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Troubled Mining: John Fryer and the Difficulties of Cross-Cultural Knowledge Transmission in Late Nineteenth-Century China

Hailian Chen
Universität Leipzig, Deutschland

Abstract John Fryer (1839-1928) was the most prolific translator of Western scientific and industrial works into Chinese. This article uncovers previously unexplored connections between his translation projects and the challenges in Chinese mining during that period. It demonstrates how difficulties in accessing both books and teaching experts shaped the development of mining education in China. These setbacks reveal two overlooked pathways for cross-cultural science communication beyond translation. The obstacles invite us to rethink how China was dis- or re-connected with the West in cultural practices in its pursuit of industrial power and wealth.

Keywords Mining. Education. Late Qing China. John Fryer. Knowledge transmission. Science communication. Book purchasing.

Summary 1 Introduction. – 2 Trade Agents and Overseas Book Purchasing Practices Before 1870. – 3 The Pathway to John Weale's Rudimentary Series on Mining. – 4 A Path Not Taken: Mining Education at Guangfangyanguan Around 1870. – 5 Persistent Efforts in Advancing Mining Education at Shanghai Polytechnic. – 6 Interrupted Convergence of Mining and Educational Practices, 1888-95. – 7 Conclusion.

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1 Introduction

Missionary translators played a crucial go-between role in disseminating Western scientific knowledge to China in the early modern and modern periods. Concepts such as 'trading zones,' or 'contact zones' (e.g. Huang 2005; Schatz, De Giorgi, Ludes 2020), imply that Chinese and Western collaborators in translation projects were challenged by difficulties in communication and coordination.[1] In late Qing China's 'Western Learning' (*xixue* 西學) wave during the Self-strengthening Movement (1861-95), more than 500 books were translated from Western languages into Chinese by missionaries, including those by the missionary-turned-translator John Fryer (Chinese name: Fu Lanya 傅蘭雅) (1839-1928). Scientific and technical subjects accounted for over 70% of all translations into Chinese (Xiong 1994, 11-12). John Fryer was the most productive translator. This Englishman, who had taught at the missionary Anglo-Chinese school before initiating the translation project, translated more than one hundred works,[2] especially from 1868 to 1896, when he worked at the Translation Bureau in the Jiangnan Arsenal in Shanghai.[3] After 1896, he left China for the University of California at Berkeley where he was the first Agassiz Professor of Oriental Languages and Literatures, and where his translating continued. As being widely studied in existing scholarship,[4] John Fryer contributed extensively to the early translations of scientific and technical textbooks, in particular to the formation and standardisation of early terminologies.

A prevailing view suggests that the Western scientific books translated and introduced to China were often outdated, incomplete, or of low quality. This perception holds that the inferior quality of the translations hindered the successful transfer of Western technology that could have otherwise facilitated China's early modernisation (Wright 2000). Wang (2022, 102-4, 122-3), for instance, points out that outdated knowledge about steam engines and heat was introduced to China in the 1870s. This text-centred approach, which evaluates the quality and effectiveness of 'missionary' translations, is heavily influenced by late Qing 'failure' narratives of the Self-strengthening Movement. However, Gow (2023, 108-10), in his study of missionary-sinologist Alexander Wylie (1815-1887), challenges the 'incomplete' or 'Jesuit conspiracy' views by examining the motivations behind

1 E.g. Xiong 1994; Wright 2000; Lackner, Amelung, Kurtz 2001; Lackner, Vittinghoff 2004; Elman 2005; Hsia 2011; Zhang 2015; Wong 2017; Bréard 2019; Song 2024.

2 There is no agreement on the exact number of works translated and composed by Fryer.

3 E.g. Dagenais et al. 2010, 2: 639-44; Wang 2000, 126-33; Tola 2021, 12.

4 Bennett 1967; Xiong 1994, 567-86; Wang 2000; and Tola 2021.

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translating Euclid's Elements in the 1850s. He argues that the selection of works for translation was largely driven by the needs of Chinese intellectuals. To gain a fuller understanding of translation history and knowledge transfer, a contextualised investigation is necessary – one that reveals the political, economic, and cultural contexts in which these translated works were embedded, and the processes through which knowledge was adapted, localised, hybridised, or appropriated within Chinese society. Concrete case studies are still much needed.

