Code of Ethics Based on an Investigation into Bylaws of Registered Professional Engineer and Constitution of Engineering Society in China], 2007.
[48]The Chinese Academy of Engineering et al., *Declaration on Engineering Ethics*, Nov. 1, 2004.

principles. This controversy reflects as well a tension between two philosophical methodologies: an applied ethics approach from the Anglo-American tradition and an interpretative or phenomenological-hermeneutic approach found in continental and Marxist traditions. The hermeneutical tradition in philosophy has received increased attention in Chinese philosophy, including Chinese philosophical studies in English.[49] Proponents of hermeneutic-influenced practical ethics argue that culture and history have been altered by engineering, so that ethical problems in engineering cannot be addressed simply by applying ethical theories. Instead, deliberation within engineering by means of what Aristotle termed *phronesis* or practical wisdom is necessary to respond to problems creatively.[50] Applied ethics, even professional engineering ethics, is only a small part of the ethics needed to deal with the challenges raised by engineering.[51]

The emphasis in practical ethics is on problem-oriented situations as well as on the empirical perspectives reflected in the ethics of participants and stakeholders.[52] Ethicists using this approach would like to utilize the practical experiences of communities, in order to promote cooperation and dialogue among participants, social scientists, and humanities scholars. The practical ethics approach maintains that the applied approach is too narrow. Ethical principles must be placed in social-practical contexts that involve complex socio-cultural realities. Practical ethics also encourages importing the discourse ethics of Jürgen Habermas[53] to engineering ethics studies in order to mediate conflicts of interest among different social power groups at particular times and places.

Comparative culture studies

As engineering becomes more international and globalized, it readily encounters cultural communication difficulties and conflicts that go beyond those which occur within any one national or cultural context. In such situations, comparative culture studies may promote better mutual appreciation of different attitudes, thinking modes, ethical codes, and values involved in engineering. Indeed, there are two axes of comparison here: (a) longitudinal comparisons between different cultures in the long history of China, and (b) latitudinal comparisons between Chinese and non-Chinese cultural traditions.

The main task of longitudinal comparisons is to identify sources from the history of technology and culture in order to understand more fully the tensions between traditionalism and modernism. This can at the same time deepen our understanding of the present. But such studies can also search for resources for harmonizing traditionalism and modernism and thus overcoming the opposition. One important contribution to this field is Wang Qian's *Zhong guo ke ji lun li shi gang* (Outline

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[49] Pfister, "Hermeneutics," 2006.
[50] Kong, "Xian dai gong cheng, ze ren lun li yu shi jian zhi hui de xiang du" [Modern Engineering, Ethics of Responsibilities Concerning Engineering and Its Dimension of *phronesis*], 2006.
[51] Zhu, "Gong cheng huo dong de lun li wen ti" [Ethical Problems in Engineering Activities], 2006.
[52] Li, "Guan yu gong cheng lun li xue de ruo gan li lun wen ti" [Some Theoretical Issues in Engineering Ethics], 2006.
[53] Harbermas, *Moral Consciousness and Communicative Action*, 1995.

History of Science and Technology Ethics in China, 2006).[54] In this book, Wang conceptualizes and compares many sets of technical practices and places them in a cultural and historico-analytic framework. Such an analysis is valuable for interpreting the ethical issues in engineering industries today. The central argument is that the relationship in Chinese cultural history between *dao* and *shu* (术, meaning literally method, skill, or art) is fundamental to understanding unharmonious tensions among technological advancements, the market economy, and public welfare in debates between traditionalism and modernism.

The main task of latitudinal comparisons is to interpret why in different value systems people would have different moral assessments of engineering design and structures. One contribution to this approach is a paper by Wang Qian and Zhu Qin on '*Dao* and *Phronesis*: Comparing Approaches to Ethics and Technology'.[55] Wang and Zhu argued that faced with challenges from unpredictable risks in the complex engineered world, new moral situations should be approached with the flexibility and moderation associated with Daoism and neo-Aristotelism rather than rule-based ethical theories.

However, both axes of comparison are not always fully differentiated. Instead, they illustrate a spectrum of approaches to examining historical-cultural backgrounds in engineering. Only the integration of longitudinal and latitudinal studies can be truly effective in contributing to a harmonization between modern engineering and traditional attitudes.

Case studies

The case studies approach has flourished for three reasons. First, case studies are popular in ethics education, especially applied ethics in the West. Second, China is the site of many engineering projects that can be the subject of useful and informative case analyses. Third, case studies in China provide good vehicles for engineers and other groups to take part in discussions of engineering ethics on the basis of their personal experiences, in ways that can also enhance their skills in ethical thinking. Following examples from the United States, Chinese textbooks include studies of such cases as the *Challenger* shuttle disaster and the Chernobyl nuclear accident.

