Facing the change and meeting the challenge: Mathematics education in China in the second half of the nineteenth century

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Abstract

This paper on the mathematics curriculum in China in the second half of the nineteenth century focuses on what happened in the teaching of mathematics in *Tongwen Guan*, with illustrative examples taken from the examination questions and students' homework assignments.

1. INTRODUCTION

The Earliest Modern Government Schools in China begins with the following passage:

> "The early decades of the nineteenth century found China virtually untouched by Western influences. Legitimate trade with Europeans was confined to Canton and Kiakhta, both far from the center of the country. Christian missionary activity, which had flourished during the seventeenth century, had been proscribed since 1724. The British Macartney embassy (1792-1793) had failed completely in its effort to persuade the Chinese government to open diplomatic relations and to permit the expansion of Anglo-Chinese trade. The Amherst mission of 1816, which had similar aims, was a fiasco. By the end of the 1830's, however, Great Britain was prepared to use force to improve the position of its merchants in China, and the so-called Opium War (1840-1842) breached the hitherto solid Chinese wall against Europeans." [Biggerstaff 1961, pp.1-2]

The author, Knight Biggerstaff, goes on to claim that the period between the first use of military force by Great Britain on China in 1840 and the overwhelming

defeat of China at the hands of Japan in the First Sino-Japanese War in 1895 was "the time when the seeds of modernization were sown in China". The "humiliating defeat by a modernized and hitherto despised Japan" prompted the Chinese people to "give serious consideration to the need for fundamental change". [Biggerstaff 1961, p.2]

This paper, which is a "zoom in" on the part of mathematics education in China in the second half of the 19th century recounted in "Mathematics education in East Asia from antiquity to modern times" [Siu 2009], tells a story of "change" and "modernization". The latter term becomes synonymous with "Westernization" (in a sense somewhat like the term "globalization" is used today!), because historical happenings brought about a dominance of Western civilization since the 17th century. In the instance of China, the story was complicated by what happened to China from the mid-19th century to the beginning of the 20th century, the plight inflicted upon her by Western powers in their intention for expansion of oversea markets and establishment of new ports. In the words of Li Hong-zhang, a leading Chinese statesman and diplomat of the late Qing Empire, China was during that period facing "an unprecedented great change in more than three thousand years of history".

As pointed out by one of the authors of this paper:

> "It will be a meaningful task to try to trace the "mental struggle" of China in the long process of learning Western science, from the endeavour of Xu Guang-qi, to the resistance best portrayed by the vehement opposition of Yang Guang-xin, to the promulgation of the theory that "Western science had roots in ancient China", to the Self-strengthening Movement, and finally to the "naturalization" of Western science in China. It is a complicated story embedded in a complicated cultural-socio-political context." [Siu 1995/96, p.171]

2. HISTORICAL CONTEXT

To understand the historical context it does well to consult a general text in history, of which there is no dearth of references. However, the period under discussion was so eventful and involved the national interests of so many countries or even different political ideologies that the historiographies of the mass of references are varying, not just in place but even in time of writing, and

conflicting, even just from a selected few [Bai 1989, Fairbank/Reischauer 1973, Fan 1947, Hsiao 1923/1925/1963, Hsü 1970/1995, Twitchett/Fairbank 1978/1980]. We prefer to let the characters that played their roles in the episode speak for themselves. That explains why at some place the authentic historical documents are quoted at unusual length, taxing on the patience of the reader. An impatient reader may choose to skip these long passages, but will miss the opportunity of seeing the arguments of different parties in a better light.

In *The Rise of Modern China* C.Y. Hsü describes "modernization" as a "search for a way to survival in the new world that had been forcibly thrust upon China by the West after the mid-19th century." He continues to point out that the Chinese, "burdened by tradition and heritage, and as yet ignorant of the nature of the Western world, groped in the dark" and looked for a way to live with the great change. What is referred to as a "mental struggle" in the preceding paragraph is, in the words of Hsü, "an extremely hard struggle against the weight of pride, disdain for things foreign, and the inveterate belief that the bountiful Middle Kingdom had nothing to learn from the outlandish barbarians and little to gain from their association." [Hsü 1970/1995, pp.9-10].

This long struggle that progressed in stages shaped modern China. According to the summary of a Chinese historian:

> "first, technologies affecting material existence; then principles concerning state and society; and finally, ideas touching the inner core of intellectual life. The Self-strengthening Movement of the T'ung-chih [Tongzhi] period, the reform movement of 1898, and the May Fourth Movement of 1919 marked the climatic points of these three stages".[Hsiao 1962, p. 130]

This series of changes was reflected in the area of mathematics education as well. This paper proposes to tell this story.

C. Y. Hsü rightly points out that "modern China represents such a broad spectrum of kaleidoscopic change that […] it cannot be satisfactorily explained by the restrictive theories of foreign imperialism, Western impact, or capitalistic and feudal exploitation." In a similar vein as explained in the works of Benjamin Elman (for instance, *On Their Own Terms: Science in China, 1500-1900* [Elman 2005]) Hsü maintains that "the dynamics of change suggests that modern Chinese history is not characterized by a passive response to the west, but by an active

struggle of the Chinese to meet the foreign and domestic challenges in an effort to regenerate and transform their country from an outdated Confucian universal empire to a modern national state, with a rightful place in the family of nations." [Hsü 1970/1995, p.13] This brought about revolutionary changes in the Chinese political system, economic institution, social structure and intellectual attitudes. Education is part of the institution, and is an important part which both influences and is influenced by the other parts.

