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Study on the Influence of Harvard University on the Development of Modern Mathematics in China

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Abstract

Harvard University was an important overseas training base for mathematical talents in modern China. In the early 20th century, a group of Chinese students went to Harvard University to study modern mathematics. After they returned to China, they presided over or participated in building early university mathematics departments, and also participated in compiling mathematics textbooks, unifying mathematical terminology in Chinese, establishing mathematical academic groups, and founding research institutions, making a seminal contribution to the institutionalization of modern mathematics in China. Through the graduates it educated, Harvard University had a significant impact on the development of modern mathematics in China in the first half of the 20th century.

Keywords

Harvard University, Modern Mathematics, International Students, Institutionalization

1. Introduction

The first doctor of mathematics in modern China was educated in Harvard University (Zhang, 1991; Zhang, 1999). Before 1930, there were 16 doctors of mathematics in China, five of whom graduated from Harvard University (Zhang, 1999). Studying the influence of Harvard University on the development of modern mathematics in China in the first half of the 20th century not only helps to examine more objectively the role of Harvard University in the history of the development

of modern mathematics in China, but also helps to understand the historical lineage of the development of modern mathematics in China in a more comprehensive way.

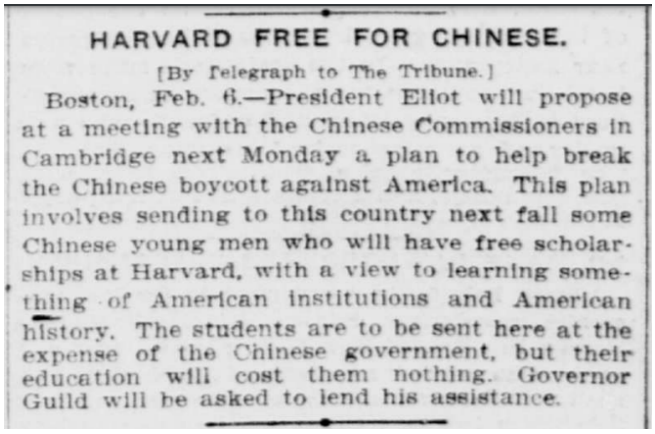
Regarding Harvard University's training for Chinese students who studied mathematics in the first half of the 20th century and their contributions after returning to China, current studies mostly scattered in the biographies of single mathematicians and articles recalling their personal biographies and contributions (Cheng, 1994; Cheng, 1995; Cheng, 1999; Cheng, 2002), Zhang Dianzhou and Liu Qiuhua made a preliminary compilation of some Chinese students studying and researching mathematics at Harvard in the early Republican period of China (Zhang, 1999; Liu, 2010). These documents, undoubtedly, provide informative materials for studying the influence of Harvard University on the development of modern Chinese mathematics in the first half of the 20th century.

Based on the newly discovered primary documents, this paper examines the historical origins of Chinese people studying mathematics at Harvard University, explores Harvard University's training for mathematics students from China in the first half of the 20th century, and discusses their contributions after they returned to China.

2. The Historical Origins of Chinese Students Going to Harvard University to Study Mathematics

At the end of the 19th century and the beginning of the 20th century, under the successive stimulation of national crises such as the defeat of the Sino-Japanese War and the invasion of China by the Eight-Power Allied Forces, the Qing government reflected on the Westernization Movement, proceeded to set up Western-style universities, sent delegations to study Western constitutionalism, and encouraged local governments to send students to study abroad (Chen & Tian, 2007).

In 1895, the Imperial Tientsin University (later renamed the Peiyang University) was established in Tianjin, with an American Charles Daniel Tenney (1857-1930) was appointed as the chief instructor, and there was a plan to send graduates to study abroad as part of the founding program (Peiyang University-Tianjin University History Office, 1990). In 1905, the Imperial Examination System was abolished. Yuan Shikai (1859-1916), then the Viceroy of Zhili and Minister of Peiyang, as the proponent of abolition of the Imperial Examination System to promote modern school education, supported Peiyang University to send students and faculty to study abroad with funds from the Tianjin Customs in 1906 (Anonymous, 1906). During the period of 1905-1906, the Qing government sent delegations to Japan, Europe, and the United States to study the constitutional system. Duan Fang (1861-1911), as the co-leader of the delegation to the United States, had always attached importance to schooling and advocated study abroad (Shu, 2016), visited Harvard University and other American universities on the way (Lin, 2017).



