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*Original Paper*

# The Application of Exemplarist Moral Theory and Problem-Based Learning in the Course of Structural Mechanics

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**Abstract**

*Structural mechanics is an important basic course for undergraduates majoring in civil engineering. However, due to the difficulty and extent of the content, students are often not able to master the course. Problem-based learning is an excellent way of teaching engineering, and character education can improve students' performance. This study explores the combined application of problem-based learning and exemplarist moral theory. In this model, students analyze the structure and force of buildings, and they learn about the historical stories behind them. In this way, students improve their morality, civility, performance, and intellect. In character education, the use of case studies and examples can increase students' interest in the course, improve classroom participation, enrich teaching connotations, and strengthen students' understanding of basic concepts and their ability to memorize them.*

**Keywords**

*Structural mechanics course, Exemplarist moral theory, Problem-based learning*

## 1. Introduction

Structural mechanics is one of the foundations of courses in civil engineering. It is also an assessment course that forms part of the entrance exam for Chinese graduate students hoping to study civil engineering. After students have understood the mechanical properties of materials, structural mechanics helps them to master the basic concepts and methods involved in the stress analysis of bar system structures. It also helps them to understand the mechanical behaviors of various structures and engage in structural analysis and calculation. It lays the foundation for subsequent professional courses and forms the basis of structural design and scientific research. The course of structural mechanics focuses on logical deduction and mathematics, both of which are difficult. Therefore, students often find the course boring and give up due to a lack of interest. Adding character education into a structural mechanics course would increase students' enthusiasm and attention, make the classroom more lively and interesting, and make the learning process more effective.

Many countries, such as Britain, Canada, Australia, Japan, and Singapore, attach great importance to character education. These countries have conducted a lot of research on this topic (Arthur et al., 2016; Cranston et al., 2010; Jerome & Kisby, 2022; Kristjánsson, 2016; Tan & Tan, 2014). The Jubilee Centre for Character and Viruses at the University of Birmingham plays a leading role in character education in the UK. The Centre argues that good character can be taught and learned (Kristjánsson, 2013). Moreover, Linda Zagzebski's exemplarist moral theory states that people can learn moral character through imitation. Thus, examples can be used as guides for character education (Zagzebski, 2013; Zagzebski, 2017). Meanwhile, MacIntyre argues that a person's morality originates from their unique history, community, and culture; thus, moral inheritance relies on tradition, historical narratives, and a kind of moral genetics (MacIntyre, 1981). Yulianti et al. (2016) included science comic books in the physics curriculum for primary school students, which stimulated students' interest in the subject, increased their academic performance, and improved their personalities. Paul et al. (2020) let junior high school students read and reflect on C. S. Lewis's *The Chronicles of Narnia* series, which had a positive impact on their personality.

There has been a lot of research into character education in primary school and high school, but there has been less research into character education in universities (Novianti, 2017). The effectiveness of character education increases as students get older (Jeynes, 2017). Therefore, character education should be integrated into university curricula (Kuh, 2004). Character education significantly improves students' performance and behavior (Jeynes, 2017). The College Board in the US has argued that the decline in ethical education is one of the main reasons for students' worsening SAT scores (Jeynes, 2003). Hidayati et al. (2020) used local wisdom to introduce character education into university courses and extracted moral and aesthetic value from examples and models. Many teachers are not willing to engage in character education at university (Ryan & Bohlin, 1999; Siegel, 2009). There are two reasons for this. First, many attempts to introduce character education have failed to achieve significant results (Nucci et al., 2014; Siegel, 2009), Second, character education often has little to do with the learning objectives of the course (Francis et al., 2018; Hart, 2022).

Problem-based learning (PBL) has been widely adopted in medical and engineering education (Perrenet et al., 2000; Reeves & Laffey, 1999). Compared with traditional teaching, PBL significantly improves students' understanding of physical concepts (Sahin, 2010) and has a positive impact on their ability to learn in more advanced courses (Polanco et al., 2004). When it comes to character education, PBL enables students to cultivate teamwork and communication skills in a positive learning environment (Macho-Stadler & Jesús Elejalde-García, 2013). In conclusion, PBL plays an important role in improving the effectiveness of teaching, promoting character education, and creating a positive classroom atmosphere.