This article, focusing on the intersection of John Fryer's translation project and educational practices in late Qing Shanghai, reveals two often-overlooked pathways of cross-cultural science communication for mobilising mining knowledge beyond translation: first, purchasing books and second, hiring teaching experts from the West. It examines how challenges in accessing either books or qualified engineer teachers shaped the trajectory of mining education in late Qing China. Expanding on my previous research on mining education, which explored textbooks, mining literacy, and the institutionalisation of global mining knowledge (Chen 2022; 2023b; 2024), this study delves deeper into the cultural practices that transformed Chinese mining during this period.

Drawing on evidence from corresponding letters and personal papers of John Fryer and Sheng Xuanhuai's 盛宣懷 (1844-1916) archival documents, along with late Qing regulations, and various Western newspapers and book catalogues, this article traces the development of mining education through Fryer's involvement in late Qing 'modernisation' and 'industrialisation' projects in Shanghai. Unlike conventional studies that focus on the curricula or regulations of individual schools, this article investigates the very basic starting points of how books on mining – a loose term used in this article for the Chinese term for 'study of mining' (*kuangxue* 礦學), including mining, metallurgy, and mineralogy – were randomly chosen and purchased with the aid of book catalogues.

This article further reveals Fryer's 'invisible' involvement in two plans for mining education that did not immediately materialise: teaching mining-related subjects at the Jiangnan Arsenal around 1870, and attempting to hire expensive foreign mining engineers from the US to establish a mining school either at Yantai or Shanghai around 1888-89. Fryer laid the foundation for translating and spreading Western mining knowledge in late Qing China (Chen 2022). He translated and compiled nearly all the relevant works (excluding, initially, those by D.J. Macgowan on geology and mineralogy) before departing from the Jiangnan Arsenal. In May 1895, one month after China's defeat in the Sino-Japanese War, he also published a set of engineering curricula (including mining) for the renowned Shanghai Polytechnic (Gezhi shuyuan 格致書院; officially founded in 1876).

Fryer's departure from China following this turbulent period in Chinese history left the implications of his curricula, especially in relation to mining education and China's broader educational reforms, underexplored. Despite a few references, little detailed information has been available. This article argues that these two interrelated plans not only laid the groundwork for the 1895 mining curricula but also reveal the significant obstacles in recruiting 'proper' foreign mining experts – another troubled dimension of cross-cultural science communication that hindered the establishment of institutional technical education in late Qing China.

2 Trade Agents and Overseas Book Purchasing Practices Before 1870

By 1867, after six years in China, John Fryer had so fully integrated into Chinese society that he referred to himself as "almost a Chinaman" (Dagenais et al. 2010, 1: 265). In May 1868, he began his translation work at the Translation Bureau of the Jiangnan Arsenal in Shanghai and made significant efforts to acquire books and apparatus to support the translation initiative. Translation did not begin from scratch; the books to be translated first had to be identified and purchased. Tola (2021, 11-12), for example, points out that Chinese officials initially selected book orders for the Arsenal, and that Fryer took over this role later, after gaining their trust, as reflected in his earliest order stating he was commissioned to procure books and equipment.

A closer examination of Fryer's correspondence regarding book purchases (discussed further below) indicates that his letters, often, if not always, specified that the book orders were placed by the Jiangnan Arsenal or its officials. This phrasing served to underscore the seriousness of the business, ensuring payment guarantees and shipping insurance, while signalling that a larger and more sustained demand was anticipated for future cooperation. As noted later, Fryer had already begun sourcing catalogues and purchasing scientific instruments as early as 1867. It is, therefore, highly possible, that Fryer was directly involved in selecting books for his initial orders, though it is also possible that he sought advice from foreign engineers or trade agents in Shanghai or other Chinese ports at the time.