HARVARD FREE FOR CHINESE.

[By Telegraph to The Tribune.]

Boston, Feb. 6.—President Eliot will propose at a meeting with the Chinese Commissioners in Cambridge next Monday a plan to help break the Chinese boycott against America. This plan involves sending to this country next fall some Chinese young men who will have free scholarships at Harvard, with a view to learning something of American institutions and American history. The students are to be sent here at the expense of the Chinese government, but their education will cost them nothing. Governor Guild will be asked to lend his assistance.

Figure 1. Harvard University's statement published in the newspaper in 1906.

At the end of the 19th century and the beginning of the 20th century, the United States was in an economic crisis, and Chinese exclusion sentiments rose, with a series of persecution of Chinese in the United States. In particular, in 1904, the United States Congress re-approved the Chinese Exclusion Act, which triggered a massive boycott of American goods in China (Bieler, 2004). On the occasion of the imminent arrival of the Chinese mission led by Duan Fang to Boston, Harvard University President Charles William Eliot (1834-1926) published a newspaper statement, as shown in **Figure 1**, on February 7, 1906: "President Eliot will propose at a meeting with the Chinese Commissioners in Cambridge next Monday a plan to help break the Chinese boycott against America. This plan involves sending to this country next fall some Chinese young men who will have free scholarships at Harvard" (Harvard University, 1906). In the summer of 1906, more than 30 students from Peiyang University, led by Tenney Charles Daniel, enrolled in Harvard University's summer school. In September of 1906, Qin Fen and 15 other students were admitted to Harvard (Lin, 2017).

The high cost of sending students to the United States was a significant expense for the Qing government. Since 1905, Liang Cheng (1864-1917), the minister to the United States, had been negotiating with the U.S. government, urging the reduction of the Boxer Indemnity to fund study in the United States. In 1906, Arthur Henderson Smith (1845-1932), an American missionary in China, took the opportunity of his return to his home country to lobby President Theodore Roosevelt (1858-1919), suggesting the use of the Boxer Indemnity to build modern education in China and subsidize Chinese students to study in the United States. At this time, the anti-China actions in the U.S. and the boycott of U.S. goods in China had reduced Sino-U.S. relations to the freezing point. In order to improve U.S.-China relations and safeguard its commercial interests in China, the U.S. government agreed to return some of the Boxer Indemnity money to fund study in the U.S. in 1908. From that time onward, Chinese students' going to study at Harvard was guaranteed a stable fund.

In October 1909, the first batch of students funded by The Boxer Indemnity

Scholarship Program went to the U.S., among which Wang Renfu and Yan Jiazou entered Harvard University to study mathematics. Subsequently, the second batch of the Boxer Indemnity Scholarship recipients including Hu Mingfu and the third batch including Jiang Lifu also arrived successively (Liu, 1980). After 1912, the trend of the Scientific Salvation Movement became more and more intense, and a number of university mathematics departments were established one after another under the impetus of the reform of education system. Influenced by the New Culture Movement, more and more Chinese students who admired science went to Harvard to study modern mathematics with the aid of the Boxer Indemnity Scholarship Program.

Thus, it can be seen that Chinese students' studying mathematics at Harvard University started in the 1900s, which was a historical product of the détente between China and the United States in the late Qing Dynasty and the reform of China's education system, and was also inseparable from Harvard University's commitment to improve U.S.-China relations by opening the door for Chinese students.