Complementing their reports on North American and European cases, Chinese scholars have identified some typical cases in their own society and history. Examples include the Sanmenxia Dam on the Yellow River and the Three Gorges Dam on the Yangtze River.[56] All such cases involve extensive and ongoing dialogues among different social groups. Most governors, scientists, engineers, and managers are largely optimistic about the electrical production from dams as a means to address energy shortages. Environmental activists from NGOs criticize the dams for upsetting local traditional cultures, relocating many people, and destroying the

[54]Wang, *Zhong guo ke ji lun li shi gang* [Outline History of Science and Technology Ethics in China], 2006.
[55]Wang and Zhu, "*Dao* and *Phronesis*," 2009.
[56]Heated debates and controversies around these cases mainly could be found at the website of the "New Threads" (http://www.xys.org) — a renowned open and public forum on scientific misconduct, science communication, and public participation of science. Other references may also be found from a Chinese quarterly, *Journal of Engineering Studies*, edited by Li Bocong.

natural environment. However, activists are accused of lacking a scientific basis for their criticisms by scientists and engineers insofar as they appeal mostly to philosophy, literature, history, and esthetics.

Case studies also reveal that affected communities are probably the most marginalized groups from these policy discourses. On one hand, people living by the dams are poor and lacking industries, with dam construction being a fast way for them to live better. On the other, since there are many natural resources and historical-cultural antiquities around the dams, the local people are living in environments that conserve and develop their experiences, customs, etiquette, and other forms of 'local knowledge'.[57] To abandon traditional cultures while improving local economies or to remain poor with a cultural heritage is a tough choice that many local communities now confront. All such discussions obviously project the need for dialogue, including dialogue between traditional and modern values. Case studies can form the basis for public deliberations, in which different social groups – not only engineers and scientists, but also critics, social activists, government officials, and others – discuss these tensions and try to promote democratic decision making with regard to large engineering projects.

Challenges

Against the background of the preceding mapping oriented primarily toward non-Chinese scholars, the concluding section of this paper is addressed more to Chinese scholars, arguing a need to push engineering ethics thinking further than has yet been done. Both engineering and engineering ethics studies in China reflect the historico-cultural context in which they developed. In the late 1800s and early 1900s, under the influence of western engineering books translated by missionaries, engineering came to be written with Chinese characters, and ethical reflections on engineering evolved in a tension between traditionalism and modernism. This development may be given schematic summary in Table 2:

As this simplified summary indicates, especially during the last six decades, China has been confronted with challenges and opportunities as never before. Drawing on resources from China's long cultural history, reconstructing the Marxist social criticism of technology, and learning from European and North American intellectuals, five different research approaches have emerged in contemporary Chinese discussions of engineering and ethics. Interactions have also occurred among these overlapping approaches to create a multitude of potential new discussions. How can science, technology, and engineering best contribute to enhancing Chinese ways of life? What is the most ethical way to deal with the social and environmental problems that often arise from technological and engineered change? How can we avoid engineering mistakes while promoting Chinese economic development?

[57]An appropriate example is the long-term controversy around constructing a dam on the Nujiang River. The people who live by Nujiang River are national minorities who want to preserve both the natural (biodiversity and natural ecology) and human (ethnic rituals, customs, etiquettes, and relations with natural world) environments as their living conditions. In contrast, engineers are optimistic about the outcomes of constructing the dam which they think will improve residents' economy and address the national natural resources challenges. Furthermore, political activists argue that the fundamental concern is the will of local residents, that is, whether they are happy to be immigrants within their own country.

Table 2. The historical development of ethical reflections on engineering.

Historical stage	Ethical perspective
Feudal society (until 1800s)	Traditional ethical value systems. Pre-professional ethics
Semi-colonial and semi-feudal society (1800s–1949)	Patriotism; "engineering could be helpful for making China strong and fighting off aggressors".
Early stage of People's Republic of China (1949–1958)	*You hong you zhuan* (both red and expert)
The Great Leap Forward (1958–1961)	Technological irrationalism; *Ren you duo da dan, di you duo da chan* (The more courage one has, the more productivity the earth will give him).
Cultural Revolution (1966–1976)	Explicit discussion of ethics rejected as a form of bourgeois or capitalist counter-revolutionary tendencies
Early stage of reform and opening-up (1976–1992)	*Fa zhan cai shi ying dao li* (Development is the first principle); *Ke xue ji shu shi di yi sheng chan li* (Science and technology constitute a primary productive force)
New stage of reform and opening-up (after 1992)	Technological development for "sustainable society"; *Ke xue fa zhan guan* (Scientific outlook on development); *He xie she hui* (Harmonious society)

In all these discussions it is possible to identify persistent tensions between traditionalism and modernism. On the one hand, contemporary engineering cannot ignore culture, and many problems are related to traditional Chinese ways of thinking and living. Engineering ethics in China has roots in its longstanding historical efforts to harmonize life with the *dao*. On the other hand, the metaphysical foundations of modern engineering are based in a scientific epistemology with roots in quite different European ways of thinking and living. Indeed, the current ethical codes of European and North American engineers have sometimes been described as grounded in consequentialist reasoning derived from the moral theory of Jeremy Bentham and other utilitarians or in deontological approaches that can be traced back to Immanuel Kant. Appeals to virtue ethics foundations which, being derived from Aristotle, might have more in common with Confucian ideas of virtue, are perhaps less prevalent, although they exist. By contrast, the challenge of trying to do moral engineering in a Chinese context is defined by an on-going effort to appreciate anew some of the resources of daoist and Confucian thinking and to reapply Marxist ideology in a contemporary context. This effort can be described as involving a dialogue between traditionalism and modernism on three levels: theory, practice, and politics.

