Scientific Research Publishing

Open Journal of Philosophy, 2024, 14, 71-81
https://www.scirp.org/journal/ojpp
ISSN Online: 2163-9442
ISSN Print: 2163-9434

The Two Kinds of Gongcheng (Engineering) in Chinese: Both on the Basic Categories, Characteristics and Framework of Philosophy of Gongcheng

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How to cite this paper: Liu, H. Y., & Song, Z. Y. (2024). The Two Kinds of Gongcheng (Engineering) in Chinese: Both on the Basic Categories, Characteristics and Framework of Philosophy of Gongcheng. *Open Journal of Philosophy, 14,* 71-81.
https://doi.org/10.4236/ojpp.2024.141006

Received: December 26, 2023
Accepted: January 29, 2024
Published: February 1, 2024

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Abstract

From the perspective of philosophy of engineering in China, this study points out the shortcomings of the category of "Creating" and the role and advantages of the category of "Doing". In this process, two concepts of "engineering" in the Chinese language were discovered. The research further points out that the fundamental characteristic of engineering is "Heavy result", and the basic characteristic is planning, time limit and heterogeneity within the community. However, the accommodation of the two engineering philosophical frameworks remains to be further studied.

Keywords

Philosophy of Engineering, Creating, Doing, Gongcheng

1. Preface

It is difficult to reach a consensus on how to view the activities of understanding and transforming nature in ancient China. When we examine from the perspective of "science", we do not consider it from the perspective of "the study of different disciplines"—the meaning of "science" in Chinese words—but from the perspective of "science" in English, so we will inevitably face an question that impossible cannot be answered: "Did ancient China have science?" or "Is it appropriate to use science to examine the natural research activities of ancient China?" when we use "technology" When examining, it is less bound by a similar frame of mind. However, the lack of humanistic spirit in the value dimension makes us not completely satisfied with this solution. Therefore, the author set

his eyes on "engineering" with anticipation. Because "engineering" avoids the confusion caused by ideas first. Even in analytic philosophy, the field of philosophical methodology of "conceptual engineering" has emerged, although their use of the word "engineering" may be a kind of simulation and metaphor.

From the perspective of historical experience, the reason why China is regarded as a civilization is, to a large extent, built by engineering. Repairing the Great Wall, governing the Yellow River, observing the heavens, teaching the people, and so on, which have become indispensable projects for every unified Chinese empire. If there was no engineering in ancient China, it would be in vain to ignore historical facts. The problem is that before using the program of "engineering" to examine the activities of understanding and transforming nature in ancient China, we need to clarify a fundamental question: what is engineering?

At the beginning of the 21st century, the philosophy of engineering emerged in Chinese philosophy and Western philosophy, marked by Li (2002) *Introduction to Engineering Philosophy: I Create, Therefore I Am* and Bucciarelli's (2003) *Engineering Philosophy*. However, with the further development, exchange and dialogue between Chinese and Western engineering philosophies, it is found that there is a clear difference between the language environment inhabited by Westerners and the language environment inhabited by Chinese, which shows the asymmetry of the meaning of the word engineering in the two contexts (Yin, 2017). The Western understanding of the term engineering focuses on the creation of individual geniuses, such as the drawings of airplanes designed by Leonardo da Vinci, while the Chinese understanding of the term engineering focuses on collective collaborative creation, such as the Great Wall of Qin built by Emperor Qin Shi Huang. When we refer to aircraft drawings and associate them with Leonardo da Vinci, we see Leonardo da Vinci as an outstanding engineer—from the perspective of history of technology, this belongs to internal history, and when we refer to Emperor Qin Shi Huang, he is not like this—what the language actually wants to convey is that the Great Wall was organized and built by the Qin government during the reign of Qin Shi Huang is, of course, external history from the perspective of history of technology. It can be seen that before we want to use the program of "engineering" to examine the artificial activities of transforming nature in ancient China, we need to be clear: in what cultural sense do we talk about "what is engineering"?

"Engineering" in the sense of Western culture was firstly excluded. Firstly, because although China has the richest historical record in the world, there are few, if not none, discussions or controversies about the details of technology and the related issues. Therefore, it is impossible to examine the activities of transforming nature in ancient China from the perspective of the internal history of technology. Secondly, we do not want to return to the "technology" agenda—science, technology and engineering are triadic according to Li Bocong. In the book *Thinking Through Technology: The Road Between Engineering and Philosophy*, Carl Mitcham mentions the rupture between techne in ancient Greece

and technology in modern times, and analyzes the changes in the "conceptual history of technology" or "metaphysics of technology", which implies the meaning of "Technology = Techne + Engineering" (Mitcham, 2008). Therefore, the use of engineering in the sense of Western culture to examine the situation in ancient China will inevitably encounter the dilemma of concept first. And that's exactly what we want to avoid.