Historians are generally divided into two groups that offer two different answers to the question: When did modern China begin? One group of historians takes the Opium War of 1839-1842 as the point of departure, the beginning of foreign imperialism in China. Another group of historians takes the arrival of European explorers and missionaries during the transition period from the Ming Dynasty to the Qing Dynasty in the first half of the 17th century as a starting point. Note that the arrival of the Europeans coincided with the rise of the ethnic group of Manchu people to power leading to the establishment of the Qing Dynasty, at the time regarded by the Han people as alien as well. The latter group of historians regards Western impact in the mid-19th century as only an extension and intensification of a process already set in motion two and a half centuries earlier. In this paper we will take the second viewpoint, but to keep the paper within a prescribed length we will confine discussion to what happened in the last fifty years of the Qing Empire, although we fully recognize that what went on from the beginning of the 17th century to the mid-19th century had its effect in no small way. (A story on the transmission of European mathematics in the early 17th century is told by one of the authors [Siu 1995/96, 2012b]. In another paper in preparation the same author will tell the story of the transmission of European mathematics in the court of Emperor Kangxi during the first part of the 18th century.) To see a more complete picture one should actually look at East Asia as a whole. The historical context is explained in general texts such as *East Asia: Tradition and Transformation* [Fairbank/Reischauer/Craig 1989] .

3. ESTABLISHMENT OF *TONGWEN GUAN*

During the Second Opium War (1856-1860) the Anglo-French allied army advanced to near Beijing (Peking) in September 1860. The troops plundered and set in flames the renowned Summer Palace in the suburb of Beijing. Emperor

Xianfeng had to flee the capital, leaving behind his sixth brother, Prince Gong (Yi-xin), to conduct negotiation with the victorious British and French envoys. (This caused the conservative officials to dub Prince Gong the disparaging nickname of "*guizi liu* (foreign devil six)" afterwards to accuse him of colluding with the "foreign barbarians"!) Prince Gong and some ministers who supported him submitted a memorial to the Emperor on January 13, 1861 that said:

> "[…]The present case is somewhat different from the (barbarian invasions) of former dynasties.[…] Now the Nien rebellion is ablaze in the north and the Taiping in the south, our military supplies are exhausted and our troops are worn out. The barbarians take advantage of our weak position and try to control us. If we do not restrain our rage but continue the hostilities, we are liable to sudden catastrophe. On the other hand, if we overlook the way they have harmed us and do not make any preparations against them, then we shall be bequeathing a source of grief to our sons and grandsons. The ancients had a saying, "Resort to peace and friendship when temporarily obliged to do so; use war and defense as your actual policy." […]
>
> After careful deliberation on the whole situation we have drafted six regulations:
>
> (1) To establish at the capital the *Tsung-li ko-kuo shi-wu ya-men* [office in general charge of foreign affairs, commonly referred to as *Tsungli Yamen*, in pinyin "*Zongli Yamen*"] […]
>
> (5) To select two persons from Canton and two from Shanghai who understand written and spoken foreign languages and send them to Peking for consultation. […]"

The first regulation led to the establishment of the Foreign Office, and the fifth regulation led to the establishment of *Tongwen Guan* (School of Combined Learning), at first intended as a language school to train interpreters but later developed into a college of western learning, along with other colleges of similar nature that sprouted in other cities like Shanghai, Guangzhou, Fuzhou, Tianjin, along with the establishment of arsenals, shipyards and naval schools [Biggerstaff 1961, Du/Lin/Guo 1991, Swetz 1974, Xiong 1994]. (Historical documents quoted in this and the next section are taken from a collection of official documents [Palace Museum 1929/30, Teng/Fairbank 1954/1965]. Transcription of names in the Wade-Giles system may differ slightly from that in the pinyin system.)

This proposal resonated with that raised in a famous essay by Feng Gui-fen, a scholar in Suzhou who had served as secretaries to high provincial officials at various intervals. Feng was probably the first one to coin the term "*ziqiang* (self-strengthening)" to emphasize the approach one should take to tackle the grave problems China was facing at the time. He said in the essay of 1861:

> "[…] Moreover, during the last twenty years since the opening of trade, a great many of the foreign chiefs have learned our written and spoken language, and the best of them can even read our classics and histories. They are generally able to speak on our dynastic regulations and government administration, on our geography and the state of the populace. On the other hand , our officers from generals down, in regard to foreign countries are completely uninformed. In comparison, should we not feel ashamed? The Chinese officials have to rely upon the stupid and silly "linguists" ["*tongshi*"] as their eyes and ears. The mildness or severity, leisureliness or urgency of their way of stating things may obscure the officials' original intent after repeated interpretations. Thus frequently a small grudge may develop into a grave hostility. At the present time the most important administrative problem of the empire is to control the barbarians, yet the pivotal function is entrusted to these people. No wonder that we understand neither the foreigners nor ourselves, and cannot distinguish fact from reality. Whether in peace negotiations or in deliberating for war, we can never achieve the essential guiding principles […]
>
> If my proposal is carried out, there will necessarily be many Chinese who learn their written and spoken languages; and when there are many such people, there will certainly emerge from among them some upright and honest gentlemen who thoroughly understand the fundamental of administration, and who would then get hold of the essential guiding principles for the control of foreigners. […]"

4. CONTROVERSY OVER THE *TIANWEN SUANXUE GUAN*

In the same essay mentioned above Feng also stressed the importance of learning mathematics and science for the country to attain wealth and strength:

> "At the same time they should learn mathematics. (Note: All Western knowledge is derived from mathematics. Every Westerner of ten years of age or more studies mathematics. If we now wish to adopt Western knowledge, naturally we cannot but learn mathematics, […])"

On December 11, 1866 the Foreign Office submitted a memorial to Emperor Tongzhi which proposed the addition of a *Tianwen Suanxue Guan* (School of Astronomy and Mathematics) in *Tongwen Guan* to which only members of the traditionally educated elite might be admitted through selection by examinations, and they would be taught by foreign teachers employed by the School. This memorial provoked a bitter controversy between the conservative officials and the progressive party in the Foreign Office.