As Fryer later revealed, the translation project aimed to introduce and disseminate Western practical knowledge through a series of one hundred treatises (*congshu baizhong* 叢書百種), similar in scope to the *Encyclopedia Britannica*, a copy of which had been ordered for Chinese officials in 1867 (Fryer 1880, 78; Guo 1984, 922). The following analysis of a British book publisher John Weale's scientific series, dating back to the 1850s, demonstrates Fryer's sustained interest in

choosing the rudimentary scientific series, supporting the notion that he was involved in book selection from the outset.

A previously overlooked aspect is the fact that, in 1867, when Fryer began seeking references for Western books on science and technology, Shanghai's cultural and commercial infrastructure, such as libraries and media presses for the foreign community, was still being developed. How, then, were foreign residents like Fryer informed about the latest Western publications on these subjects during this period? In the following, I outline the three primary trade agents with whom Fryer collaborated between 1868 and 1870.

During the period from 1868 to 1870, John Fryer ordered over two hundred items, including books, apparatus and other materials for the Jiangnan Arsenal through foreign trade agents.[5] One of the foreign agents (*yanghang* 洋行, lit. '[trans-]oceanic agent') involved in these transactions was Mackenzie & Co. (Chinese name: Longmao 隆茂), managed by James and David Mackenzie. This firm, initially operating as ship chandlers and storekeepers in Shanghai by 1862,[6] evolved into a general agency by 1865, with four to eight employees during the 1860s and 1870s.[7] Fryer's first contact for book orders was Mr. John Battison, a co-director at Mackenzie & Co., in 1868. At that time, the firm was based at 10 Sichuan Road, Shanghai. However, Battison advised Fryer to direct the order to another agent, Smith, Elder & Co. (Dagenais et al. 2010, 1: 348).[8]

Smith, Elder & Co., a family-owned publishing house founded in 1819, became one of the prominent agencies (as bankers and publishers) in British overseas trade, particularly in India, after 1860. Initially focused on exporting books and stationery for East India Company officers, the firm issued its own *Smith, Elder & Co.'s Monthly Circular*, which included both literary reviews and "A Catalogue of

5 Dagenais et al. 2010, 1: 348-52, 374-8, 384-6, 392-9, 419-20, 424-6, 428-34, 458-9.

6 James Mackenzie and David Mackenzie possibly refer to 'J. McKenzie' and 'D. McKenzie', respectively, whose names have been found registered as storekeeper and assistant at a Shanghai ship chandler agent 'Richards, P. F. & Co' (Longtai 隆泰) in 1856 and 1857 (*Shanghai Almanac for the Bissextile or Leap Year 1856 and Miscellany* 1856; *Shanghai Almanac for the Year 1857* 1857). Cf. Fung 2024, 173.

7 *The China Directory for 1862* 1862, 43; *The Chronicle and Directory for China, Japan and The Philippines for 1865* 1865, 211.

8 The editors transcribed the name 'J. Bathson' and 'Mr. Bathson' in the current edition of *Fu Lanya dang'an* (*The John Fryer Papers*), including in a letter dated February 1, 1870 (Dagenais et al. 2010, 1: 427). But the Shanghai directories suggest that 'John Battison' had registered at Mackenzie & Co since 1862, especially in 1868, except for the year of 1863, which appears as 'John Batteson' (*The Chronicle and Directory for China, Japan, and the Philippines, for the Year 1868* 1868, 219; *The Chronicle and Directory for China, Japan, and the Philippines, for the Year 1869* 1869, 229; *The Chronicle and Directory for China, Japan, and the Philippines, for the Year 1870* 1870, 231; *The China Directory for 1862* 1862, 43; *The China Directory for 1863* 1863, 44). This article adopts the name 'John Battison'.

Miscellaneous Articles", illustrating and describing everything at 'home' that could be exported to the East (Huxley 1923, 9-31, 164-5; Finkelstein 2020, 517). In the 1850s, Smith, Elder & Co. was commissioned to purchase books for the Shanghai Library (Wong 2011, 34-35), which possibly continued until at least 1861, given that it printed a catalogue of the Shanghai Library in 1862.[9] After the dissolution of George Smith's partnership with Henry King in 1868, Henry S. King & Co. took over the firm's Indian and export operations, continuing its role as a bookseller for both domestic and export markets (Huxley 1923, 177-8).