3. Harvard University' Training for Mathematics Students from China in the First Half of 20th Century

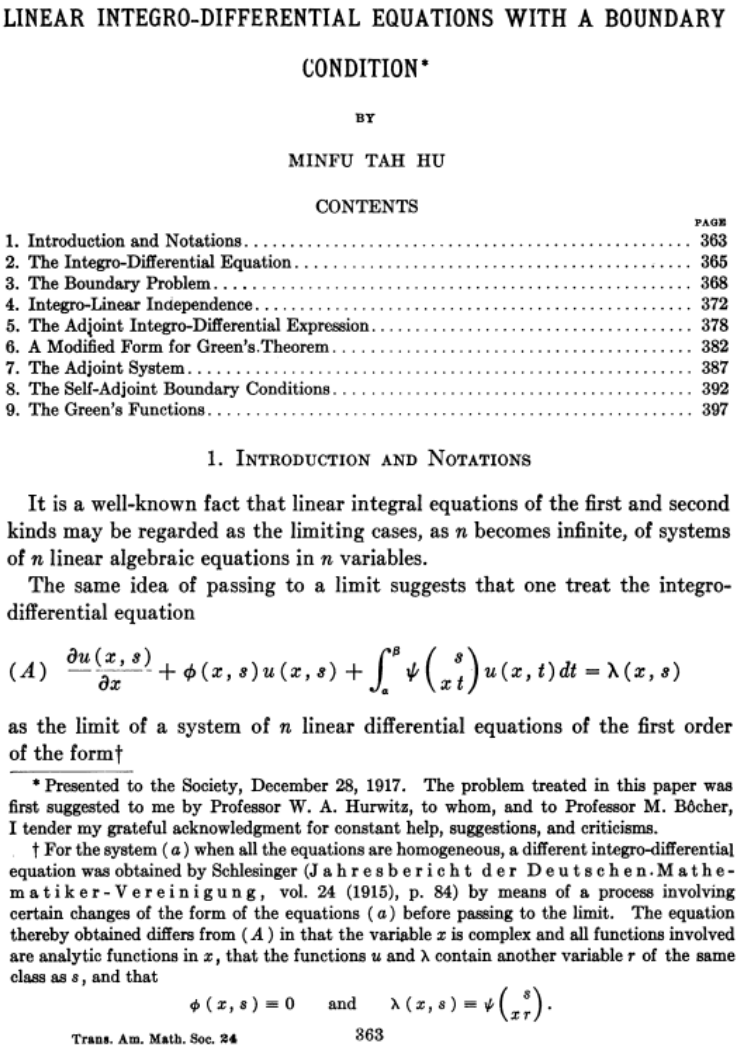
Harvard's Department of Mathematics was founded in 1727. Like other university mathematics departments in the United States, it focused primarily on teaching rather than researching before 1900 (Nadis & Yau, 2013). In the late 19th century, William Fogg Osgood (1864-1943), Maxime Bôcher (1867-1918), and Julian Lowell Coolidge (1873-1954) joined Harvard, bringing not only new courses but also new ideas in mathematical research. They were active in publishing papers and monographs, and revitalizing graduate education. With the arrival of a new generation of mathematicians, such as George David Birkhoff (1884-1944) in 1912, Harvard's Department of Mathematics rose rapidly to become one of the best in the United States in the 1910s, and from then on, it could provide mathematical training on a level comparable to that of European universities (Batterson, 2009).

In 1906, Qin Fen came to Harvard to study mathematics. At this time, Osgood, Bôcher and Coolidge were all teaching in the department. At Harvard, he excelled in his studies, received a scholarship, and obtained his bachelor's and master's degrees in 1909 (Anonymous, 1909; Cate, 1909). He originally planned to continue his studies at the University of Cambridge in England after graduation, but failed to do so and returned to China in 1910 (Ding & Song, 2012). According to the current information, Qin Fen was the first Chinese to study mathematics at Harvard University.

In 1909, Wang Renfu and Yan Jiazou who were selected as the first Boxer Indemnity Scholars came to the United States, but they missed college enrollment and were arranged to study in the preparatory schools. Wang Renfu entered Harvard University's Department of Mathematics in 1910 and returned to China after receiving his bachelor's degree in 1913 (Chen & Tian, 2007). Yan Jiazou, enrolled

at the University of Illinois in 1910 to study mathematics and science, and went to Harvard to study mathematics for his master's degree in 1913, and returned to China in 1914 (Chen & Tian, 2007).

Hu Mingfu, one of the second batch of Boxer Indemnity Scholars, went to Cornell University in 1910 (Lu & Hu, 2014). And after graduation in 1914, he went to Harvard University to study integral equations, which was a relatively popular field of study at that time. Under the guidance of Bôcher, he got the Harvard Ph.D. degree in 1917 with his dissertation, *Linear Integro-Differential Equations with a Boundary Condition*, under the name Minfu Tah Hu (Yuan, 2010). The paper was recommended for publication because of its high academic standard in the prestigious journal *Transactions of the American Mathematical Society* (Hu, 1918), as shown in **Figure 2**. This was the first doctoral dissertation of Chinese in mathematics, and Hu Mingfu became the first Ph.D. in mathematics in China (Zhang, 1991; Zhang, 1999).