On January 28, 1867 the Foreign Office submitted a second memorial on this issue appended with a set of six regulations for the proposed School. This

memorial is defensive in tone, refuting several anticipated arguments by opponents. Indeed, the proposed name of the School already indicates their caution, with "*tianwen*" and "*suanxue*" being Chinese terms that had been in use for ages, while the broader objective for establishing the School was to teach mathematics and science. The new term coined for science at the time was "*gezhi*", borrowed from the term "*gewu zhizhi* (investigating things and extending knowledge)" in the doctrine of neo-Confucianism of the 12th century. Even if the term possessed such a Chinese label, it was still considered to be too new that the proponents of the School preferred to use "*tianwen suanxue*" instead.

Anson Burlingame, appointed as Minister to China by President Abraham Lincoln of the USA in 1861, sensed the significance of this incident and reported it to William Henry Seward, then Secretary of State of the USA, with the two memorials translated and attached with his letter dated April 10, 1867 [US Department of State 1861-1954].

> "[…]It appears that the machinery of western nations, their artillery, their steamers, and their military tactics, are, without exception, the result of mathematical (or physical) science. […]We, your Majesties' ministers, have, therefore, resolved to propose the establishment of an additional department, and to invite educated men, both Manchus and Chinese, who have attained the grade of master of arts, or have been promoted among the bachelors of arts, who are over twenty years old, and well versed in their native literature, to […] be examined at our office with a view to admission into this new institution. We would also admit officials of the fifth grade or under, being still young and possessed of good parts, of either race, who may be inclined to enter and pursue these studies, […]we would proceed to invite men from the west to give instruction in the college, with the expectation that the scholars would thus acquire a complete knowledge of astronomy and mathematics. […]"
>
> "[…]Cavillers, who have not so carefully examined into this question, will undoubtedly allege that there is no pressing urgency for us now to bring forward this scheme; or they will object that it is wrong to discard our national usages and arts in order to adopt those from the west; and some will even assert that it is a humiliation for China to employ foreigners instead of natives. […] If, therefore, we ourselves can understand clearly the principles, and learn the construction of such things, their utility will be all our own. […] that it is impolitic to discard our national arts and modes in order to adopt those from the west, is a very prejudiced remark. Now, it has been ascertained that the foundation of western (astronomical) science was derived from the original observations of the Chinese; and, indeed, those nations believe that their arts originally came from the east. But their learned men, being skilled in deep analysis, and clever at working out an idea, were soon able to eliminate what was old (or erroneous) and develop new [thoughts and modes,]

which they thereupon presumed to call foreign and outside; while at bottom they were nothing more nor less than Chinese art and science. […]Furthermore, the learning and arts of foreigners were highly approved by our most holy Emperor [canonized the] humane, viz, the Emperor Kanghi; […]Among the six liberal arts, mathematics holds a high place. […]The third objection, that it is disgraceful to learn from foreigners, is still more unreasonable and stupid; for of all shame worthy things in the world, the most shameful is to willingly be inferior to one's fellow.[…]"

To the second memorial the Emperor added the remark, "Let the thing be established in conformity to the proposed plan." Five weeks later a censor Zhang Cheng-zao submitted a memorial to point out that the educated elite should not be distracted from the traditional scholarly curriculum to learn such "petty techniques" and should pay attention to cultivate the character, and that it was sufficient to send either young students in the Astronomy Bureau or artisans and technicians in the Ministry of Public Works to pursue this kind of study.

On the same day an Imperial edict rejected the criticism from Zhang and said:

"[…] we consider that the sciences of astronomy and mathematics are branches of knowledge of which no scholar should be ignorant; they can in nowise be looked upon as mere mechanical arts. These sciences will be more easily mastered by regularly educated person, who have of course more power of application and general intelligence, than others. […] The plan is simply borrowing western science in order to supplement and illustrate that already existing in China. The sacred philosophy [of Confucius] is not thereby abandoned, nor do we enter on any out-of-the-way path of investigation. What injury, then, can result to the public mind, or to the interests of true scholarship by its adoption?"

However, the Imperial edict did not deter the conservatives. A grand secretary named Wo-ren submitted a memorial with a much stronger tone of dissent, pleading for abolishment of the proposed plan, on March 20, which was not to be taken lightly because this grand secretary was also the tutor of Emperor Tongzhi, who was at the time but an 11-year-old boy, considering the deep respect a student paid to the teacher in traditional Chinese culture. In rebuttal the Foreign Office answered with a long memorial dated April 6. These two memorials depict the conflict so vividly that it is worth quoting both almost in their entirety.