However, the adoption of "engineering" in the sense of Chinese culture is not a smooth thing. We must take into account the impact of modern Western learning spreading to the East and the "great changes unseen in 3000 years" on Chinese culture. Similar to the rift between techne and technology in the West, engineering has also undergone such changes in Chinese culture, for example: Chinese will not remember who the engineer who designed and built the Qin Zhidao, but Zhan Tianyou, the engineer who designed and built the Beijing-Zhang Railway, has entered the national memory of the Chinese; the humanistic values associated with the Qin Zhidao lie in the "Great Unification" and "resistance to the Xiongnu", while the Beijing-Zhangjiakou Railway is well-known for its design of figure looked like "人" in Chinese words. We have a vague notion that there are two kinds of "engineering" or "gongcheng" in Chinese language. Therefore, it is necessary to clarify them in the Chinese context.

2. History of Ideas: Gongcheng and Engineering in China

The clarification of the term "engineering" is not an attempt to redefine it. In fact, different dictionaries, books, and articles have different definitions of "engineering", indicating that there is no consensus. We don't want to be one of them. What we want to do is to reveal the two ideas or notions of "engineering" (gongcheng) in Chinese history.

2.1. Version-1 Engineering

"Engineering" or "Science of engineering" is a concept that has spread from the West to the East.

In 1895, the Tianjin Beiyang Western School (i.e. formerly the Bei Yang Da Xue Tang) offered five majors, one of which was science of engineering, which was incorporated into China's formal education. From the very beginning, the content of engineering has been filled with Western science and technology since modern times, until now. Although there were some adjustments during the period, for example, the Chinese Academy of Engineering, as the highest academic institution, has nine faculties, among which the Faculty of Medicine and Health has incorporated traditional Chinese medicine as an important part, and a new Faculty of Engineering Management has been set, etc. All of these have certain national characteristics. But the basic framework of engineering has not changed, it is mainly composed of engineering science and engineering technology.

Here the word gongcheng in its meanings are actually regarded translation as the English word engineering. And the word is generally used as the plural form,

i.e., engineerings. In other words, it refers to a collection of many disciplines of engineering and their knowledge. For example, civil engineering, bioengineering, computer engineering, and many more. There is neither engineering matrix nor such a "first engineering" as metaphysics is to philosophy or physics is to science. It is a general term, a pseudonym, a nominalist concept. We write it down as *Engineering I*.

2.2. Version-2 Gongcheng

The word gongcheng can be traced back to the Warring States period (no later than 251 BC) in *the Gong Ren Cheng* (工人程)—one of the Qin dynasty bamboo slips of the Sleeping Tiger Land. A scholar believe that the sentence reading should be "work + human process", in which people is a measure word, and the lower-class people are used as various measurement methods. The original meaning of worker's process was procedural regulations on work, that is, a separate legal provision for the measurement and conversion of the labor force of workers (Wu, 2021).

In the more than 2000 years that followed, a series of new meanings developed on this basis, but they remained the same. However, if the emphasis is on gong, the general righteousness can be boiled down to: or with the help of tools, or ingenuity, or manpower, or social division of labor; If the emphasis is on cheng, the general meaning can be boiled down to: or as a measure, or as a standard, or as a rule, or as a consideration and evaluation.

In the *Gongcheng Zuofa Zeli* promulgated by the Ministry of Industry of the Qing Dynasty—the last dynasty of ancient China and the eve of modern China, the Lei faDa family of the Qing Dynasty style house and Liu Tingzan and others of the sales and calculation house were all engineers. The role of the implementer who is responsible for the planning, design, management, operation or evaluation of the project is almost the same as that of the engineer in the modern sense (Chen & Sun, 2013). Engineering here has a specific meaning, that is, the conscious organization, management and assessment of manual activities. This gongcheng is referred to as *engineering II*.

There are two versions of Engineering or Gongcheng. And it is precisely because of this that the philosophy of engineering developed in China, which has basically modernized, is so different from the engineering philosophy that has emerged in the West—modern Chinese accept and understand the word engineering from the West, but the influence of ancient engineering concepts makes modern Chinese confused when facing another one. The Chinese school of engineering philosophy is now faced with two paths: either abandon the ancient spirit and completely fall into modern civilization, as the engineering school of the philosophy of technology did, or find its own roots, thus establishing a direct relationship with it, and draw nourishment from it to strengthen itself, as the humanistic school of the philosophy of technology did. We hope, of course, the latter.