LINEAR INTEGRO-DIFFERENTIAL EQUATIONS WITH A BOUNDARY CONDITION*

BY

MINFU TAH HU

CONTENTS

1. Introduction and Notations

It is a well-known fact that linear integral equations of the first and second kinds may be regarded as the limiting cases, as n becomes infinite, of systems of n linear algebraic equations in n variables.

The same idea of passing to a limit suggests that one treat the integro-differential equation

$$(A)\quad \frac{\partial u(x,s)}{\partial x} + \phi(x,s)u(x,s) + \int_a^\beta \psi\begin{pmatrix} s \\ x\ t \end{pmatrix} u(x,t)\,dt = \lambda(x,s)$$

as the limit of a system of n linear differential equations of the first order of the form†

* Presented to the Society, December 28, 1917. The problem treated in this paper was first suggested to me by Professor W. A. Hurwitz, to whom, and to Professor M. Bôcher, I tender my grateful acknowledgment for constant help, suggestions, and criticisms.

† For the system (a) when all the equations are homogeneous, a different integro-differential equation was obtained by Schlesinger (Jahresbericht der Deutschen Mathematiker-Vereinigung, vol. 24 (1915), p. 84) by means of a process involving certain changes of the form of the equations (a) before passing to the limit. The equation thereby obtained differs from (A) in that the variable x is complex and all functions involved are analytic functions in x, that the functions u and λ contain another variable r of the same class as s, and that

$$\phi(x,s) \equiv 0 \quad \text{and} \quad \lambda(x,s) \equiv \psi\begin{pmatrix} s \\ x\ r \end{pmatrix}.$$

Trans. Am. Math. Soc. 24 363

Figure 2. The first Chinese doctoral dissertation in mathematics completed by Hu Mingfu at Harvard University in 1917.

China's second doctoral dissertation in mathematics was also born at Harvard, completed by Jiang Lifu in 1919. Jiang Lifu, one of the third batch of Boxer Indemnity Scholars, entered University of California at Berkeley in 1911, and after graduation in 1915, he went to Harvard University to study non-Euclidean geometry under Coolidge, and received his Ph.D. degree in 1919 with his dissertation, *The Geometry of a Non-Euclidean Line-Sphere Transformation*, signed Chan Chan-Tsoo (Jiang, 1987). The main point of the dissertation was to discuss a one-to-one correspondence between a straight line in projective space and a sphere in non-Euclidean space using algebraic and differential geometric methods. Jiang Lifu aspired to transplant modern mathematics to China, and went to Harvard University preparing for this ambitious goal (Wu, 1990). In 1918, he worked as a teaching assistant for Osgood who was the head of the Department of Mathematics (Liu, 1996), so that he could closely observe and learn how Osgood teach and manage the Harvard's Department of Mathematics.

Jiang Lifu's students at Nankai, including Liu Jinnian, Jiang Zehan, Yang Shanji, and Shen Youcheng, influenced by Jiang Lifu and went to Harvard to pursue degrees in mathematics (Editorial Committee of Mr. Jiang Zehan' Memorial Collection, 1998). At this time, Harvard's Deparment of Mathematics had a strong faculty. Although Bôcher had passed away, the department still had Osgood and Birkhoff, as well as young teachers such as Marson Morse (1892-1977) and Joseph Leonard Walsh (1895-1973). Liu Jinnian, the first graduate of the Department of Mathematics at Nankai University (Guo, 2019), supported by the Tsinghua School's Program for U.S.-Bound Students in 1925, went to Harvard to study the restricted three-body problem, which was an international frontier problem at the time, under the guidance of Birkhoff who was the president of the American Mathematical Society. Birkhoff had previously become a leading mathematician in the field because of his successful proof of the "Poincaré's theorem" in the two-dimensional case. At Harvard, Liu was not only exposed to the cutting edge of research but also received academic training from the leading master in this field. He received his Ph.D. degree in 1930 with his dissertation *Contributions to the Restricted Problem of Three Bodies*, under the name of Liu Chin-Nien (Yuan, 2010).

Jiang Zehan came to Harvard with the aid of Tsinghua School's Program for U.S.-Bound Students in 1927. Here, he took "Complex Domain Geometry" taught by Coolidge and "Differential Equations" taught by Birkhoff. At the end of his first year, he received a master's degree and the honor of John Harvard Fellow for his excellent examination results and two master's theses (You, 1996). He was influenced by his undergraduate teacher, Jiang Lifu, to become interested in geometry, and in the summer of 1928, he chose to follow Morse to work on critical points in topology, a cutting-edge problem in topology. In 1930, Jiang received his Ph.D. with his dissertation, *Existence of Critical Points of Harmonic Functions of Three Variables,* under the name Kiang Tsai-Han (Yuan, 2010). His training in topology at Harvard laid the foundation for his later introduction of topology into China.