Character education focuses on students' moral character, civic character, performance character, and intellectual character (Baehr, 2017). Courses in structural mechanics can use the spiritual values and aesthetic accomplishments contained in case studies and examples to conduct character education. This involves influencing students' character through the environment. In this way, students can learn from examples of morality (cooperation and comparison), civility (tolerance, respect, determination, patriotism), behavior (tenacity, self-discipline, resilience, patience, striving, and grit), and intellect (curiosity, open-mindedness, attention, carefulness, and thoroughness.)

This paper summarizes cases where PBL and character education could be combined in a course on structural mechanics. It uses buildings as examples for PBL, encouraging students to learn the stories behind buildings while also analyzing their structure. The rich content of these stories means that the teaching process is natural and not deliberate. Students can immerse themselves in the history of architecture and imagine why and how the buildings were built. Thus, the students have a strong sense of substitution.

Based on the model of exemplarist moral theory, famous civil engineers and mechanics are used as examples for character education. Their valuable qualities (such as their selfless dedication, tenacity, diligence, fighting spirit, patriotism, and craftsmanship) can light up students' lives.

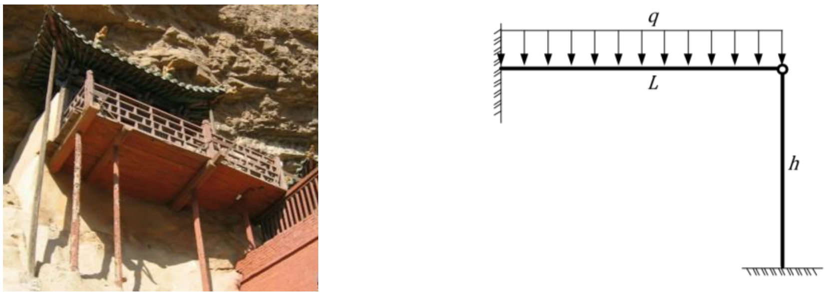
## 2. Problem-Based Learning and Character Education Using Ancient Architecture

Chinese civilization extends back more than 5,000 years (He et al., 2021; Li et al., 2021; Renfrew & Liu, 2018). In Ancient China, in addition to the Great Wall and the Imperial Palace, a large number of beautiful and spectacular buildings were created (Ivashko et al., 2020; Steinhardt, 2019). The building materials used in ancient buildings were very simple: soil and wood. Thus, civil engineering is called "soil and wood" in China. Ancient buildings were usually primitive and simple in terms of their structure, so it is easy to analyze the force of their structure. This makes them very suitable case studies for a course in structural mechanics. Through the study of ancient architectural structures, such as the Hanging Temple (Ivashko et al., 2020), the Yongding earth buildings (Luo et al., 2020; Luo et al., 2019), the Lugou Bridge (Deng et al., 2022; Hartmann & Su, 2021), and the historical stories behind them, students can learn the relevant mechanical knowledge and understand architectural aesthetics, but they can also become more patriotic, improve their cultural confidence, and foster their national pride.

### *a.* XuanKongSi (Hanging Temple)

XuanKongSi is located in Datong City, Shanxi Province. Its name means "Hanging Temple." It is glued to the side of a vertical cliff, 50 meters above the ground, as shown in Fig. 1a. It was built in 491 AD. It is 32 meters long and comprises 40 houses. As shown in Fig. 1b, XuanKongSi is built using a wooden frame structure with the cliffs as its foundation, horizontal logs as the beams, and vertical logs as the columns. Its mechanical model is shown in Fig. 1c. XuanKongSi symbolizes the great cultural achievements of the Chinese nation and the wisdom of the Chinese people.

a. Overall drawing of XuanKongSi (From the network)