Fryer's collaboration with Henry S. King & Co. was short-lived, likely ending with his last order in January 1870 (Dagenais et al. 2010, 1: 424). As indicated in Fryer's letters, several issues led to his growing dissatisfaction with the firm: delayed deliveries, such as the anatomical plates ordered on July 31, 1868, which did not arrive until early May 1869 (385, 388); some apparatus arrived either defective or poorly packed (381, 420); the firm's local receiving agents, Fogg & Co., mistakenly opened a package, damaging the books (388, 398);[10] the firm's slow response to orders, forcing Fryer to turn to other suppliers for urgent items (408);[11] and the failure to honour a promised ten percent discount on book prices, which would have reduced the cost by approximately £10 (381, 452-3). The delays may have been partly due to the reorganisation of business between Smith, Elder & Co. and Henry S. King & Co. However, it is clear that the overseas ordering process for books and apparatus, especially shipping various items to China, presented a new challenge for the trade agents, even for well-established firms like Smith, Elder & Co. and its successor.

The uncertainties associated with remote mail communication prompted Fryer to seek more reliable avenues. With the Arsenal's demands no longer permitting delays, and in order to gain the trust of the Qing government and secure his new position, Fryer returned to working with Mackenzie & Co. in the latter half of 1869 to order books, machinery, and apparatus (Dagenais et al. 2010, 1: 419-20). Several letters from this period suggest that personal meetings during social occasions played a significant role in strengthening Fryer's relationship with Mackenzie & Co. In his postscripts attached to the goods ordering letters, Fryer mentioned social interactions with the firm's clerks. For instance, he met Mr. W.H. Devine on a

9 A book catalogue, titled *Catalogue of the Shanghai Library. Comprising all books included in the collection up to December 1861*, was printed by Smith, Elder & Co. in London, in 1862. The supplement to this catalogue, containing books added to the Shanghai Library from January 1862 to May 1865, was printed by another agent, Lucy and Gregory, also in London (Cordier 1880, 1: 1071).

10 The firm Fogg & Co. was Henry S. King & Co.'s local agents in Shanghai.

11 Fryer's complaints on delays in one letter were dated August 26, 1869.

Friday evening (420)[12] and shared an afternoon tea with Mr. James Buchanan (427),[13] as well as with John Ute, a foreman at the Jiangnan Arsenal.[14] Fryer also invited Mr. Battison, co-director of Mackenzie & Co., to join one of these meetings (427).[15]

Prior to 1868, selling scientific books and apparatus to China was not the primary business of the aforementioned trade agents. John Fryer had requested catalogues from various overseas publishers and booksellers, emphasising that subjects such as "machinery, navigation, naval architecture, gunnery, metallurgy, [and] photography" were of growing interest to Chinese officials and their friends (i.e., private persons outside of Qing government). His letters emphasised that these "illustrated lists of articles and goods" were specifically requested by officials at the Jiangnan Arsenal, who might place much larger orders in the future (Dagenais et al. 2010, 1: 386, 392).

3 The Pathway to John Weale's Rudimentary Series on Mining

Before examining Fryer's selection of mining book catalogues, it is important to note that the widespread reception of scientific and technical learning did not unfold smoothly in Western education systems, even by 1870. The promotion of science education, particularly technological subjects as opposed to classical literature and philosophy, was a lengthy process that involved overcoming cultural prejudices and resistance from elite circles in Europe and the United States (e.g. Fox, Guagnini 1993, 3-4). This previously overlooked aspect of a 'culture in transition' denotes the novelty of modern education and mass consumerism of reading materials in the West during the 1860s. The rapid growth of publishing practical how-to manuals, guidebooks on science, engineering, and the practical arts, as opposed to classical or religious literature, was driven not only by the professionalisation of science but also by the rise of mass education. This shift sought to meet

12 W. H. Devine was registered as clerk at Mackenzie & Co. *The Chronicle and Directory for China, Japan, and the Philippines, for the Year 1869* 1869, 229; *The Chronicle and Directory for China, Japan, and the Philippines, for the Year 1870* 1870, 231.