Yang Shanji and Shen Youcheng were both graduates of the Department of Mathematics of Nankai University in 1926 (Guo, 2019). Yang went to Harvard to study mathematics in 1929, by the aid of Anhui Province's Scholarship for students studying in the United States, and eventually received a master's degree (Anonymous, 1929a; Anonymous, 1929b). Shen, with the financial support of the Rockefeller Foundation, went to Harvard in 1931 to study mathematics under the supervision of Walsh. He studied the theory of interpolation and approximation of functions, an emerging field at the time. And in 1935, he received his Ph.D. degree under the name Shen Yu-Cheng for the dissertation *On Interpolation and Approximation to an Analytic Function by Rational Functions with Preassigned Poles* (Yuan, 2010). The paper was later published in the first volume of the *Journal of the Chinese Mathematical Society* in 1936 (Shen, 1936).

In the 1930s, Zhao Fangxiong and Shi Xianglin went to Harvard to study mathematics by the aid of Tsinghua University's Program for U.S.-Bound Students. After graduating from the Department of Electrical Engineering of the Massachusetts Institute of Technology (MIT) in 1930, Zhao went to Harvard and obtained his master's degree in 1931, but his doctoral studies were interrupted when he was recalled by Zhao Yuanren to teach at the Department of Mathematics at Tsinghua University in 1933 (Li, 1996). Shi Xianglin studied topology under Jiang Zehan in Tsinghua University, and went to Harvard in 1936 to study differential geometry and topology under Hassler Whitney (1907-1989), one of the founding fathers of differential topology. In 1941, He got his Ph.D. at Harvard with the dissertation *Mapping of 2-manifolds into space*, under the name Shih Hsiang-Lin (Yuan, 2010). This paper was later published in the *Duke Mathematical Journal* in 1943; another paper he wrote while at Harvard, *The Geometry of Isotropic Surfaces*, published in *Annals of Mathematics* in 1942 (Cheng, 1999). The fact that his papers was published by two top journals showed the high level of his research at Harvard.

In the 1940s, Tan Caide and Qin Yuanxun went to Harvard to further their studies in mathematics. At this time, Harvard University was already a world-class mathematics research center. Tan followed Birkhoff's son Garrett Birkhoff (1911-1996) to study differential equations, and received his Ph.D. degree in 1945 with the dissertation *On the Solution of Ordinary Linear Homogeneous Differential Equations of the Secondary Order in the Complex Domain*, under the name Taam Choy-Tak (Yuan, 2010). Qin, an outstanding graduate of Zhejiang University, entered Harvard University in 1944 to follow Mac Lane Saunders (1909-2005). He received his Ph.D. degree in 1947 with his dissertation *Regular Families of Curves and Pseudoharmonic Functions*, signed Chin Yuan-Shun (Yuan, 2010).

Through the above comprehensive study, it can be seen that, although Harvard University was a latecomer on the world stage of mathematics, a group of Chinese students, such as Qin Fen, Wang Renfu, Hu Mingfu, Jiang Lifu, and Jiang Zeihan, came to this university to study modern mathematics in the first half of the 20th century under the historical chance. Thanks to Harvard's first-rate teachers such

as Osgood, Boscher, Coolidge, Birkhoff, Morse, Walsh, Whitney, the Chinese students obtained high-level mathematical training here. At Harvard, Chinese students gained not only modern mathematical knowledge but also mathematical research ability. They immersed themselves in and closely observed the teaching and management methods of Harvard's Department of Mathematics, which not only broadened their academic horizons, but also inspired their future career aspirations. For example, when Jiang Zehan was in America, he realized that: "Birkhoff, Morse, Lefschetz, etc. make their achievements in the United States, and become internationally famous, while many of their teachers (e.g., Osgood, etc.) are educated in Europe, this process spans a period of about half a century. I also study abroad today, and should learn from the history of the development of the United States by uniting peer workers, introducing new theories of modern mathematics to China rapidly, determining to spend our lives in teaching and researching, hope to make China stand tall in the world of modern mathematics in fifty years" (Editorial Committee of Mr. Jiang Zehan' Memorial Collection, 1998).