The memorial from Wo-ren said :

"[…] Mathematics, one of the six arts, should indeed be learned by scholars as indicated in the Imperial decree, and it should not be considered an unworthy subject. But according to the viewpoint of your slave, astronomy and mathematics are of very little use. If these subjects are going to be taught by Westerners as regular studies, the damage will be great. […]Your slave has learned that the way to establish a nation is to lay

emphasis on propriety and righteousness, not on power and plotting. The fundamental effort lies in the minds of people, not in techniques. Now, if we seek trifling arts and respect barbarians as teachers regardless of the possibility that the cunning barbarians may not teach us their essential techniques---even if the teachers sincerely teach and the students faithfully study them, all that can be accomplished is the training of mathematicians. From ancient down to modern times, your slave has never heard of anyone who could use mathematics to raise the nation from a state of decline or to strengthen it in time of weakness**.** The empire is so great that one should not worry lest there be any lack of abilities therein, If astronomy and mathematics have to be taught, an extensive search should find someone who has mastered the technique. Why is it limited to barbarians, and why is it necessary to learn from the barbarians?

Moreover, the barbarians are our enemies. In 1860 they took up arms and rebelled against us. Our capital and its suburb were invaded, our ancestral altar was shaken, our Imperial palace was burned, and our officials and people were killed or wounded. There had never been such insults during the last 200 years of our dynasty. All our scholars and officials have been stirred with heart-burning rage, and have retained their hatred until the present. Our court could not help making peace with the barbarians. How can we forget this enmity and this humiliation even for one single day?

Since the conclusion of the peace, Christianity has been prevalent and half of our ignorant people have been fooled by it. The only thing we can rely on is that our scholars should clearly explain to the people the Confucian tenets, which may be able to sustain the minds of the ignorant populace. Now if these brilliant and talented scholars, who have been trained by the nation and reserved for great future usefulness, have to change from their regular course of study to follow the barbarians, then the correct spirit will not be developed, and accordingly the evil spirit will become stronger. After several years it will end in nothing less than driving the multitudes of the Chinese people into allegiance to the barbarians. Reverently your slave has read the instruction to the grand councilors and officers of the nine government bureaus in the *Collected Essays of the K'ang-hsi Emperor,* in which he says, "After a thousand or several hundred years, China must be harmed by the various countries of Europe." The deep and far-reaching concern of the sage Emperor is admirable. Even though he used their methods, he actually hated them. Now, the empire has already been harmed by them. Should we further spread their influence and fan the flame? […]".

The memorial in rebuttal from the Foreign Office said:

"[…]Your ministers have examined the memorial of Wo-jen: the principles he presents are very lofty and the opinion he maintains is very orthodox. Your ministers' point of view was also like that before they began to manage foreign affairs; and yet today they do not presume to insist on such ideas, because of actual difficulties which they cannot help.[…]

From the beginning of foreign relations to the present there have been twenty or thirty years. At first the officials inside and outside the capital did not grasp the crux of the

matter, and whether they negotiated peace or discussed war, generally there were empty words without effect; and so the incident of 1860 arose. At that time the foreign troops approached our city wall, and the gun-fire and flames illuminated the sky. The capital was in peril day and night. Scholars and officials either stood about, putting their hands in their sleeves, or fled away confusedly. Our deceased Emperor did not consider his ministers , I-hsin [Prince Kung] and others, to be unworthy, and ordered them to remain in Peking to manage the peace negotiations. […]It has been eight years since the conclusion of the [1860] treaty. The matters in negotiation between China and the West have been extremely difficult. Your ministers jointly have tried their best to maintain the situation, […] Therefore your ministers have pondered a long-term policy and discussed the situation thoroughly with all the provincial officials. Proposals to learn the written and spoken languages of foreign countries, the various methods of making machines, the training of troops with foreign guns, the dispatching of officials to travel in all countries, the investigation of their local customs and social conditions and the establishment of six armies in the area of the capital in order to protect it --- all these painstaking and special decisions represent nothing other than a struggle for self-strengthening. […]

Your ministers have also discussed this in correspondence with Tseng Kuo-fan, […] and others. They all agreed that the clever methods for manufacturing [steamships and firearms] must begin with mathematics.[…].

We are afraid that the people who are learning these things will have no power of discrimination and are likely to be led astray by foreigners, as Wo-jen fears. Therefore we have deliberated and decided that those who participate in the examinations must be persons from regular scholastic channels. […]

Wo-jen says that the barbarians are our enemies. Naturally this shows that he also has the intention of lying on faggots and tasting gall [i.e. nurse vengeance]. But let us ask, is his nursing of vengeance in this way for the purpose of gaining a temporary fame, or is he going to seek actual results? […] Now upon reading Wo-jen's memorial, one gathers that he considers this action to be absolutely impracticable. The grand secretary has long enjoyed a flourishing reputation for Neo-Confucian studies. As soon as his idea is expressed, there will undoubtedly be a large number from among the scholars and officials who will agree with him. […] this memorial of Wo-jen will not only inhibit scholars henceforth from going forward, but also, we are particularly afraid, will make those inside and outside the capital, who are sincerely performing their duties with no inclination to empty talk, become disappointed and discouraged. […]

If we remain contented with our ignorance, we are deeply concerned lest the situation will deteriorate like a stream running downhill every day. Yet as soon as we seek for some method of pursuing knowledge, then again public opinion will criticize us right and left. […]

Even though we run the risk of receiving the criticism of the empire we will not try to avoid it. But the grand secretary [Wo-jen] considers our action a hindrance. Certainly he should have some better plans. If he really has some marvelous plan which can control