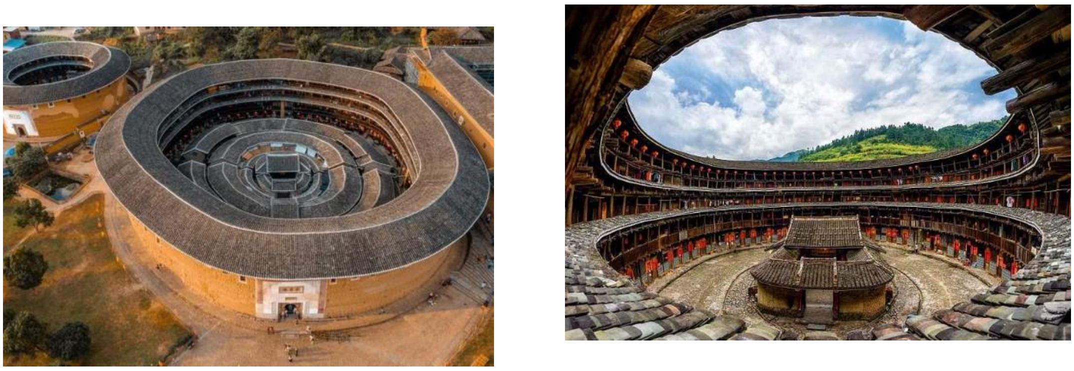
b. Partial structural drawing of XuanKongSi (From the network)

c. Mechanical model of XuanKongSi

**Figure 1. XuanKongSi and Its Mechanical Model**

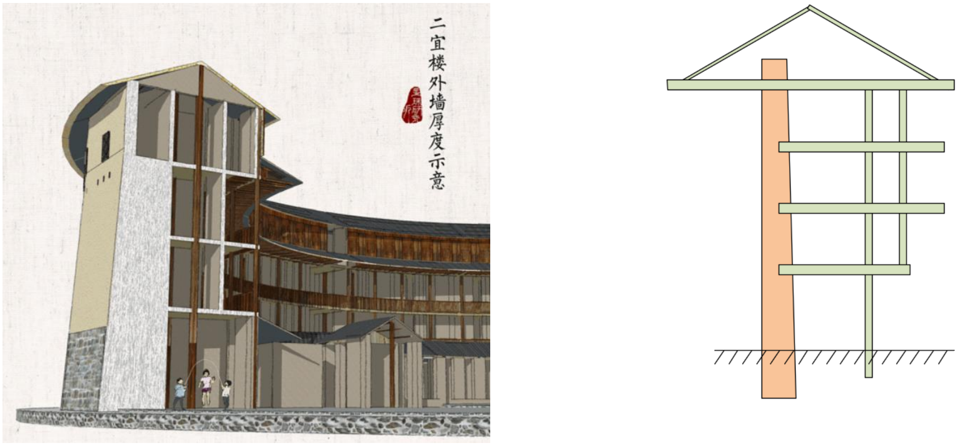
***b.* Yongding Earth Buildings**

The Yongding earth buildings are the family settlements of the Hakka people, an ethnic group composed of the ancient Han people who fled south to escape war over more than a thousand years. The Yongding earth buildings have many features, including earthquake resistance and fire prevention. They also protect from invasion. They have ventilation and lighting, and they are warm during the winter and cool in summer. There are more than 20,000 earth buildings in the 2,200 square-kilometer area of Yongding District, Longyan City, in the southwest of Fujian Province. The oldest existing earth building is 1,300 years old. The largest earth building is Chengqi Earth Building (Fig. 2a), which took 81 years to build. Chengqi Earth Building has a diameter of 73 meters and a corridor perimeter of 229.34 meters. It has 400 rooms and can accommodate more than 800 people. Yongding earth buildings have unique aesthetic characteristics (Fig. 2b). The earth buildings are mixed load-bearing structures of soil and wood. A cross-sectional view is shown in Fig. 2c. The main stress-bearing components are a spatial beam column wood frame, a rammed earth wall, a wooden floor plate, and a wooden roof. The mechanical model is shown in Fig. 2d. Yongding earth buildings reflect the tradition of unity and friendship handed down by the Hakka people from generation to generation. They are outstanding for their defensive function and reflect the poor living conditions of the ancestors of the Hakka people.



a. Chengqi Earth Building (From the network)

b. Beautiful view of an earth building (From the network)