13 The family name 'Buchnnan' (transcribed in Dagenais et al. 2010, vol. 1) should be 'Buchnan', see registered clerk names of Mackenzie & Co. in *The Chronicle and Directory for China, Japan, and the Philippines, for the Year 1869* 1869, 229; *The Chronicle and Directory for China, Japan, and the Philippines, for the Year 1870* 1870, 231.

14 Dagenais et al. 2010, 1: 427; *The Chronicle and Directory for China, Japan, and the Philippines, for the Year 1870*, 230.

15 As noted earlier, Battison, instead of Bathson, should be the right family name (*The Chronicle and Directory for China, Japan, and the Philippines, for the Year 1869* 1869, 229; *The Chronicle and Directory for China, Japan, and the Philippines, for the Year 1870* 1870, 231).

the growing demand for school textbooks and cater to the emerging middle and working-class readers interested in popular science (e.g. Eliot 2020, 471-84; Mollier, Cachin 2020, 485-97).

John Weale (1791-1862), a prominent British book publisher, gained recognition for distributing popular instructional and guidebooks on scientific and practical knowledge. Beginning in 1849, he published a rudimentary dictionary covering architecture, fine arts, and various branches of engineering, including civil, naval, mechanical, and mining. Designed to guide the "student and the operative workman in the onward path of knowledge" (Weale 1849-50, vi-vii), the dictionary was a success, with 10,000 copies sold by 1860, including distribution to British colonial markets like India. By the fifth edition in 1876, sales reached 20,000 copies (Weale 1860, viii; 1876, vii-viii).

Weale expanded his success by transforming the dictionary into a series of concrete treatises, known as the rudimentary (scientific) series. Launched in the early 1840s, these affordable, illustrated volumes targeted beginners and covered a wide range of scientific and industrial topics. The volumes were priced at just one shilling initially (later rising to between one and two shillings) and aimed to make technical education accessible.[16] By 1861, over one hundred volumes had been planned. The series was widely praised, with reports claiming that "every schoolboy knew the merits of Weale's rudimentary series". It garnered further acclaim by winning the prize medal at the International Exhibition in London (1862) and in Philadelphia (1876).[17] Weale's rudimentary series was regularly updated and continued to be advertised and sold by publishers even after John Weale's death, first by Virtue & Co. (under James S. Virtue) and later by Crosby Lockwood & Son, remaining available at least until 1896.[18]

16 The price of each volume in the 1849-50 version of Weale's rudimentary series was one shilling, see the four pages of "Mr. Weale's New Series of Rudimentary Works for Beginner", appended to Allen 1849-50. Allen's treatise, as noted later in this article, was purchased by the Shanghai library in 1852. Note on advertisements of book catalogues cited in this article: book catalogues were often included as advertisements in volumes published by the same or affiliated publishers and typically appended to the end of the main text. Many of these catalogues have been digitised along with the books by Google Books and other online library platforms. Consequently, when accessing a book such as Allen (1849-50) via Google Books, the accompanying catalogues are often found at the end of the digital volume.

17 Advertisements of Weale's series are commonly seen in almost every book published by Crosby Lockwood & Co from the 1870s to 1890s. For example, "A Catalogue of Books", published by Crosby Lockwood & Son in January 1888, is appended to Michell 1881 (digitised via Google Books) as an advertisement of "Weale's Rudimentary Series". The different publishing years – 1881 for the book and 1888 for the advertisement – showcase that the books were well received and continued to sell steadily years after their initial publication.