3. The Flaws of the Category of "Creating" in Engineering Philosophy of China

According to a certain study of paper, the book Introduction to the Philosophy of Engineering has been cited more than 600 times in China (Hu & Li, 2022). It can be seen that Professor Li Bocong's saying that I create things, therefore I am has been widely circulated as a motto of engineering philosophy. But the term creating is powerful in the distinction between engineering and science, and ambiguity in the distinction between engineering and technology. Because the created thing is an artificial thing, and as he himself said, "technology is used in English to refer to an artificial thing, and the artificial object becomes the 'common object' of the philosophy of technology and the philosophy of engineering." (Li, 2021).

The problem with Chinese engineering philosophy is that, on the one hand, it is influenced by ancient engineering concepts and puts forward the triadism of science, technology and engineering from the perspective of life of Gongcheng, and on the other hand, it is influenced by the modern concept Engineering, and from the perspective of the manufacture of artifacts, it takes "Creating" as the ontological category of philosophy of engineering. This result leads an inconsistency and logical contradiction within the theory, that is, the engineering of creation is inherently anti-trianist. In the following, we will elaborate on the defects in the category of "creation" from the three types of man-made objects.

3.1. Scientific Artifacts

The first is the experimental object, which has distinctive scientific characteristics and can be called a scientific artifact. Two textbook examples can be given here.

One of them is the manufacture of air pumps. In their book Leviathan and the Air Pump, Steven Chapin and Simon Schaefer argue that the manufacture of air pumps involves a struggle for the legitimacy of the experiment itself, which is often seen as an integral part of modern science. In terms of specific content, the manufacture and demonstration of the air pump is an experiment related to the scientific theory of whether there is a vacuum of matter.

The second is the manufacture of oxygen. Although it has been integrated into the increasingly mature and complex industrial production chain of oxygen production in modern times, we can still find it in the most basic laboratory teaching of junior high school chemistry, such as potassium permanganate heating to produce oxygen. This is because the concept of oxygen itself is the product of scientific analysis of the composition of air, and the experiment of producing oxygen is based on the theory of molecular chemical reaction equations.

It can be seen that experimental science is not a simple activity of observation and discovery, but it has produced many artifacts that have not been found in history. This is also an important manifestation of the convergence of contemplation and operation (or scholarly tradition and artisan tradition) in modern

science.

3.2. Technical Artifacts

The second is technical objects, which have distinctive empirical and experimental characteristics, and can be called technical artifacts. From ancient times to the present, there have been many kinds of technology, but they can be roughly divided into two types.

One technology is an improved type. For example, Cai Lun's improved papermaking technology and Cai Hou paper, and Watt's improved steam engine. Because of its far-reaching influence, we often call it a technological invention, but strictly speaking, Caihou paper and watt steam engine are both technical improvements. They don't need to presuppose theories and problems in mechanics, heat, or chemistry in their heads, but rather through intuitive experience, hands-on ability, and wise thinking.

The other type of technology is inventive. Typical inventive technical activities are often closely related to science, and they either take a certain amount of scientific theoretical knowledge as a necessary preparation and premise, such as Edison, who himself understands scientific theories such as electricity and chemistry, and has his own laboratory, and cannot ignore the scientific factors in his invention activities; or in order to be used in a certain process of exploring the unknown after it is made, for example, the large-scale astronomical clock-tower (Shui Yun Yi Xiang Tai) invented and manufactured by Su Song and others in the Song Dynasty is generally regarded as an important instrument for national astronomical observation in the Song Dynasty. However, Jiang Xiaoyuan is inclined to think that it is a simple state ritual and does not have the ability to operate for a long time (Jiang, 2017).

But in general, there is no scientific incentive for technical activity to verify the truth of theories, and its real focus is on the finished products and products that are available for use. Moreover, from the polished stone tools of the primitive period to the modern supercomputers, the scope of technical activities is enormous, and the types of technical products are extremely large, and not many of them have intersections with science. It is clearly inappropriate to use invention as the fundamental nature of technical activity.

3.3. Articfacts of Engineering

Finally, there is the artifacts of engineering, which has a distinct comprehensive characteristic, and can be called gongcheng artificiality. As mentioned above, from the perspective of "manufactural" rather than "social" (e.g., social engineering), we briefly discuss the content of the synthesis of engineering artefacts in the following two aspects.