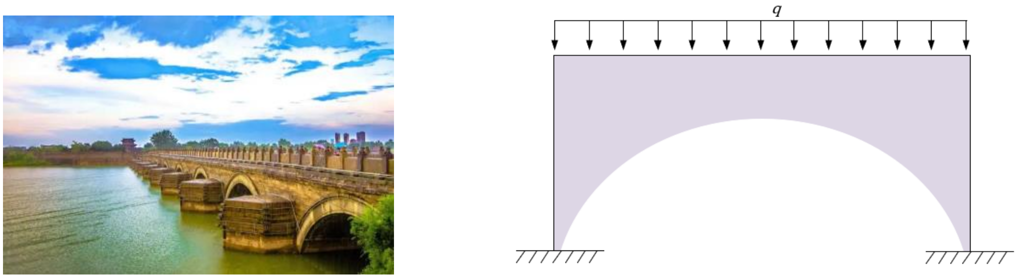
c. Sectional drawing of an earth building (From the network)

d. Mechanical model

Figure 2. An Earth Building and Its Mechanical Model

### *c.* Lugou Bridge

Lugou Bridge (Fig. 3a) was built in 1189 and is located in Fengtai District, Beijing. It has a total length of 266.5 meters and a width of 7.5 meters. It has 10 piers and 11 bridge openings. There are 501 stone lions on the bridge. Lugou Bridge is a multi-arch bridge, and its mechanical model is shown in Fig. 3b. The majestic and beautiful Lugou Bridge shows the greatness of Ancient China, but this disappeared after the Japanese invasion. On July 6, 1937, the Japanese army conducted an exercise at Lugou Bridge. Later, they lied and said that they had lost a soldier. They asked to enter Wanping City to investigate the incident. After their request was rejected by China on July 7, Japan shelled Lugou Bridge and Wanping City. This is known as the July 7 Incident. The Chinese garrison rose to fight back, which led to the war against Japan. The stone lions on Lugou Bridge bear witness to the humiliation that China has suffered in modern times (Fig. 3c).



a. Lugou Bridge (From the network)

b. Mechanical model

c. The Japanese army crossing Lugou Bridge in China (From the network)

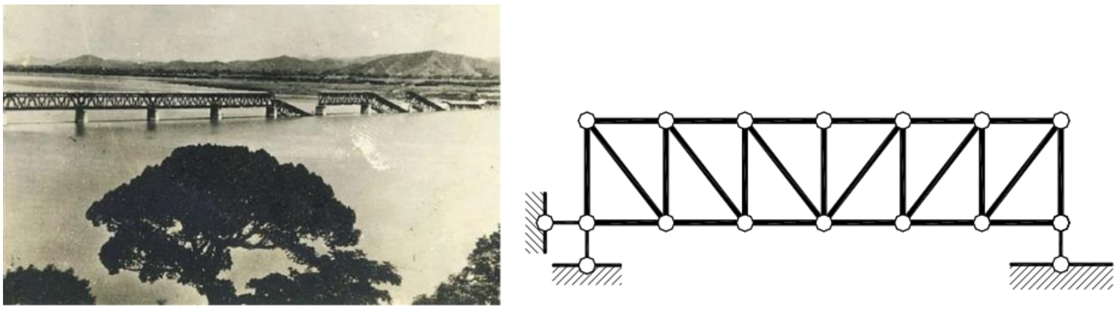
**Figure 3. Lugou Bridge and Its Mechanical Model**

## 3. Problem-Based Learning and Character Education Using Modern Architecture

The Opium War in 1840 marked the start of modern history in China. Due to its neglect of science and its exploitation by foreign countries, China has become backward and weak. Thus, it has not been able to build modern buildings independently. However, several decades after the founding of the People's Republic of China in 1949, China became strong and rich. It is now able to build the most difficult, complex, and magnificent buildings in the world. One reason for this is the popularization of education, science, and technology. Mao Zedong said that being backward meant being beaten, so it was the duty of students to study hard. By studying the Qiantang River Bridge (Haijing, 2020), the Qinghai Tibet Railway (Qin & Zheng, 2010; Su & Wall, 2009), the Hong Kong–Zhuhai—Macao Bridge (Hu et al., 2015; Yang, 2006), and other cases, students can learn how China's construction capacity developed over the past 100 years. The efforts made by several generations of Chinese people to build the motherland have inspired the students to have a strong sense of honor and pride for the motherland.