18 E.g. the advertisement of Weale's series announced that the series were in the property of Mr. J.S. Virtue since 1862, cf. *The Bookseller: A Handbook of British and*

Many of the well-received treatises in Weale's series were published in the late 1850s and early 1860s, yet they remained in circulation through the 1890s. This enduring popularity, exemplified by Warrington W. Smyth's work on coal mining, aligns with the rise of technical and mass education in the West. Originally intended for Weale's rudimentary treatise, Smyth's treatise was first published by Virtue Brothers & Co. in 1867. However, it continued to appear as part of Weale's series,[19] which by 1891 had reached its sixth edition. Advertisements for the work often emphasised the academic credentials and professional titles of authors, such as Smyth being described in the US book trade journal as "President of the Geological Society, and Chief Inspector of the Mines of the Crown and of the Duchy of Cornwall".[20] These marketing strategies underline the continued importance of authority and reputation in the publishing industry, particularly in the creation of authoritative technical works. When Fryer and other missionaries in the 1860s selected works for translation, such as those published in the 1850s, it is essential to understand this within the context of the slow updating process in best-seller markets, rather than simply labelling their choices as 'out of date'. This perspective provides a more nuanced view of the selection process, highlighting the enduring relevance of older works in the evolving landscape of technical education.

Did John Weale's rudimentary series influence Qing China? This question has been largely overlooked in previous scholarship, with only a general reference to Weale appearing in John Fryer's book-purchasing list. However, the answer is certainly affirmative, and the influence began earlier than typically acknowledged. Evidence suggests that parts of Weale's rudimentary series reached Shanghai no later than 1852. This early introduction of Weale's series played a crucial role in shaping the development of technical education and knowledge transfer in late Qing China, marking the beginning of a broader process of integrating Western scientific and industrial knowledge into Chinese learning and practice.

As Western foreigners began settling in Shanghai after 1843, the city saw not only an influx of foreign commodities to meet the daily needs of its new residents but also the development of cultural

Foreign Literature 1862, 50, 155; *The Publishers Circular and General Record of British and Foreign Literature* 1859, 22(528), 465.

19 For example, Smyth's work appears in both advertisements appended to the book, Weale, Hunt 1873: "A Selection from Lockwood & Co.'s Publications in Industrial and Chemical Science" n.d., 6; and "New List of Weale's Rudimentary, Scientific, Educational, and Classical Series" 1873, 7.

20 "Virtue & Yorston's List. New Publications" 1868, 74.

infrastructure such as schools, clubs, and libraries.[21] One notable establishment was the Shanghai Library, founded in 1849. By 1854, it housed 1,276 distinct works and subscribed to 30 periodicals and newspapers (Pott 1928, 86). By 1870, it had grown to approximately 8,000 volumes (Lang 1875, 43; Shu 2018, 89-91). From 1852 onwards, the library obtained books abroad via the above-mentioned firm, Smith, Elder & Co. (Wong 2011, 34-35), which were often announced in Shanghai's English-language newspapers, initially in *The North-China Herald* (1850-67) and later in *The North-China Daily News*.

Preliminary analysis of these acquisitions before 1870 reveals that most were related to language, religious literature, and popular entertainment. However, in September 1852, thirteen treatises from Weale's rudimentary series were added to the library, including the aforementioned dictionary of terms. Twelve of these treatises focused on subjects such as architecture, bricks and tiles, ventilation, drainage, land surveying, road construction, and contract law.[22] It is very likely that foreign engineers and technical staff – numbering around 250 by that time – working on city planning and infrastructure projects in Shanghai (Bickers 1999, 125) referred to these works. Later, these treatises would become important sources of knowledge for John Fryer as he sought Western scientific and technical resources in the 1860s.[23]

As revealed in his correspondence with merchant brokers, Fryer demonstrated a particular enthusiasm for acquiring books from Weale's series. The practical knowledge contained in these works had already been widely taught at educational institutions in Great Britain, aimed at training artisans and workers, in an earlier generation than Fryer's. For example, Alexander Wylie, a Scottish missionary-sinologist, was likely familiar with articles from *Penny Magazine* or *Penny Cyclopædia* that were published by the Society for the

21 For a concise overview of the early development of the foreign settlement in Shanghai, cf. Bickers 1999, 123-7; Pott 1928. As noted during a public meeting of foreigners in 1852, the establishment of a central venue in Shanghai for libraries, chess-clubs, billiard-clubs, and other public recreational activities and events was still highly desirable. *The North-China Herald* 1852, 3(113), 30; 1852, 3(114), 34.

