Chapter 3
The Rise of Philosophy of Engineering in the East and the West

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Abstract Philosophy of engineering, a new branch of philosophy, came into being both in the East and the West at the beginning of the 21st century. Although Chinese and Western scholars in the field of philosophy of engineering worked independently and did not come into immediate contact with each other during the developing process, they synchronized their steps forward unexpectedly. Their efforts made philosophy of engineering score substantial progress in academic and institutional aspects. Nevertheless, there are still some important problems in philosophy of engineering that need to be worked out. One of the most important problems is whether it is possible and necessary to establish philosophy of engineering. The kernel of this problem is the relationships among science, technology and engineering. This article puts forward the triism or trichotomy on science, technology and engineering. Science, technology, and engineering are three kinds of different activities and have important differentiations. There are many differences between scientific community and engineering community. Engineering is a complex phenomenon and philosophy of engineering is and should be an important branch of philosophy.

3.1 Introduction

Philosophy of engineering is a new branch of philosophy that only recently came into existence. At the end of the 20th century philosophy of science and philosophy of technology became well established. However philosophy of engineering remained in an embryonic stage. In 1991, *Critical Perspectives on Nonacademic Science and Engineering* edited by Paul T. Durbin, was published in USA. This book, in which some authors focused their attention on philosophy of engineering, is an important contribution to philosophy of engineering. It is the fourth volume in

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the series *Research in Technology Studies* edited by Steven L. Goldman and Stephen H. Cutcliffe.

In the foreword of that volume, the series co-editors Goldman and Cutcliffe said, "The resulting collection of essays ranges very widely indeed, from a technical analysis of one facet of engineering reasoning to the politics of design. Taken together, the essays begin to define the parameters of an as yet virtually nonexistent discipline, namely, philosophy of engineering." (Goldman and Cutcliffe 1991, p. 7)

Although several authors of that volume, such as Goldman, Taft H. Broome, Billy T. Koen and Carl Mitcham, fully supported that philosophy of engineering was a new discipline, there were also some others who did not make their attitudes to philosophy of engineering clear.

In the Introduction to the volume, Durbin was skeptical about philosophy of engineering being a new discipline. As the editor of the volume, Durbin prudently avoided using the term of "philosophy of engineering". He wrote, "When I first conceived this project, I had in mind a narrower focus – the so-called R&D community" (Durbin 1991, p. 11). It seemed that he preferred to express the need for a philosophy of R&D rather than the need for a philosophy of engineering.

Taft H. Broome was an active pioneer of philosophy of engineering. In his essay "Bridging Gaps in Philosophy and Engineering", Taft H. Broome mentioned three different modes: philosophy and engineering, philosophy in engineering, and philosophy of engineering. He pointed out that philosophy of engineering was still in its embryonic stage at that time (Broome 1991, pp. 265–267).

In fact, the situation that philosophy of engineering was still in its embryonic stage was also reflected in other authors' attitudes towards the establishment of this new discipline.

At the same time in China, just as in the West, there were also a few Chinese scholars who tried to open up a new academic field: philosophy of engineering. Bo-cong Li submitted a presentation "On Engineering Realism" to an international conference held in Beijing in 1992. In the next year Li revised the paper and published it in *Studies in Dialectics of Nature* (Li Bo-cong 1993).

At the end of the last century, while philosophy of science was centrally situated in the field of philosophy, philosophy of technology, as Pitt (1995), Ihde (1995) and Rapp (1995) pointed out that, was only situated in a marginal region of the field of philosophy. Since some philosophers regarded philosophy of engineering as a part of philosophy of technology, philosophy of engineering was just situated in a marginal region of the marginal region of the field of philosophy.

Goldman considered that engineering was an extremely complex phenomenon that deserved to be studied in its own right. He sighed with emotion, "Today, then, philosophy of science is a fully accepted and highly respected branch of philosophy, while philosophy of engineering carries as much professional distinction as philosophy of parapsychology" (Goldman 1990, p. 140).