> foreign countries and not let us be controlled by them, your ministers should certainly follow the footsteps of the grand secretary, exhausting their mean abilities in careful discussions with him, in order to show our harmony and mutual help, and to console your Imperial anxiety. If he has no other plan than to use loyalty and sincerity as armor, and propriety and righteousness as a shield , and such similar phrases, and if he says that these words could accomplish diplomatic negotiations and be sufficient to control the life of our enemies, your ministers indeed do not presume to believe it. […]"

Wo-ren stubbornly submitted yet another memorial a week later to reiterate his points. On April 23 the Foreign Office submitted two memorials in succession. The first one pointed out the damage caused by the opposition party in the greatly diminished number of applicants to the proposed School for fear of being held in contempt or ridicule. In the second one the Foreign Office made a clever move by taking up Wo-ren's boast that a country as large as China must have lots of competent astronomers and mathematicians who could be employed as teachers, only that the Foreign Office failed to locate them for the past two decades. They expressed pleasure that Wo-ren knew of the existence of such competent teachers and recommended the Emperor to order Wo-ren to form his own School and supervise it, working alongside for a better outcome.

Two days later Wo-ren submitted a memorial to say that he saw no reason why the work started by *Tongwen Guan* should be stopped and asked to be relieved of the assignment to set up another similar school, which was not necessary. He admitted that he knew of no skilled astronomers nor mathematicians to set up another school. The Emperor accordingly relieved him of this responsibility on the same day. It is interesting to read a letter from Burlingame to Seward dated May 8, 1867 in which he reported that Prince Gong told him that Wo-ren was appointed an additional member of the Foreign Office but that Wo-ren earnestly requested that his appointment might be rescinded. Burlingame added the remark, "This is considered by us a very skilful method of silencing the leader of the opposition." Finally the disturbed grand secretary had to plead for relief of duty on the ground of illness!

An ending note of this controversy was a very lengthy memorial submitted on June 30, 1867 by an expectant Magistrate named Yang Ting-xi, which connected the prevailing drought and plague at the time with dissatisfaction of the Heaven with this action of the *Tongwen Guan*, and even levied slanderous accusations upon the motives of members of the Foreign Office. The points raised before by Wo-ren were reiterated but further expanded into a list of ten wrong doings of the

Foreign Office. However, being an official of relatively low rank, Yang was promptly reprimanded in an Imperial edict that called him ignorant and his memorial absurd. It looks like the controversy ended with victory for the progressive party. In actual fact there was no winner in the battle. The proposed School could not attract enough students, not to say good students, in the beginning years until later after Li Shan-lan was appointed Professor of Mathematics in 1869, and when better students were transferred from similar language schools set up in Shanghai and Guangdong. Resulting from intricate court politics and the inconsistent attitude of Empress Dowager Cixi towards the progressive party for balancing her own power, Prince Gong, though seemingly had an upper hand in this battle, started to lose power as the prime leader of the Self-strengthening Movement.

The one advantage gained through this controversy was that people became more aware of the importance of mathematics. Looking back at this episode we realize that the role of mathematics and science was actually never in question. Basically the episode was a reflection of court politics and clash between Chinese traditional culture and modern practice, aggravated by a suspicion of foreign influence due in most part to what foreign aggression had brought upon China in the 1840s and 1860s. As Biggerstaff puts it, "Cultural pride and ignorance of the outside world could explain this attitude, particularly among the ruling class, but experience with Western arrogance and aggression inevitably added resentment to this natural feeling. […] There was mistrust of the use of foreigners as teachers, particularly when the foreign teachers were Christian missionaries.[…] Surely the foreign teacher would supply misinformation harmful to China or use his position to subvert his students --- to undermine their loyalty to their cultural heritage and to their government. […] many educated Chinese feared what they regarded as a threat to the privileged position conferred upon them by their mastery of the subject matter of the traditional examination." [Biggerstaff 1961, pp.71-73]

The Self-strengthening Movement started as an effort to gain wealth and strength for the country in the face of foreign aggression, exemplified by slogans such as "learn the strong techniques of the [Western] barbarians in order to control them". The trend of thinking converges with that of the "statecraft school", also known as "*shixue* (concrete learning)", which stressed "*jingshi zhiyong* (practical use in administering society) and which became prevalent

among intellectuals since the early years of the Qing Dynasty [Ge 1994]. Mathematics and science were regarded as tools for achieving this aim. The overwhelming defeat in the First Sino-Japanese War in 1895 spelled a sign of failure of this effort, to be aggravated later by the humiliating occupation of the capital and nearby cities by the expeditionary force of the Eight-Nation Alliance in 1900 . However, what went on in the second half of the 19th century did contribute to a gradual professionalization of mathematicians in China and their view on mathematics [Dauben 2002, Elman 2005, Horng 1991, Hu 1998, Leung 1995, Li 2005, Tian 2005].

To justify learning from the Westerners the proponents of the Self-strengthening Movement explicated the relationship between traditional (Chinese) learning and new (Western) learning in the context of Chinese culture by borrowing traditional dichotomies in Chinese philosophy such as "*li*(principle)" and "*qi*(ether, matter)", or "*ti*(substance)" and "*yong*(application)", or "*dao*(principle)" and "*qi*(instrument)" . Mathematics was therefore placed in the category of "*qi*". Towards the late 19th century the study of Western mathematics raised the status of mathematics to the level of "*dao*" in the minds of mathematicians, who were themselves gradually becoming members of a professional community. Some intellectuals, notably the three leading figures in the "Hundred-day Reform" of 1898, Kang You-wei, Liang Qi-chao and Tan Si-tong, even saw in mathematics the benefit that it brings to the growth of a whole-person in the broader context of a liberal education [Siu 2012b]