22 *The North-China Herald* 1852, 3(114), 35. The newspaper *The North-China Herald* listed only abbreviated titles of the books received, along with their corresponding serial numbers in the local library, for example, "827 On bricks and tiles", referring to Dobson 1850.

23 In Changxue Shu's study of early Western technical works on construction preserved in today's Shanghai Library, six volumes from John Weale's series published before 1856 are identified (Shu 2018, 90-1). However, her discussion does not clarify whether these works were part of the library's collection prior to 1870 – before John Fryer began acquiring books in 1868 – or whether they were later obtained through the Jiangnan Arsenal's book procurement efforts. This ambiguity highlights the challenges in fully reconstructing the origins and pathways of Western technical knowledge in late nineteenth-century China.

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Diffusion of Useful Knowledge and popularly circulated among working classes (Gow 2023, 33-4). Given that Fryer received his education in Bristol and graduated in 1860 (Bennett 1967, 4-5), it is very likely that Weale's textbook series were already known by Fryer while he was in school. Moreover, the early missionary schools in China's treaty ports, including those in Shanghai, and particularly the Jesuit-run Bibliotheca Zi-ka-wei, also known as the Xujiahui Library, or in Chinese: Xujiahui Cangshulou 徐家匯藏書樓 (King 1997), may have introduced Weale's series of educational and classical works (if not the rudimentary works),[24] although this requires further investigation.

Although it is unclear which publisher's circulars or catalogues were available to Fryer in early 1868, it is worth noting that the aforementioned library had purchased (or possibly subscribed to) several popular British magazines, as mentioned in the same news item from 1852. These included *Blackwood's Magazine*, *Sharpe's London Magazine*, *Chambers' Edinburgh Journal*, *The Quarterly Review*, and *The Westminster Review*,[25] all of which provided up-to-date publishing news and announcements across various fields. Additionally, both private and public subscriptions of 'home' (mostly, British) magazines for foreigners in Shanghai likely increased between 1851 and 1871. By 1870, the budget for purchasing books from England had remained steady at £200-250 annually for several years (Lang 1875, 43), while the British resident population had grown from 256 in 1851 to 894 in 1871 (Bickers 1999, 125).

For example, in March 1867, John Fryer wrote to his brother George in England asking him to send him the magazine, *The Family Herald*, regularly. In the same letter, Fryer also asked his brother to send magnesium wire "for the sake of showing experiments to the Chinese" and catalogues of scientific instruments with prices. Although no further details about these catalogues have been found, my evidence suggests that Fryer had at least seen the catalogue of

24 The shortage of textbooks was a persistent challenge for Christian colleges in nineteenth-century China. In addition to teaching classical Chinese, English textbooks on English (instead of the classic Latin and Greek in the Chinese context), mathematics, religion, and later on literature and sciences were often used by the teachers. Translating textbooks into Chinese was greatly developed after 1877, and particularly, after 1895. Cf. Lutz 1971, 66-8. It is noteworthy that the Bibliotheca Zi-ka-wei, established by the Jesuit mission in 1847, was likely another significant resource for John Fryer to consult catalogues of Western publications. Nonetheless, the available evidence does not indicate that Fryer referenced the Bibliotheca Zi-ka-wei in connection with his book-ordering activities between 1867 and 1870. Given the nature of this Jesuit-run library, which served missionaries studying Chinese language and culture and provided instruction in Western languages, religion, and basic sciences to Chinese students, it is plausible that Weale's series of educational and classical works were available there. This possibility, however, requires further verification. I wish to express my gratitude to Prof. Iwo Amelung for drawing my attention to the Bibliotheca Zi-ka-wei.

25 *The North-China Herald* 1852, 3(114), 35.