These above-mentioned facts showed that philosophy of engineering was not yet formed as a new branch of philosophy until the beginning of the 21st century.

3.2 Substantial Progress of Philosophy of Engineering at the Beginning of the 21st Century

This situation of philosophy of engineering has varied along with the running of times.

At the very beginning of the new millennium, philosophy of engineering emerged as a distinctive discipline of philosophical inquiry in the United States, Britain, Western Europe, as well as in China. The first several years of the 21st century witness the rise of philosophy of engineering both in the East and the West.

Meanwhile, some encouraging progress in the field of philosophy of engineering was made in publications, academic activities and institutions. This progress may be viewed from two aspects, the academic aspect and the institutional aspect.

In the first place, four monographs on philosophy of engineering, which were published one after another from 2002 to 2007, have attracted considerable attention separately in China and the West. Li Bo-cong's *An Introduction to Philosophy of Engineering* was published in China in 2002 (Li Bo-cong 2002). In the next year, Louis L. Bucciarelli's *Engineering Philosophy* came off the press in Europe (Bucciarelli 2003). In 2007 other two monographs, *Philosophy of Engineering* edited by Yin Rui-yu, Wang Ying-luo and Li Bo-cong et al. (Yin Rui-yu et al. 2007b) and *Philosophy in Engineering* edited by Jan F. Frederiksen, Steen. H. Christensen and Jørn Jensen et al., appeared separately in China and Europe (Frederiksen et al. 2007).

Although the titles of above-mentioned books are similar, their contents and target readers are quite different. Besides above-mentioned books, another one on philosophy of engineering has been written by Goldman (2004). The fact that four monographs came out in such a short time certainly marked an important milestone in the development of philosophy of engineering. Besides monographs, two annals, *Engineering Studies* (Du Cheng and Li Bo-cong 2004, 2006, 2007) and *Engineering and Philosophy* (Yin Rui-yu et al. 2007a), appeared in China in succession.

From the point of view of scientific sociology, academic institutions play a very important role in academic progress. In 2003, the Graduate University of Chinese Academy of Sciences established the Research Center for Engineering and Society, which is dedicated to interdisciplinary studies of engineering and do research in the fields of philosophy, sociology and history of engineering. The Research Center has edited and published yearbooks Engineering Studies since 2004.

In May 2004, Chinese Academy of Engineering (CAE) held a workshop on philosophy of engineering Xu Kuang-di, the president of the CAE, addressed at the workshop, and a number of academicians of the CAE and philosophers attended. This event was considered as a milestone in the development of philosophy of engineering in China, because it was the significant prologue to a striking progress of philosophy of engineering in China.

A forum on philosophy of engineering sponsored by the CAE was held in Beijing in December, 2004. Most important of all, the First National Conference on Philosophy of Engineering was held in December 2004 in Beijing, and the Chinese Society for Philosophy of Engineering was formally organized at that conference.

The Second and the Third National Conference on Philosophy of Engineering were held in Shanghai in September 2005 and in Xi'an in July 2007 respectively. They were organized in cooperation with the CAE, and took place jointly with a forum on the frontiers of engineering sponsored by the CAE. The Chinese National Conference on Philosophy of Engineering will be held every two years in the future. The Chinese Society for Philosophy of Engineering has decided to edit the annals *Engineering and Philosophy* every two years.

By and large, tremendous progress is being made in the field of philosophy of engineering in China at the beginning of the 21st century. It is interesting that although Chinese and West scholars in the field of philosophy of engineering did not come into immediate contact with each other during last two decades, they synchronized their steps forward in progress unexpectedly.

In contrast to the humble situation of philosophy of engineering in the last two decades of the 20th century in the West, more and more attention was drawn to the field of philosophy of engineering from the beginning of 21st century. In the first place, the Steering Committee for the Philosophy of Engineering was founded in USA. In 2005, an e-forum on engineering and philosophy was held in UK. In the next year, the first organizational meeting of ETSI (Engineering and Technology Organizational Studies) was held in Illinois, USA.