4. Contributions of the Chinese Harvard Mathematics Graduates

After these graduates returned to China, they worked hard with their colleagues in teaching and researching, which remained unswerving even in the exceptionally difficult period of the war, and made seminal contributions to the institutionalization of modern mathematics in China.

4.1. Building University Mathematics Departments in China

In the first half of the 20th century, a number of modern universities were established, and upon their return to China, they quickly devoted themselves to the construction of university mathematics departments, including the Department of Mathematics at Peking University, the first university mathematics department in China, as well as those of Datong University, Nankai University, Xiamen University, and National South-West Associated University.

Wang Renfu and Qin Fen joined Peking University in 1914 and 1915 separately, and together with Feng Zuxun, they founded the Department of Mathematics (Guo, 2019). For more than ten years, three of them took turns to serve as the head of the Department of Mathematics, the head of the Departmental Professors Association, and the head of the Departmental Research Institute. And they initially explored the way of modern university mathematics departments in China (Ding, Yuan, & Zhang, 1993). Wang Renfu taught analytic geometry, modern geometry, theory of differential equations, differential geometry, higher plane curves, etc. (Guo, 2019), becoming an early disseminator of knowledge of modern geometry in China. Qin Fen taught courses in modern algebra, astronomy, mechanics, history of mathematics, etc. (Guo, 2019), becoming an early disseminator of knowledge of modern algebra in China. In addition, Qin Fen and Wang Renfu taught part-time at other universities. After 1931, Wang Renfu left Peking University to join the

Department of Mathematics at Beiping Normal University, while Qin Fen joined politics and stopped teaching.

Jiang Zehan joined Peking University in 1931, and soon began to reform the mathematics department on the model of Harvard in the U.S. and Nankai in China. In 1934, he became the head of the department, and further reformed the department's affairs and teaching work by modeling it on the system of European and American universities, and strengthened the relationship with the European and American mathematical communities (Ding, Yuan, & Zhang, 1993). He taught many courses such as algebraic topology and differential geometry, and held discussion classes on topology. In addition, in 1931, he also taught topology part-time at the Department of Mathematics at Tsinghua University, which was the first topology course in China. Jiang Zehan was also the founder of algebraic topology in China. After Shen Youcheng graduated from Harvard in 1935, Jiang Lifu asked him to assist Jiang Zehan at Peking University. In addition to teaching, he was also engaged in researching on analytic function theory, especially in the interpolation theory of functions of a complex variable, which was a continuation of the content of his doctoral dissertation (Ding & Li, 2006). A series of results had been achieved, and many papers had been published in international high-level mathematical journals. It could be said that the scientific research of the Department of Mathematics at Peking University was at the leading level of the country at that time, and some of them even reached the international advanced level (Ding, Yuan, & Zhang, 1993).

Hu Mingfu joined Datong University in 1917. He founded the Department of Mathematics together with Wu Zaiyuan and served as its chairman for a long time. His student Liu Shuting later became the first female doctor of mathematics in China. In addition to teaching at Datong University, he also taught analytic geometry and calculus on a part-time basis at Jiao Tong University and National Southeast University. Unfortunately, he died young of drowning in 1927 (Utopia University Mathematical and Physical Research Society, 1928). Later, the Department of Mathematics at Datong University was incorporated into Fudan University.

Jiang Lifu founded the Department of Mathematics at Nankai University in 1920, and presided over it for a long time. Despite the shortage of faculty, he continued to follow the Harvard University training model with strict teaching requirements, and trained a number of important backbones of modern Chinese mathematics, such as Chern Shiingshen, Jiang Zehan, Liu Jinnian, Shen Youcheng, Wu Daren, Sun Benwang. Around 1926, he was also invited to Xiamen University to preside over the Department of Mathematics for one year (Editorial Committee of Mr. Jiang Zehan' Memorial Collection, 1998). In addition, he founded the Department of Mathematics at Lingnan University in 1949, and later participated in the foundation of the Department of Mathematics at Sun Yat-sen University. Liu Jinnian returned to Nankai after graduating from Harvard in 1930, and devoted the rest of his life to the Department of Mathematics at Nankai.

In addition, Yan Jiazou was the early head of the Department of Mathematics at Tangshan Road Construction and Mining College, and Mao Yisheng was one of his students, but unfortunately Yan left mathematics education soon afterward due to his political career. Zhao Fangxiong and Shi Xianglin joined Tsinghua University and National Central University separately after they returned to China, and both of them served as department chairmen (Cheng, 1995; Cheng, 1999).