To start with, from the perspective of the form of engineering artefacts, there are both material and immaterial. Before the advent of computer networks, almost all engineering artifacts only needed to pay attention to their hardware, that is, to pay attention to the structure, materials and wear and tear of engi-

neering objects; when software as a logical product appeared, design defects increasingly became the focus of engineering attention, and how to deal with the degradation and update of software became a new issue. Because they have different failure rate curves (Pressman, 2011). Of course, whether to focus on one or both, depends on the characteristics of the project. Although not all projects are engineering, all gongcheng are project-based in Chinese.

Additionally, from the perspective of the elements of engineering artifacts, engineering artifacts are the product of multiple scientific theories (including engineering science) and various technical analyses (including engineering technologies). We call this process engineering-ing (工程化). Some scholars have proposed that every discipline that can truly be called science has to go through three stages of growth: the first stage is descriptive, the second stage is analytical, and the last stage is engineering-ing (Song, 1997). For example, from classical mechanics, to modern analytical mechanics, to mechanical engineering and bridge engineering, to biology, genetics, bioengineering, and genetic engineering.

However, we can see that the word synthesis does not distinguish between science and technology in category of Creating. Whether it is a material or immaterial product, we can rely on the category of technology to explain, so why we use engineering? Moreover, if engineering science is also a kind of science, then why should we set a philosophy of engineering in addition to the philosophy of science? Occam's razor's motto, do not add substance if it is not necessary, points out to us the weakness of the gongcheng philosophy of Creating.

To sum up, simply using the category of Creating to explain engineering activities is in itself contrary to the triadism of science, technology and engineering proposed by Li Bocong. Not only does Creating fail to distinguish engineering from science and technology, but emphasize the inseparable characteristics between them to some extent.

4. Philosophy in Doing: Basic Characteristics of the Fact of Engineering

4.1. The Coming of Doing and Exiting of Creating

Once engineering is elevated to the object of philosophical research, then it should not be regarded only as a common-sense concept, but should expand its generality and universality in addition to its concreteness and particularity. At the very beginning, creation" was defined by Mr. Li Bocong as an explanation of material engineering or natural engineering, and had nothing to do with "social engineering". Therefore, the category of Creating not only fails to meet the requirements of engineering philosophy in terms of three types of artefacts, but also has obvious limitations as the core category of social engineering.

"If 'social technology is the knowledge system in which people transform the social world, control social relations, and adjust the operation of society', then, from a philosophical point of view, social engineering is the development and application of this knowledge system" (Tian, 2006). In the same way, Hsue-shen

Tsien regarded the technology of organizing and managing the construction of socialism as social engineering (Qian & Wu, 1979). But it is difficult for us to think of an adjusted social relationship as an artificial entity.

Sunny Y. Auyang tried to bridge this gap by introducing organizational techniques. "When it comes to creating technology, engineers aren't just inventing, they're innovating," he said… Innovation, with its broad prospects, requires both technical and social insight (Auyang, 2017). In the case of subway design and construction, for example, engineers need to coordinate among commuters, contractors, drivers, politicians, environmentalists, and various other interest groups involved with them, which inevitably affects the design of the subway system, the layout of stations, and so on. Such a statement is valid. However, there is a lack of further clarification and demarcation at the theoretical level.

Therefore, replacing "Creating" with "Doing" has become a new trend in the ontology research of engineering philosophy. Zhang Yunlong regarded Doing as a superordinate concept of creating engineering and social engineering, with the former encompassing the latter two. "Doing, including personnel and material things, is 'social engineering' and 'creating engineering'" (Zhang, 2022). On July 17, 2022, the Engineering Philosophy Committee organized three academic frontier lectures on the philosophy of engineering with the theme of Doing, marking the consensus reached within the engineering philosophy community on the core category of Doing in China.

4.2. Three Characteristics of Facts of Engineering

If the issue of heavenly workmanship and artificiality (or "God as creator" and "Human as creator") is still related to the perspective of artifact entity, then the artificial characteristics of the project are determined from the perspective of "Doing". And this word artificial is a result-oriented activity. It can be said that focusing on results is the fundamental characteristic of engineering.

According to Aristotle, there are two ways in which things are generated, namely nature and production, and there are two kinds of results produced by production, which are physical objects and states of affairs. He said: "Thought starts from the original, from the form, and production starts from the result of thought." (Aristotle, 2003). In fact, it is from the perspective of results that "technology and engineering" are distinguished from "scientific" activities.

But "results-oriented" has a different meaning in technology and engineering. Technology also focuses on results, but there are also technologies that focus on process, such as game technology (that is, technology attached to games, while games focus on experience and process). Therefore, results-oriented is not the fundamental characteristic of technology, but only the characteristic of a certain part of technology.