Surprisingly, in 2007 two series of seminars, spring 2007 seminar series in USA and a philosophy of engineering seminar in UK, and two international conferences on philosophy of engineering, International Research Conference on Occupational Bildung and Philosophy in Engineering held in Denmark in May and WPE-2007 (Workshop on Philosophy & Engineering) in Netherlands in October, were held separately in Europe and in USA.

From the facts above-mentioned it is reasonable to assert that philosophy of engineering is rising in the East and the West at the beginning of the 21st century.

3.3 Trichotomy of Science, Technology and Engineering

In order to open up a new branch of philosophy, philosophy of engineering, we need to answer a crucial question "is it possible and necessary to form a new branch of philosophy: philosophy of engineering?"

In the 20th century, scholars from various countries had much discussion on the mutual relationship among science, technology and engineering. Many scholars claimed that technology is applied science and engineering is applied science too. Under this view that I called monism on science, technology and engineering it is impossible and unnecessary to define philosophy of engineering as well as philosophy of technology as a new branch of philosophy, because both philosophy of technology and philosophy of engineering are only a small part of philosophy of science.

Another view on science, technology and engineering is dualism, under which technology is independent of science and engineering is regarded as a part of technology. Under this dualist view on science, technology and engineering, it is possible and necessary to define philosophy of technology as a new branch of philosophy,

but it is impossible and unnecessary to define philosophy of engineering as a new branch of philosophy.

I put forward a new doctrine called triism or trichotomy on science, technology and engineering (Li Bo-cong 2002, p. 3). On the basis of this triism or trichotomy of science, technology, and engineering, it is natural that not only philosophy of science and philosophy of technology but also philosophy of engineering should come into existence.

In order to express my view on the relations among science, technology, and engineering fully, I coined the term triism according to which science, technology, and engineering are three different kinds of activities (Li Bo-cong 2002, pp. 3–6). Science should not be confused with technology, and technology should not be confused with engineering.

Because technology should not be confused with science, philosophy of technology should be separated from philosophy of science. And for the same reason, philosophy of engineering should be separated from philosophy of science.

It is noticeable that few scholars paid their attention to the discussions on mutual relationship between technology and engineering. But it is a big issue indeed. On one hand, technology and engineering are closely related – there is no engineering without technology and technology can be applied to engineering. On the other hand, they are different – engineering always involves non-technological factors, and is the unity of both technological and non-technological factors. So engineering shouldn't and can't be confused with technology. Engineering activity contains economical factors, management factors, social factors, political factors, ethic factors and psychological factors, besides technological factors. The "non-technological factors" often play a more important role in engineering. Since engineering should not be confused with technology, philosophy of engineering should be separated from philosophy of technology.

In brief, the trichotomy thesis or triism of science, technology and engineering gives a basis for defining a new branch of philosophy, philosophy of engineering.

The differences of science, technology and engineering are in the focus of trichotomy thesis or triism of science, technology and engineering.

The following are some important differentiations among science, technology, and engineering.

(1) Viewed from their content and nature, scientific activity takes discovery as its core, technology activity takes invention as its core, and engineering activity takes making as its core. The thesis that science, technology, and engineering are three different kinds of activities is a fundamental one in the ontology of engineering.
(2) Viewed from their achievements, scientific activity, technological activity, and engineering activity yield three different kinds of achievements. Scientific activity results in academic achievements, or new scientific knowledge, such as new theories, new scientific principles, new scientific concepts, or academic dissertations. Technological activity results in technological achievements, or new technological knowledge, such as a patent for an invention, "know-how", or

blueprints. Engineering activity results in engineering achievements, or material products and material facilities that mean material wealth, such as a power station, a building, a new railway, a new car, or a new computer. Scientific knowledge belongs to all mankind, while technological knowledge, such as patents, belongs to their inventors or a certain company. As to engineering achievements, its nature is not knowledge, but material wealth.