5. EXCERPTS FROM EXAMINATION PAPERS AND HOMEWORK ASSIGNMENTS

When the American missionary William Alexander Parsons Martin became the head of *Tongwen Guan* with Li Shan-lan appointed as Professor of Mathematics in 1869, a two-system curriculum was introduced. One took eight years and the other five years to complete. The eight-year system took in younger boys around fourteen or fifteen as entrants, who spent the first two years learning foreign languages (English, French, Russian, German) and translation, and spent the third year learning geography and history. In the remaining five years translation was an important part of the training, with mathematics, astronomy, science, economics and politics introduced. The five-year system was for older

students for whom it was thought that is was too late to start learning foreign languages but who were better prepared to learn mathematics and science to greater depth. They were taught mathematics and science in Chinese, using books books translated from Western texts in those subjects. In their first year they would learn the mathematics that was taught to students of fourth year in the eight-year system. Besides, in this five-year system, much attention was paid to the learning of Chinese traditional mathematics to enable students to integrate Chinese traditional mathematics with Western mathematics.

A detailed account of the two-system curriculum can be found from many sources [Gao 1992, Zhu 1983]. It was recorded that students in the five-year system studied, in addition to the mathematics learnt by students in the eight-year-system, also *Jiuzhang Suanshu* (Nine Chapters on the Mathematical Art, a Chinese mathematical classic believed to be compiled between the first century B.C.E. and the first century C.E.), *Jihe Yuanben* (probably based on the Chinese translation of the first six books of *Elements* by Xu Guang-qi in collaboration with the Italian Jesuit Matteo Ricci in 1607 and the subsequent nine books by Li Shan-lan in collaboration with the English missionary Alexander Wylie in 1857) and *Siyuan Jie* (On the *Siyuan* method of solving equations), the last subject probably based on the mathematical classic *Ceyuan Haijing* (Sea Mirror of Circle Measurement) of 1248 by Li Ye. Alongside with such study on Chinese traditional mathematics students would learnt algebra, trigonometry and calculus from books translated from Western texts.

By looking at some questions sampled from yearly examinations of *Tongwen Guan* one may obtain a better picture of the content and level of the curriculum. (Question papers can be found in many sources [Chen/Deng 1998, Gao 1992, Zhao/Xue 1995, Zhu 1983]. In the translated version we try as far as possible to retain the original format but in some cases resort to a mathematical language we are more accustomed to today.)

Some questions were apparently set to test students' grasp of the content of *Ceyean Haijing*. Not only is the nature of the problems same as those in that book book but also the technical terms so that someone unfamiliar with the text would not know what is asked at all. (We retain those technical terms in the translation without further explanation, since it would require a rather lengthy explanation

but which may not benefit further understanding of the underlying mathematics.) Examples are:

> Given the "*da cha xian jiao he*" and the "*xiao cha xian jiao jiao*" of a right triangle, find the diameter of the inscribed circle. What is an algebraic expression for the diameter? (Question 6, 1873)
>
> Given the "*bian xian*" and "*di gou*" of a right triangle, find the diameter of the inscribed circle. What is an algebraic expression for the diameter? (Question 8, 1873)
>
> In a right triangle with sides *a*(*gou*), *b*(*gu*) and *c*(*xian*), $c-(b-a)=6$ and $c-a=8$. Find a, b, c. (Question 9, 1872)
>
> Given a right triangle with sides *a*(*gou*), *b*(*gu*) and *c*(*xian*) with $a^2-a=c+(b-a)$. If it is only known that $b=2[c-(b-a)]$, find a, b, c. (Question 1, 1872)

Some questions were set to test students' skill in solving equations by using either the Chinese traditional *siyuan* method or the Western method of algebra. (The presentation in the examination paper is completely different from the modern format, which we adopt here for typographic convenience, but the unfamiliar format reflects the usage of symbols in the translated texts of the time.) Examples are:

> Solve the cubic equation ("*li fang shi*")
>
> $$x^3+x^2+9x-30=0.$$ (Question 10, 1872)
>
> Solve the quartic equation ("*san cheng fang shi*")
>
> $$x^4+10x^3-75x^2-625x+2199=0.$$ (Question 11, 1872)

Some questions were set to test students' knowledge in applying mathematics to work out problems in physics or surveying. Examples are:

> A bullet shot from a gun fired upwards begins to fall after 20 seconds. Find the height it reaches and draw a diagram to explain it. (Question 6, 1872)
>
> A mountain is of height 10.5 *li*. The line of vision drawn downwards makes an angle of $1°6'45"$ with the horizon. Find the diameter of the earth. (Question 2, 1873)
>
> A path across the summit of a hill is of length 25 *li* on each side and both are inclined at an angle of 45 degrees to the horizontal. If a horizontal route is to be dug straight across to join the two extremities, what is the length of the route? (Question 8, 1872)

Some problems were set to test students' knowledge of calculus, which was at the time a very new subject introduced into China through the translation of Elias Loomis's *Elements of Analytical Geometry and of Differential and Integral Calculus* (1850) by Li Shan-lan in collaboration with Alexander Wylie in 1859, bearing the title *Daiwei Ji Shiji* (Analytical Geometry and Differential and Integral Calculus Step by Step). Examples are:

> Expand $u=(w+x)^n$ into a binomial series. (Question 5, 1878)

> A circle is revolved about a tangent line to it. Find the volume of revolution. (Question 6, 1878)

Some problems on geometry indicate that students learnt more than what is in the book *Elements*. One interesting example is:

> A cylinder has height equal to the diameter of its base circle. Then the area of its lateral surface is equal to the surface area of a sphere of diameter equal to the diameter of the base circle, which is equal to 4 times the area of the base circle. Explain why. (Question 3, 1873)

Finally, for comparison purpose we give some sampled questions set for students in the eight-year-system to indicate that heavier demand was placed on students in the five-year system. At the same time these sampled questions show that problems set for students in the eight-year-system are more "down-to-earth". Examples are:

> How many times does a clock strike in one day and night? Check the answer by addition and multiplication. (Question 1 for eight-year-system, 1878)
>
> San Francisco is 20654 *li* from Shanghai. If a steamer travels at 818 *li* per day, how many days does a round trip take? (Question 3 for eight-year-system, 1878)
>
> A thunder is heard 15 seconds after a flash of lightening is seen. Given that sound travels at 560,000 *li* per second, find the distance to the place where the lightening had struck. (Question 5 for eight-year-system, 1878)

Usually one can see more of the curriculum by looking not just at examination papers but other works of the students as well, such as homework assignments, term papers or project reports. We can thereby sense the mood of a wider community. In the late 19th century such works were labeled as "*keyi*", which were sometimes collected into book form by the respective schools, either *Tong Wen Guan* or other private academies. Some of these works were also published in periodicals founded by the foreign missionaries, an important new feature in the propagation of Western learning at the time. We first look at two examples in more mathematical details that serve to illustrate some interesting aspects.

The periodical *Zhongxi Wenjian Lu* (Record of News in China and West) with English title *Peking Magazine* was founded in 1872 by the American missionary William Alexander Parsons Martin and the English missionary Joseph Edkins. Besides news and articles the periodical posed mathematical problems from time to time. Today this is rather commonplace for a periodical in mathematics, but it was a novel practice in those days in China. In Issue No. 5 (December 1872) there appeared a problem that says:

> A plane triangle (acute, right or obtuse) contains thee circles of different radii that touches each other. Want to fix the centres of the three circles. What is the method?

The problem was posed by the School of Astronomy and Mathematics of *Tongwen Guan*, for it was followed by the remark:

> All students in *Tongwen Guan* retreated from trying this problem. Whoever can solve the problem should send the diagram [of the solution] to the School of Astronomy and Mathematics and would be rewarded with a copy of *Jihe Yuanben*. The diagram [of the solution] would be published in this magazine so that the author would gain universal fame.

Indeed somebody submitted a solution that was published in Issue No. 8 (March, 1873), but was commented on by another reader in Issue No. 12 (July, 1873) together with an acknowledgement of the error and a further comment by the School of Astronomy and Mathematics. This kind of fervent exchange of academic discussion carried on in public domain was a new phenomenon of the time in China.

Mathematically speaking we are looking for three circles placed inside a given triangle, each touching two sides of the triangle as well as the other two circles. It is interesting to note (not an easy exercise) that the three radii can be expressed in terms of the three sides of the given triangle and are thus determined, in particular not necessarily all different as the problem in *Peking Magazine* demanded.

This problem became well-known in the Western world after it was first proposed by the Italian mathematician Gianfrancesco Malfatti in 1803. (This problem, originally posed as a problem on optimal area and solved only in the early 1990s, has a very interesting history [Andreatta/Bezdek/Boroński 2010]) The first geometric construction by straight-edge and compasses was proposed by the famed Swiss geometer Jacob Steiner in 1826 without proof, later supplied by the Irish mathematician Andrew Hart. It is worth noting, from the active discussion generated around this problem, how enthusiastic the Chinese were in learning mathematics from the Westerners in the late 19th century. This problem was apparently introduced by Westerners only two to three decades after the problem became well-known in the West, at a time when the Chinese were just beginning to familiarize themselves with Euclidean geometry, which was not part of their traditional mathematics.

In a book on "*keyi*" by students of Longcheng Academy, a private academy famous for its mathematics curriculum, one finds two articles in 1897 that were on

this same three-circle-in-triangle problem, with different solutions and remarks made by the professor at the end. One solution is particularly interesting because it made use of a hyperbola to solve the problem, while the hyperbola is a mathematical object that was totally foreign to Chinese traditional mathematics and was newly introduced in a systematic way only by the mid-19th century. Knowledge on conic sections, particularly on the ellipse, was transmitted into China along with astronomy in the 17th century. A more systematic treatment came with the introduction of calculus in the mid-19th century. Li Shan-lan translated a book titled *Yuanzhui Quxian Shuo* (Explanation on Conic Sections) in collaboration with the English missionary Joseph Edkins in 1859 [Lui 2003]. We lack the documentary evidence to ascertain whether the student independently discovered such a solution on his own or learnt of it from some other source.

The Malfatti problem was posed a bit earlier than Malfatti did by the Japanese mathematician Aijima Chokuyen (also known as Aijima Naonobu). A related problem that asked for the radius of the inscribed circle of the triangle in terms of the radii of the three touching circles was proposed by another Japanese mathematician Takatada Shichi and solved by Kazuhide Omura in his book *Sanpo Tenzan Tebikigusa* (Algebraic Methods in Geometry) of 1841[Fukagawa/Rothman 2008]. Another question of historical interest would be to study how familiar Chinese mathematicians were with Japanese mathematics at the time, or would they pay no attention at all to *Wasan* (Japanese mathematics) of the Edo period, thinking that *Wasan* was but a "tributary" of Chinese traditional mathematics?