From this point of view, in the basic structure of engineering, result occupies an important position. And from this fundamental characteristic, we can deduce two basic characteristics of the project, which are planning and time-bound.

Aristotle's "starting from the results of thought" can be understood into two

parts: one is that in terms of the product of engineering, it necessarily includes the product of thought; and the other is that in terms of engineering activities, man must plan in order to act.

The so-called planning refers to the pre-conception and planning of the purpose, conditions, rationality and other related issues before the project practice activities of the project subject. Western engineering philosophy in particular regards engineering design as an important object of discussion. Liu Guanzhong also proposed that in industrial design, we should change from the way of thinking of "creation" to the way of thinking of "making things", because the purpose of design is neither manufacturing nor circulation, but use (Liu, 2015). The planning of the project includes but is not limited to design. But for the purpose of "using things", they are consistent.

The importance of the result in the work of the project also indicates the constraints specific to the project. In terms of motivation, unit of activity, and way of thinking, these conditions can be summarized as "time-bound" characteristics.

From the perspective of motivation, engineering does not have a never-ending pursuit like science and technology, and every engineering practice is a "new start" in a "special situation", because engineering needs are often different. From the perspective of the activity unit, the project is based on the project, which requires it to complete the pre-planning within the limited time and social resources. Although "post-academic science" also presents the characteristics of "project-based", this is the product of a special stage, and for those original sciences and disruptive technologies, "projects" cannot be regarded as their essential characteristics. From a mindset point of view, engineering does not accept failure. "Trial and error" is not legitimate in engineering thinking. In short, whether it is from the product, the project or the thinking, it can be seen that the finite nature of time has become an important consideration in engineering practice.

In addition, heterogeneity within the engineering community is also one of the basic characteristics of engineering. The "man-made" of engineering does not include all "man-made" activities, it excludes individual and private activities in the first place. Engineering has been a collective human activity from the very beginning, and it often has a certain social public character. To a certain extent, it is also shown that the criterion of "professionalism" gives way to the source of the "purpose-result" consideration in engineering activities.

In his book *Introduction to the Sociology of Engineering*, Li Bocong discussed in detail the various components of the engineering community. He proposed two types of engineering communities: professional community (i.e., engineering community) and "engineering activity community". The latter is fundamental in nature, while the former is a derived sub-community (Li, 2010). This is in stark contrast to the "scientific community". Engineering activities include various types of people, which reflects the heterogeneity within the engineering community.

To sum up, it is appropriate to refer to the general "project" in terms of the ontological category of "doing things". It not only re-establishes the status of the triadism of science, technology and engineering in the fundamental characteristics of "emphasizing results", but also derives the three basic characteristics of engineering: planning, time limit, and heterogeneity within the community. In addition, it is possible to incorporate both "ideological products" and "material products" into the process results. It can be seen that this category has a certain vitality and development prospects.

5. Conclusion

There are two kinds of engineering in Chinese.

"Engineering I." is the "gongcheng" in engineering formed by imitating science in modern times, highlighting its scientific and technical core elements, and considering design as its core work. As Pressman puts it, "The development of the engineering discipline will result in a series of standard design devices." Standard screws and orderable integrated circuits are just two of the thousands of standard devices used by mechanical and electronics engineers when designing new systems. The use of reusable components allows engineers to focus on the truly innovative part of the design, i.e., what is truly new in the design (Pressman, 2011). Western engineering philosophy research is based on this, and some scholars have pointed out its characteristics (Chen & Zhang, 2006).

"Engineering II." is an abstract and constructed "gongcheng" from the history of engineering practice and the analysis of the ancient Chinese word "工程", highlighting its philosophical, general and ontological nature, and taking "community action" as its core work. On this basis, Chinese scholars represented by Li Bocong put forward the basic topics of engineering philosophy, such as the planning of the engineering process, the implementation of the engineering process, the use of materials and life, and the integration of heaven, earth and man (Li, 2002). Moreover, the ontological category of engineering philosophy has undergone a certain development, and has changed from "Creating" to "Doing" at the beginning.

To sum up, the emergence of engineering philosophy in China has a certain inevitability. And it ultimately manifests itself as a "philosophy of engineering"—that is, the study of engineering itself from a philosophical point of view (i.e., Engineering II.), rather than just a "philosophy of science of engineering" (i.e., Engineering I.)—which, like the philosophy of physics, also shows that traditional Chinese culture still has tenacious vitality in the wave of modernization.

Funding

This work was supported by the Project of the Inner Mongolia Program of Philosophy and Social Science Funding [2016NDB074]; Inner Mongolia Normal University First-class Discipline Construction Special Fund Project [3201002201].

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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