(3) From an epistemological viewpoint, scientific thinking, technological thinking, and engineering thinking are three different thinking styles. Scientific knowledge, technological knowledge, and engineering knowledge are three different kinds of knowledge.
(4) Scientific community, technological community, and engineering community are three kinds of different communities. Scientific community consists of scientists. Technological community consists of inventors, engineers, designers and technicians. However engineering community consists of investors, managers, engineers, workers, and other stakeholders.
(5) Scientific activity, technological activity and engineering activity should be measured by different standards. Scientific standards are different from technological standards, and technological standards are different from engineering standards.
(6) When we study scientific activity, technological activity, and engineering activity, we find that they are quite different in their institutional aspects. Scientific institution, technological institution and engineering institution are three kinds of different institutions. They have different institutional arrangement, institutional environment, operational modes and norms of activities, different evaluating standards and evolutional methods, and different management principles, developing modes and goal orientation.
(7) Scientific culture, technological culture and engineering culture have different contents and characteristics.
(8) In the field of sociology, the problem of public attitude to science and the problem of public attitude to technology have aroused scholars' concerns, but the problem of public attitude to engineering has not aroused scholars' concerns so far.

Emphasizing on differences of science, technology and engineering does not mean that we deny the close relationship among them. On the contrary, the triism or trichotomy of science, technology and engineering gives prominence to problems of transformation from science, such as theoretical principles, into technology, such as patents, and from technology into engineering.

3.4 Scientific Community and Engineering Community

Although the term "scientific community" was not proposed first by Kuhn, it became very popular due to Kuhn's influential work *The Structure of Scientific Revolutions*. We should pay attention to the fact that besides scientific community there are many

other communities. Among various communities in society, engineering community is of an extreme importance. Engineering community is larger than scientific community. Especially, engineering community plays a more important role in society.

While philosophers paid great attention to scientific community, they neglected engineering community nearly completely. However, engineering community should be the focus of attention in the field of philosophy of engineering and sociology of engineering. Scientific community and engineering community are different in their goal orientation and memberships.

Scientific community pursues truth, while engineering community pursues benefits. Scientific community comprises scientists, and engineering community comprises engineers, managers, investors, workers and other stakeholders. There are a lot of important and complex issues about engineering community, such as why different individuals have to form an engineering activity community, such as a firm, how they organize an engineering activity community, and what kinds of relations exist in the engineering activity community, and so on.

The fact that engineering community is an important category both in the field of philosophy of engineering and in the field of sociology of engineering suggests that philosophy of engineering should be closely related to sociology of engineering. In order to enhance the research in the field of philosophy of engineering, we should do sociological research on engineering at the same time.

Engineering community is a very important subject in the field of philosophy of engineering. However it has been totally neglected. It should be noted that we have to pay more attention on the study of engineering community. From the point of view of engineering community, Karl Popper's theory of "three Worlds" has some serious defects.

Popper regarded the third world or World 3 as the essential products of the human mind. From the point of view of philosophy of engineering, in addition to the three worlds proposed by Popper, there should be the fourth world or World 4, which is parallel to World 3 but different from World 3. I regarded world 4 as the essential products of the human body. It is engineering community which creates objects that consists of world 4. While World 3 comprises spiritual products, World 4 comprises material products.

Although both World 1 and World 4 are material worlds, they are qualitatively different. The former is a natural world, and the latter that consists of artifacts, such as power stations, railroads, airlines, computers, and clothes, is a new one created by humans. Basing on philosophy of engineering I would like to develop a new kind of realism, dubbed "engineering realism", In the field of traditional realist philosophy philosophers focus their attention on what reality is, while in the field of philosophy of engineering philosophers focus their attention on why and how engineering reality is created and used by engineering community or human beings.

According to Popper, World 2 refers to human minds, but according to the theory of four Worlds, World 2 refers to engineering community that consists of individuals as the unity of mind and body. Because the real agents in engineering activities are human groups with machines, issues of organizations and institutions become supremely important.

World 4 is qualitatively different from World 3. In contrast to World 3, which does not act on World 1 by itself, World 4 can act on World 1 by itself (Li Bo-cong 2002, pp. 411–430).