The second example appeared in another periodical *Gezhi Huibian* (Collection of Articles in Science) with English title *Chinese Scientific and Industrial Magazine* founded in 1876 by the English missionary John Fryer. In the issue published in April of 1877 there appeared a mathematical problem with the remark that it was taken from a test paper of the School of Astronomy and Mathematics in *Tongwen Guan*. The author was Gui-rong, who was probably still a student at the time, but was appointed an assistant lecturer of the School two years later. The problem says:

> The expression 0/0 is said to take the value 0 by some or the value 1 by some. Is it equal to 0 or 1? Prove it.

Gui-rong offered two (in fact three) explanations. In the first explanation he said that 0/1 = 0, so (1−1)/1 = (1−1), or (1−1)/ (1−1) = 1, that is 0/0 = 1. He went

on to say that were 0/0 =0 (not 1), then 0/0 = 0/1 or (1−1)/ (1−1) = (1−1)/1, which is a contradiction (with same numerators but different denominators for the two equal fractions). In the second (in fact the third) explanation he said that 1/1 = 1, 2/2 = 1, 3/3 = 1, 10/10 = 1, 100/100=1, 1000/1000 = 1, even (infinity)/(infinity) = 1, hence 0/0 = 1. Were 0/0 some other number, how come in all the other cases the answer is 1?

When we look at his argument today we know where he went wrong. But it is interesting to see from this piece of work how students of those days went about proving a mathematical result, a kind of process still of a novel nature to them. What is even more interesting is a long passage that follows the mathematical argument offered above. It is a long passage (much longer than the mathematical argument just given!) that draws on the content of the ancient book *Yi Jing* (Book of Changes) and mentions about revealing the mystery of the universe, reminding the reader of the kind of text which one finds in the prefaces of many Chinese mathematical classics. It indicates that many Chinese learners of Western mathematics in that period, being brought up in classical learning, were still attracted to the indigenous culture.

Several more brief examples will suffice to further depict the mood of the time. In the collection of "*keyi*" of Nanjing Academy one finds an essay with the title "How calculus supplements algebra?", while another essay is on a problem of dividing a sum of 100 *qian* to purchase 100 fowls comprising cocks, hens and chickens of three grades, having known the cost of each type of fowls. This so-called "hundred-fowls-hundred-*qian*" problem, which was a classic problem in Chinese traditional mathematics dated back to the 5th century C.E., was solved by the student using algebra. One question set in the Longcheng Academy actually asked students to compare and contrast the *tianyuan* method and algebra in solving equations. With the introduction of a reformed education system by Imperial decree in 1902 (with its supplemented version implemented in 1903) and the abolishment of state examination in 1905 [Li 2005, Chapter 5] China followed the curriculum of the other modern nations. In particular, the effort devoted to integrating Chinese traditional mathematics and Western mathematics came to an end. After a hundred years, we may learn something from this kind of integration for the benefit of mathematics education [Siu, 2009, 2012a].

In the area of mathematical research we give one example, that on the test of primality explained by Li Shan-lan in his *Kao Shu Gen Fa* (Methods to Examine Primality), which was published in a series of three articles that appeared respectively in Issue No. 2 (September 1972), No. 3 (October 1872) and No. 4 (November 1872) of *Peking Magazine*. This series of articles might have led to a myth that was prevalent in the Western world for some time, namely, that ancient Chinese knew a special case of Fermat's Little Theorem and erroneously took it to be a criterion for primality, that is, n is a prime if and only if $2^{n-1}-1$ is divisible by n. The episode surrounding the discovery of Li Shan-lan is an instructive illustration of the polarized attitude different foreigners took towards Chinese mathematics of the time in the late 19th century [Han &Siu 2008].

6. EPILOGUE

Initially we planned to tell a fuller story. After reading a lot of books and historical material we realize that the story would be too long and its scope too vast for a paper of this length, not only because of the mathematical content but more so because of the intricate and encompassing context that weaves together mathematics and the historical, cultural, social and political aspects. Feeling awed before this grand picture and realizing the limited time and capacity we possess we confine attention to a more focused topic, the curriculum surrounding the School of Astronomy and Mathematics of *Tongwen Guan*. By so doing we have not paid due attention to the role played by two other important factors on mathematics education in China during that period, namely, the mathematics curriculum in the many private academies and the school system set up by the foreign missionaries. Each by itself would constitute another paper.

Towards finishing the paper and looking back, we cannot help but heave a sigh at some moments of "missed opportunities" during that period. Is the Self-strengthening Movement a failure? One historian of science and mathematics says:

> "The analysis of this transmission of Western science to China as a failure relies on the implicit assumption that what China then needed or should then have been inclined to achieve was the reproduction of the European pattern of scientific development. This assumption, which is questionable, questionable, actually stems from the interpretation of 19th century history

in terms of the Chinese incapacity to face Western intrusion for lack of appropriate military technology." [Jami, 1992, p.83]

Indeed, as suggested by Qian Mu in his 1951 book [in Chinese] *Introduction to the Cultural History of China*, without the brutal intrusion of western powers, development of the Chinese culture in the political, social and scientific arenas may achieve a totally different but harmonious existence [Siu 1995/96, p.138]. History proceeded in the way it was and the scenario developed into the one we are in today. To conclude, on this very occasion of the centenary of the 1911 Revolution that founded the Chinese Republic, we take off our story tellers' hats and humbly dedicate this paper to the Chinese people and their Westerner friends who gave so much of their lives and effort selflessly during that period of change and challenge to the cause of bringing China in place among other nations of the modern world.

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