In the National South-West Associated University during the war period, there were there heads of the Department of Mathematics in succession, two of whom were Jiang Zehan and Zhao Fangxiong, and more than one-third of the professors were Harvard graduates (Peking University, Qinghua University, Nankai University, & Yunnan Normal University, 1998). Here, Jiang Zehan lectured on advanced algebra, topology, etc., while Shen Youcheng lectured on advanced calculus and the theory of bit functions, and Liu Jinnian lectured on the theory of ideal sets, in addition to which they held seminars on Lie group, topology, algebra, analysis, and other topics. The mathematical journals and monographs shipped to Kunming by Jiang Lifu were very helpful for the teaching and researching at that time. During the eight years, the Department of Mathematics published a total of 127 research papers and many of the papers had reached the international advanced level (Xu, Guo, & Yuan, 2004). In fact, the Department of Mathematics at National South-West Associated University already had the level of training doctoral degree, but China had not set up a doctoral degree system at that time (Zhang, 1999).

4.2. Compiling Mathematics Textbooks

During the first half of the 20th century, the reform of educational system in China created an urgent need for appropriate mathematics textbooks. Under this circumstance, these Harvard graduates were actively involved in the development of mathematics textbooks for universities and middle schools.

For example, Qin Fen and Jiang Lifu, with the aid of China Foundation for the Promotion of Education and Culture, they participated in organizing experts to compile high school and college textbooks (Zhang, 1999). Jiang Lifu was also appointed as a member of the editorial board of "University Series"of the Commercial Press, and published a number of college mathematics textbooks, such as *Introduction to Higher Algebra* (Song, 2022). Qin Fen himself had written no less than ten secondary school textbooks, covering algebra, geometry, arithmetic, trigonometry and other secondary school subjects, and many of them are quite influential. According to a national survey in 1919 (Ni, 1919), the most widely used secondary school algebra textbook was *Algebra*, co-edited by Qin Fen and Qin Yuan; the second most widely used secondary school geometry textbook was *Geometry*, co-edited by Qin Fen and Qin Yuan; and the second most widely used secondary school arithmetic textbook was *Arithmetic*, co-edited by Qin Fen and Xu Shanshiang. In particular, the textbook *Algebra*, published in 1914, had reached

its 31st edition by 1930 and 39th edition by 1932, which showed the high popularity and influence of his textbooks.

4.3. Unifying the Mathematical Terminology in Chinese

In the first half of the 20th century, there were two national efforts to unify the translation of mathematical terminology, and the results were concentrated in *Compendium of Mathematical Terminology* which was compiled and reviewed by the Scientific Terminology Review Committee in 1938 and in *Mathematical Terminology* compiled and printed by the National Compilation and Translation Center.

In 1923, the Scientific Terminology Review Committee commissioned the Science Society of China to propose a draft of mathematical Terminology, which was assigned to Hu Mingfu and Jiang Lifu. The fact that there was no honorarium for the drafting work showed the dedication of the participants to Chinese mathematics. After ten years, 3216 mathematical terms were unified and published in 14 batches in the journal *Science* between 1925 and 1932. In 1938, the Scientific Terminology Review Committee compiled them into a book and published it named *Compendium of Mathematical Terminology* (Cao, 1938).

In 1932, the National Compilation and Translation Center was established, and 15 Chinese mathematicians, including Jiang Zehan, Jiang Lifu, and Wang Renfu, etc., were appointed to form a Mathematical Terminology Review Committee by the Ministry of Education (MOE). 3426 mathematical terms were determined in September 1935. In October 1935, the MOE issued the results of the review to the whole country. After the completion of the manuscript, it was not published in time due to the July 7th Incident. Finally, it appeared as *Mathematical Terminology* in 1945 (National Compilation and Translation Center, 1945).

Harvard graduates such as Jiang Lifu, Hu Mingfu, Jiang Zehan, and Wang Renfu deeply involved in unifying the Chinese translation of mathematical terminology, which contributed to the dissemination and localization of modern mathematics in China in the 20th century. Many terms are still in use today, such as the translation of "topology" 拓扑学, which was proposed by Jiang Lifu.