### *a.* Qiantang River Bridge

The Qiantang River Bridge (Fig. 4a) was designed and built by Mao Yisheng, a Chinese Bridge expert. It was the first double-layer railway and highway bridge to be designed and built independently by the Chinese people. Its mechanical model is that of a truss bridge, as shown in Fig. 4b. It was completed and opened to traffic on November 17, 1937, when Shanghai had been taken over by the Japanese army. To prevent the Japanese army from using the Qiantang River Bridge to transport its military supplies, Mao Yisheng blew it up on December 23, 1937, once the refugees had been evacuated. Thus, the Qiantang River Bridge was blown up by its builders just one month after its completion. Because Mao Yisheng destroyed all the design drawings, it took the Japanese army seven years to repair the lower railway bridge, which they completed in October 1944. Less than a year later, China won the war against Japan. Mao Yisheng said that building bridges can be patriotic and bombing bridges can be patriotic too.

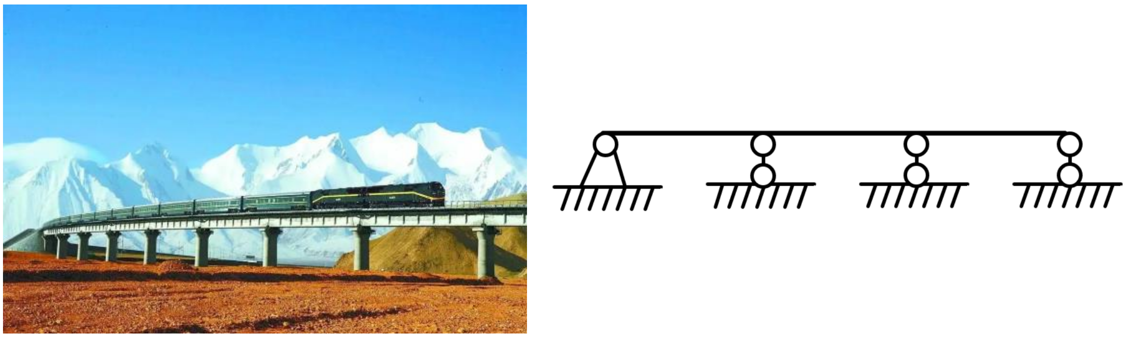


a. The destroyed Qiantang River Bridge (From the network) b. Mechanical model

**Figure 4. Qiantang River Bridge and Its Mechanical Model**

***b.* Qinghai-Tibet Railway**

The Qinghai-Tibet Railway is a railway connecting Xining in Qinghai Province with Lhasa in Tibet Autonomous Region. It is the highest altitude railway in the world and the longest railway to cross frozen soil. Fig. 4 shows a section of the continuous beam bridge that the Qinghai-Tibet Railway uses, as well as its mechanical model. The Qinghai-Tibet Railway is of great significance to China because Tibet borders India, Pakistan, Nepal, and other countries. Its geographical position is very important. The Qinghai-Tibet Railway has strengthened the ties between Tibet and other vast areas in China, promoted cultural exchanges between Tibetans and other ethnic groups, and strengthened ethnic unity. The construction of this railway has decreased the poverty and backwardness of the Qinghai Tibet Plateau. It has promoted unity, progress, and prosperity among multiple ethnic groups.



a. A section of the continuous beam bridge of the Qinghai Tibet Railway (From the network) b. Mechanical model

**Figure 4. A Section of the Continuous Beam Bridge and Its Mechanical Model**

The Qinghai-Tibet Railway had to overcome three major construction problems. It had to cross thousands of miles of frozen soil, deal with severe cold and oxygen deficiencies, and ensure the surrounding environment was protected. The Qinghai Tibet Railway won a special prize in China's National Scientific and Technological Progress Awards in 2008, which is a great honor in China. The Qinghai-Tibet Railway uses world-beating technology. It has allowed researchers to obtain dozens of patents and publish more than 1,000 papers. It has promoted scientific and technological progress in the fields of permafrost engineering, plateau medicine, and environmental protectionism (Wei et al., 2009; Wu et al., 2010; Zhang et al., 2008).