(1) On the level of theory, there is a dialogue between *gong cheng* as a traditional Chinese artisan-based form of engineering and modern scientific engineering. Traditional engineering was largely a form of indigenous, tacit knowledge. In this way, technical knowledge was pursued and gained in harmonious processes that involved operators, instruments, and objects. Knowledge transfer took place between masters and apprentices (often male relatives) in ways that some Chinese scholars have interpreted as a form of intellectual property protection. In contrast to such a traditional production and management of technical knowledge, modern engineering is a form of technoscience. Some master-apprentice relations remain in technoscientific engineering practice, but their importance has diminished. Tacit

knowledge has been marginalized in favor of knowledge learned in formal classrooms and from books.

Such reconstructions have involved two kinds of dialogues: between skilled artisans and modern engineers and between human experience and experience mediated or transformed by scientific instruments. In theoretical discussions, as a result, questions sometimes occur concerning which kinds of knowledge are more reliable. More specifically, in some local engineering context, which is to be given the greater weight: the skilled artisans' long years of personal experience or engineering knowledge based on science and mediated by instruments?

(2) On the level of practice, dialogues occur between implicit, pre-professional codes of behavior and modern professional engineering ethics codes. Before modern engineering had been introduced into China, pre-professional ethics was embedded in artisans' activities. Especially after the Song dynasty (960 CE to 1279 CE), consumer goods production involved quality problems such as counterfeits. In order to guarantee production quality, the *wu le gong ming* (engrave artisan names on products) code was developed that encouraged artisans to take responsibility for their work and enabled consumers to identify those who made defective goods. Today the complex dynamics of modern engineering and associated divisions make *wu le gong ming* practice incompletely effective and no longer possible. Efforts to replace *wu le gong ming* with the socialist morality of *you hong you zhuan* or *ren you duo da den, di you duo da chan* have also proved inadequate. In the transition from artisan responsibility to mass production there seems to be a need for some kind of government regulation to avoid issues such as the 'tainted milk' problem of 2008 and similar cases.

Any system of institutional regulation must depend to some extent on standards of engineering practice that stress professional competence and the avoidance of conflicts of interest, as these have been articulated especially in North American codes. To some extent Chinese engineering illustrates what the philosopher John Dewey (who spent a number of years in China, precisely during the period in which interest was growing in modern engineering) called 'cultural lag' in its slowness to adopt such codes. At the same time, it is appropriate that Chinese engineers should also reflect on the extent to which daoist and Confucian ethical traditions could serve as a basis for an appropriately Chinese version of engineering ethics that would not simply adopt or imitate western models. There is a wealth of literature emerging in Europe and North America that could contribute to such reflection.[58]

(3) On the level of politics, the problem of cultural lag is perhaps less present than at the levels of theory and practice, and China might even be described as a leader. For instance, it can be argued that China has invested fewer resources in military weapons engineering and is making more of a political commitment to renewable energy engineering than the United States and many European countries. In part this may be attributed to the previously noted historical fact that in Chinese culture *gong cheng* was not directly associated with the military or pursed as a means to conquer nature, but has consistently been pursued within the framework of the ideal of harmonizing 'relations' in accordance with *dao*. Any *dao*-orientation includes relations not only between nature and society but also between the Chinese people and others.

[58]Three useful representatives of this literature are Stephen C. Angle's *Sagehood: The Contemporary Siginificance of Neo-Confucian Philosophy* (2009) and Donald J. Munro's *A Chinese Ethics for the New Century* (2005) and *Ethics in Action: Workable Guidelines for Private and Public Choices* (2008).

Furthermore, from the perspective of Confucianism, *gong cheng* must include an aspect of moral cultivation. From the Qin dynasty (third century BCE) to the Tang (10th century CE) there existed an explicit moral culture related to technical productions called *yi she* (anti-luxury or restrain extravagance). The Confucian tradition manifests a strong criticism of the pursuit of wealth and luxury goods, a criticism that has remained embedded in Chinese culture even to the present, and can be understood as a basis for some of the contemporary criticisms of the pursuit of excessive wealth and an emphasis on consumption in contemporary Chinese society. The subordination of engineering to economic interests has led to the creation both of questionable needs and consumer products. The dialogue between traditionalism and modernism here thus becomes one concerning how to relate traditional Confucian values to engineering of 'appropriate technologies' for the Chinese developing context instead of the engineering of 'extravagant' or 'luxury' goods that do not benefit the majority of the Chinese people.

Finally, there is the political issue of globalization. As engineering becomes more international, ethical problems arise from misunderstandings between different cultures. As emphasized previously in this article, Chinese scholars are increasingly interested in European and North American ideas, and starting to do comparative and collaborative research. We Chinese may need to rethink the Chinese culture in order to address ethical issues associated with engineering more effectively in a globalized world. The philosophy of engineering and studies on engineering ethics in China has a responsibility to think globally and to rethink locally in order to redefine the significances of 'made in China'.

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