4.4. Establishing Chinese Mathematical Academic Organizations

After attending the annual meeting of the American Mathematical Society (AMS) in 1916, Hu Mingfu published an article introducing the AMS and its annual meeting to China in the journal *Science* (Ren & Zhang, 1995).

In 1935, the Chinese Mathematical Society was founded, and Wang Renfu and Qin Fen were elected as the first directors, and Jiang Zehan was elected as the vice-president. In 1936, the *Journal of the Chinese Mathematical Society* was established, with Jiang Zehan as an editorial board member, and Shen Youcheng published his doctoral dissertation in the first volume of the journal to support its establishment. In 1940, Jiang Lifu was elected as the first president of the new

Chinese Mathematical Society, and Jiang Zehan was elected as a member of the board of directors (Ren & Zhang, 1995).

It is clear that Harvard graduates played an important role in the founding of the Chinese Mathematical Society.

4.5. Founding Mathematics Research Institutes

In 1941, the Academia Sinica appointed Jiang Lifu as the director of the preparatory office of the Institute of Mathematics, and engaged Jiang Lifu, Jiang Zehan, and Chern Shiingshen as part-time researchers. In 1947, the Institute of Mathematics of the Academia Sinica was founded, and Jiang Lifu was appointed as the first director. In 1950, Jiang Zehan was involved in the preparation for the Institute of Mathematics of the Chinese Academy of Sciences and served as the vice-director of the preparatory office. Harvard graduates were involved not only in the founding of national-level mathematical research institutes, but also in the creation of research institutes within the university. In 1917, the Institute of Science at Peking University was established, with Qin Fen presiding as the first director of the institute's mathematics department (Anonymous, 1917), which pioneered mathematical research at Peking University.

5. Conclusion

Chinese students going to Harvard University to study modern mathematics began in the 1900s, which was a historical comprehensive product of the change from confrontation to détente between China and the United States and the reform of China's educational system. The insightful people from the political, educational, and religious circles of China and the United States paved the way for Chinese students to study in the United States, while Harvard University opened the door for Chinese students to improve U.S.-China relations.

In the first half of the 20th century, more than ten Chinese students, including Qin Fen, Wang Renfu, Yan Jiazou, Hu Mingfu, Jiang Lifu, Liu Jinnian, Jiang Zehan, Yang Shanji, Shen Youcheng, Zhao Fangxiong, Shi Xianglin, and Qin Yuanxun, were sent abroad to study mathematics at Harvard University. Under the influence of the Scientific Salvation Movement and the New Culture Movement, they were selected and funded successively by local governments' finances, the Boxer Indemnity Scholarship, and Tsinghua School's Program for U.S.-Bound Students, to seek new knowledge in mathematics at Harvard. They studied and researched in areas such as integral equations, differential equations, non-Euclidean geometry, nonlinear dynamics, numerical analysis, topology, differential geometry, harmonic analysis, and other modern mathematics, covering analysis, geometry, and algebra, with international cutting-edge topics. Moreover, at Harvard, they saw the infinite possibilities of Chinese mathematics in the future, and found a role model to follow in building Chinese mathematics. The mathematical knowledge and academic training they gained at Harvard, as well as their vision and academic interests, provided a solid foundation for them to build modern

Chinese mathematics.

After they returned to China, together with their domestic colleagues, they not only participated in building university mathematics departments in Peking University, Nankai University, Datong University and other colleges and universities, but also took an active part in the compilation of mathematical textbooks, the unification of mathematical Terminology, the establishment of the Chinese Mathematical Society and other academic societies, and the foundation of the Research Institute of Mathematics of the Central Academy of Sciences and other research institutes, which contributed to the development of modern mathematics in China and the cultivation of Chinese mathematical talents.

The institutionalization of modern mathematics was the most important historical achievement of mathematics in the first half of the 20th century in China. The establishment and construction of mathematics education institutions represented by university mathematics departments, the emergence and development of mathematics research institutions represented by the Institute of Mathematics of the Academia Sinica, the foundation and growth of mathematics academic societies represented by the Chinese Mathematical Society constitute, as concrete details, together constituted the historical process of the institutionalization of modern mathematics in China.

In all of these accomplishments, Harvard graduates deserved much of the credit. It could be said that Harvard University made an outstanding historical contribution to the cultivation of early talents in modern Chinese mathematics. And through the groundbreaking work of these graduates after their return to China, Harvard had a profound influence on the historical development of Chinese mathematics in the first half of the 20th century and even in the 20th century.

Conflicts of Interest

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

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