### *c.* Hong Kong–Zhuhai–Macao Bridge

The Hong Kong–Zhuhai–Macao Bridge (which was started in 2009 and completed in 2018) is a bridge and tunnel project connecting Hong Kong, Zhuhai, Guangdong, and Macao. The total length of the bridge and tunnel is 55 km. Figure 5 shows the Hong Kong–Zhuhai–Macao Bridge and its mechanical model. The Hong Kong–Zhuhai–Macao Bridge is the longest oversea bridge in the world. It has the longest service life, the largest amount of steel, the most difficult technical content, the most complicated construction processes, the most expensive level of investment, and the largest amount of scientific patents out of any bridge in the world. During the construction of the Hong Kong–Zhuhai–Macao Bridge, about 300 research projects were carried out, about 500 papers were published, 18 monographs were published, 30 standards and guidelines were compiled, 11 software copyrights were obtained, about 1,000 projects of innovation were completed, 40 construction methods were created, 63 technical standards were formed, and more than 600 patents were created. The construction team successively solved 10 world-class technical problems. For example, they had to create artificial islands rapidly, design deeply buried pipe structures, and ensure the composite foundation of tunnels. The project led to the construction of 20 bases and production lines, formed core technologies with independent intellectual property rights in China, and established an industrial technology system for constructing infrastructural connections across the seas.

a. Main bridge of Hong Kong-Zhuhai-Macao Bridge (From the network)

b. Mechanical model

**Figure 5 The Hong Kong-Zhuhai-Macao Bridge and Its Mechanical Model**

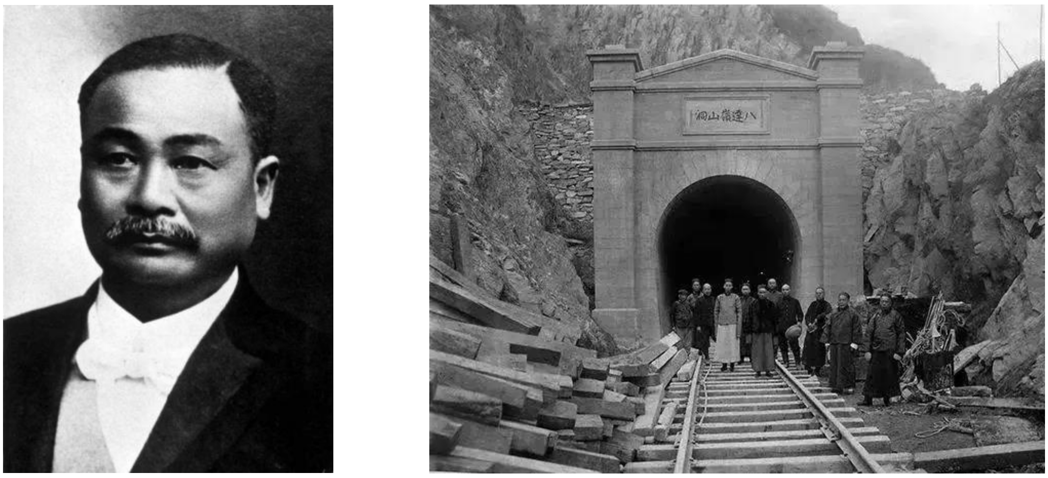
## 4. Character Education with the Exemplars

Outstanding scientists have extraordinary intelligence, but they also often have admirable character. Zhan Tianyou (the father of the Chinese railways), Qian Weichang (the father of modern Chinese mechanics), and Qian Xuesen (the father of Chinese aerospace have been selected as examples for the course (Feigenbaum, 2003; Kirby, 2010; Ning, 2011; Qiu, 2009; Wang, 2010; Zha, 2012). By learning from real stories and examples, students can gain the ideal of serving the country with their knowledge. They will learn the importance of "being poor but stronger" in response to difficulties, as well as a strong sense of honor and pride in the motherland.