3.5 Why Philosophy of Engineering is Important

From discussions above, we can draw a conclusion that we need not only philosophy of science and philosophy of technology, but also philosophy of engineering as well.

Goldman pointed out that philosophers had neglected research on engineering practice for a long time. He said, "[the] Western intellectual tradition displays a clear preference for understanding over doing, for contemplation over operation, for theory over experiment" (Goldman 1990, p. 127). In fact the Chinese intellectual tradition displays a same preference as the Western intellectual tradition does.

Nowadays, a lot of things, including cultural circumstances, engineering practice, philosophical community and engineering community, have been radically changing over time.

Gaps in engineering and philosophy are being filled gradually. We expect that philosophy of engineering will move from a marginal region of the marginal region in the field of philosophy to the central region in the future.

More and more philosophers and engineers have realized that philosophy of engineering is of great importance. Mitcham stated: "Why is philosophy important to engineering? Ultimately and most deeply it is because engineering is philosophy and through philosophy engineering will become more itself" (Mitcham 1998). I entirely agree with this conclusion. In addition to his statement, I'd like to say: "Why is engineering important to philosophy? Ultimately and most deeply it is because philosophy is engineering, and through engineering philosophy will become more itself."

I consider Karl Marx's *Eleventh Feuerbachian Thesis*, "Until now philosophers have only attempted to interpret the world; the point, however, is to change it", as the first principal of philosophy of engineering. Engineering practice is the most important approach for human being to change the natural world. Engineering activity is not only technological activity but also economic activity, political activity, social activity, ethical activity, and so on. Managers, engineers, leaders, researchers of engineering must pay their attention not only to technological aspect of engineering but also its economic aspect, political aspect, social aspect, environmental aspect, and ethical aspect. Both philosophers and sociologists need to focus their attention on these issues.

There are two different opinions about human nature that is the nucleus of philosophy. Many philosophers define human beings as rational animals, but others define human beings, in Benjamin Franklin's words, as tool-making animals.

From the point of view of epistemology, the dictum "Cogito ergo cum" is the basis of philosophy. However from the point of view of philosophy of engineering,

the dictum "I create therefore I am", or "I make therefore I am", is the basis of philosophy (Li Bo-cong 2002, pp. 12–19). I think that philosophy of engineering may not only be a branch of philosophy that is parallel to philosophy of science and philosophy of technology, but also philosophy in itself.

Engineering practice is the direct productive force. In engineering practice people have established not only the relationships between human and nature, but also the relationships between different persons and the relationships between individuals and society. Consequently, there are many important and profound philosophical issues that are related to and get involved with engineering practice.

In fact, philosophy is above all about how to lead a better life with wisdom. The very vitality of philosophy roots deeply in the real world, especially in engineering practices, which are the most elementary and common activity in human society. From such a perspective, wisdom is first of all the wisdom of engaging in engineering activity. It is impossible for human beings to survive and flourish without engineering.

To deal with a lot of issues concerning engineering, philosophy does matter. Under the new historical conditions, philosophers need to build a closer relationship with engineering, to probe into the essence of engineering, and, furthermore, to explore the field of philosophy of engineering and the frontier of philosophical studies. It is through philosophy of engineering that engineering and philosophy can be related more closely.

As a new discipline, philosophy of engineering has opened up unlimited possibilities for us. In order to exploit them effectively, engineers, philosophers, and other people who are interested in studies in that field, need to get involved in a research nexus in which they can learn from each other, exchange ideas rationally and freely, and make further progress in philosophy of engineering.

Considering the relation between philosophy of science and philosophy of engineering, Goldman pointed out, "Philosophy of engineering should be the paradigm for philosophy of science, rather than the reverse" (Goldman 1990, p. 140). I agree with this entirely. It is said that philosophy of science is a discipline that has had a great past. At present it is certain that philosophy of engineering is a discipline that has a glorious future.

Nowadays, philosophy of engineering is situated on a new starting point. Philosophy of engineering is expected to have a glorious future.

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