### *a.* Zhan Tianyou (Jeme Tien Yow)

Zhan Tianyou, known as the father of the Chinese railways and the father of modern Chinese engineering, presided over the construction of the Beijing–Zhangjiakou Railway, which was the first railway independently designed and built by the Chinese people. Zhan Tianyou developed the "shaft digging method" and the "herringbone" line, which shocked the world. Zhan Tianyou planned and built the Shanghai–Jiaxing, Luoyang–Tongguan, Tianjin–Lugou Bridge, Jinzhou, Pingxiang–Liling, Xincheng–Yixian, Shantou–Chaoan, Guangzhou–Wuchang railways, among others.

Before the construction of the Beijing–Zhangjiakou railway, Zhan Tianyou said, "China has a large population, a vast territory, and abundant resources, but it is shameful that it relies on foreigners to build its railways." In 1909, the Beijing–Zhangjiakou Railway was completed two years ahead of schedule. Zhan Tianyou broke the monopoly of foreigners in technology, which increased the Chinese people's confidence in the country. Railways can be built by Chinese people themselves, as can mines, machinery, and factories.



a. Zhan Tianyou (From the network)

b. Badaling Cave, part of the Beijing-Zhangjiakou Railway

**Figure 6. Zhan Tianyou and Beijing-Zhangjiakou Railway**

### *b.* Qian Weichang (chien wei-zang)

Qian Weichang is known as the father of modern Chinese mechanics and the father of Chinese applied mathematics. Although Qian Weichang has made outstanding achievements in mathematics and physics, he scored 5 points in physics, 20 points in mathematics and chemistry, and 0 points in English in the entrance examinations for Tsinghua University in 1931. He was eventually admitted to the Chinese department, however, with full marks in both Chinese and history. In the same year, Japan launched the September 18th Incident. Every man is responsible for the rise and fall of their country. Qian Weichang, therefore, clapped his hands on the table and said the following: "I don't want to study history. I want to learn how to make aircraft and artillery. I decided to transfer to the physics department to revitalize China's military strength."

In 1939, with the support of the Board of the British Boxer Indemnity, Qian Weichang and 22 other students were allowed to study in Canada. However, after boarding the ship, they found that their passports contained Japanese visas. The students could not accept this national humiliation, so they tore up their passports and gave up studying in Canada. It was not until 1940 that Qian Weichang finally went to Canada to study. After the surrender of Japan, Qian Weichang returned to China and participated in progressive movements such as the Anti-American Support of Japan Movement, the Anti-Civil War movement, and the Anti-Hunger movement. Due to the difficulties he faced in life, Qian Weichang planned to go back to the Jet Propulsion Research Institute of the California Institute of technology in the United States to resume his post. However, when asked whether he would be loyal to the United States if China and the United States were at war, Qian Weichang angrily gave up going to the United States.

Qian Weichang studied mechanics at the age of 36, Russian at the age of 44, batteries at the age of 58, and computers at the age of 64. Qian Weichang was engaged in mechanical research for a long time, and he made outstanding contributions to plate and shell problems, generalized variational principles, the analytical solutions of ring shells, and the macro glyph coding of Chinese characters. In his later years, Qian Weichang said, "I have no major. The needs of the motherland are my major."

**Figure 7. Qian Weichang (From the network)**

### *c.* Qian Xuesen (Tsien Hsue-Shen)

Qian Xuesen is known as the father of Chinese aerospace, the father of Chinese missiles, and the father of Chinese automation. He is an aerodynamics scientist, a systems analyst, the founder of cybernetics in engineering, and the recipient of the “Two Bombs and one Satellite Award.” Danny Kimble, the deputy commander of the US Navy, commented that Qian Xuesen was worth five divisions wherever he was. However, Mao Zedong thought that Qian Xuesen was much more powerful than the five divisions.

Qian Xuesen studied at the Massachusetts Institute of Technology and the California Institute of Technology from 1935 onwards. In 1945, he was sent to Germany to investigate Nazi German rocket technology. In 1949, he served as the director of the Jet Propulsion Center at the California Institute of Technology. After the founding of New China in 1949, he wanted to return to China to participate in the construction of New China, but he was detained by the United States when he went to the border and was closely monitored for five years. It was not until 1955, when Premier Zhou Enlai offered exchanges for 11 captured American pilots, that Qian Xuesen successfully returned to China.

Under the leadership of Qian Xuesen, China’s first atomic bomb was successfully exploded on October 16, 1964. China’s first hydrogen bomb was successfully exploded in the air on June 17, 1967. China’s first man-made satellite was successfully launched on April 24, 1970. Qian Xuesen’s achievements in the United States were very good but not convincing enough. The contribution he made to the People’s Republic of China was truly remarkable.

**Figure 8. Qian Xuesen (From the network)**

## 5. Conclusion

Using PBL, the structural mechanics course uses traditional buildings and modern buildings to carry out structural analysis, stress analysis, and aesthetic training. At the same time, it creates an atmosphere for character education by telling the historical stories behind the buildings, and gradually influencing students’ character. According to exemplarist moral theory, teachers should select some outstanding and admirable scientists to use as examples. They should tell students about them so they can develop a good character by imitating them. This will ensure that students not only have a solid grasp of mechanical knowledge but also cultivate architectural aesthetics, moral character (morality, character, cooperation, and comparison), civility (tolerance, respect, determination, patriotism), good behavior (tenacity, self-discipline, resilience, patience, striving, and grit), and intellectual character (current, open-mindedness, attention, intellectual carefulness, and intellectual thoroughness.)

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## References

Arthur J, Kristjánsson K, Harrison T, Sanderse W, & Wright D. 2016.

Baehr J. 2017.

Cranston N, Kimber M, Mulford B, Reid A, Keating J. 2010.

Deng Y, Jia Y, Li Y, Li A. 2022.

Feigenbaum EA. 2003.

Francis LJ, Pike MA, Lickona T, Lankshear DW, Nesfield V. 2018.

Haijing L, and Sally K. Church. 2020.

Hart P. 2022.

Hartmann R, Su MM. 2021.

He K, Lu H, Sun G, Ji X, Wang Y, et al. 2021.

Hidayati NA, Herman J. Waluyo, and Retno Winarni. 2020.

Hu Z-n, Xie Y-l, Wang J. 2015.

Ivashko Y, Kuśnierz-Krupa D, Peng C. 2020.

Jerome L, Kisby B. 2022.

Jeynes WH. 2003.

Jeynes WH. 2017.

Kirby WC. 2010.

Kristjánsson K. 2013.

Kristjánsson K. 2016.

Kuh GD, and P. Umbach. 2004.

Li P, Liao Z, Zhou Z, Wu Q. 2021.

Luo Y, Yang M, Ni P, Peng X, Yuan X. 2020.

Luo Y, Yin B, Peng X, Xu Y, Zhang L. 2019.

Macho-Stadler E, Jesús Elejalde-García M. 2013.

MacIntyre A. 1981.

Ning W. 2011.

Novianti N. 2017.

Nucci LP, Narvaez D, Krettenauer T. 2014.

Paul S-AS, Hart P, Augustin L, Clarke PJ, Pike M. 2020.

Perrenet JC, Bouhuijs PAJ, Smits JGMM. 2000.

Polanco R, Calderón P, Delgado F. 2004.

Qin Y, Zheng B. 2010.

Qiu J. 2009.

Reeves TC, Laffey JM. 1999.

Renfrew C, Liu B. 2018.

Ryan K, Bohlin KE. 1999.

Sahin M. 2010.

Siegel H. 2009.

Steinhardt NS. 2019.

Su MM, Wall G. 2009.

Tan C, Tan CS. 2014.

Wang Z. 2010.

Wei M, Guodong C, Qingbai W. 2009.

Wu TY, Ding SQ, Zhang SL, Duan JQ, Li BY, et al. 2010.

Yang C. 2006.

Yulianti D, Khanafiyah S, Sulistyorini S. 2016.

Zagzebski L. 2013.

Zagzebski L. 2017.

Zha Q. 2012.

Zhang T, Baker THW, Cheng G-D, Wu Q. 2008.