Weale's rudimentary series, advertised as "Mr. Weale's Publications for 1861", which was often included with John Weale's own publications around 1860.[26]

Why is the 1861 catalogue important for our understanding of mining? Weale's rudimentary series had been expanding throughout the three decades from 1840 to 1870. The advertised 35-page catalogue, "Mr. Weale's Publications for 1861", listed 7 volumes of the Rudimentary Series – on mines, smelting works, and the manufacture of metals, as shown in figure 1. So far, this is the only catalogue version I have found that specifies the titles of these seven volumes.[27] These included treatises on the metallurgy of copper, silver, lead, and iron; treatises on the mining of coal, gold, zinc, tin, nickel, cobalt, etc.; and a treatise on electro-metallurgy.

Notably, the 1861 catalogue provides the prices for only two of these volumes: volume 1 (on metallurgy of copper), priced at 2 shillings, and volume 7 (on electro-metallurgy), at 1 shilling and 6 pence.[28] Fryer ordered exactly seven volumes in his first order of 1868, listing their titles in the same sequence as advertised in the 1861 catalogue. He even estimated the price of 2 shillings for the unpublished volumes (Dagenais et al. 2010, 1: 350) **[fig. 1]**.

Table 1 John Fryer's ordering list of Weale's series on mines and metallurgy

Name of Work	Publisher	Price		
		£	s	c
Metallurgy of Copper	Weales	-	2	0
Do Silver and Lead	Do	-	2	0
Do Iron	Do	-	2	0
Gold Mining & Assaying	Do	-	2	0
Zinc, Tin, Nickel & c	Do	-	2	0
Coal Mining	Do	-	2	0
Electro Metallurgy	Do	-	1	6
*Coal & Coal Mining (The Newest & Most Complete Work)	…	2	0	0

Source: Dagenais et al. 2010, 1: 350.

26 The advertisement "Mr. Weale's Publications for 1861" was appended to Weale 1860. Nevertheless, Fryer placed an order to purchase the dictionary later in 1870 (Dagenais et al. 2010, 1: 459). Therefore, the 1861 catalogue might have been found by him along with other works.

27 The analysis in this article of John Fryer's purchase of John Weale's series, particularly the seven volumes on mining and metallurgy, substantially expands on the evidence presented in one of my earlier publications, cf. Chen 2022, 47-8.

28 The advertisement "Mr. Weale's Publications for 1861" n.d., 9.

Furthermore, one oversight by Fryer provides additional evidence that he had seen "Mr. Weale's Publications for 1861". After the 35-page catalogue (although advertised as "40 pages"), an additional page was appended, containing an advertisement for John Grantham's treatise on iron ship building, which included a description of the accompanying plates. This page likely caught Fryer's attention for two reasons. First, the price for both the plates and the text was listed as 25 shillings, and Fryer indeed recorded £1 5*s* in his order list.[29] Second, Fryer mistakenly attributed the publisher of Grantham's treatise to Lockwood, as indicated in his 1868 book order (Dagenais et al. 2010, 1: 349), when it should have been John Weale (Grantham 1858).[30]

This error was likely caused by a note at the bottom of the advertisement stating, "[t]his work may be had of Messrs. Lockwood & Co., No. 7, Stationers' Hall Court, and also of Mr. Weale". At that time, Fryer was unaware of the relationship between John Weale and his sales agent, Lockwood & Co. An 1859 advertisement, for example, announced that John Weale's rudimentary, educational, and classical series "will henceforth be supplied by Lockwood & Co.", who had been appointed as the sole agent for distributing Weale's publications.[31] Although Grantham's work was eventually delivered to Shanghai, only the plates were included, as Fryer's 1869 letter reveals. Consequently, he had to request that the bookseller send the accompanying text separately (Dagenais et al. 2010, 1: 398).

In addition to the works on mining and metallurgy, Fryer also selected works on naval engineering and steam engines from the Weale's series. These choices reflect Fryer's confidence in the quality and reliability of Weale's publications. Translating the entire set of Weale's Rudimentary Series on mining and metallurgy would have provided Chinese readers with a systematic collection of elementary textbooks for beginners. As Gow (2023, 108-10) observed regarding missionaries' translation of the seemingly outdated and incomplete Euclid's Elements in the 1850s, historical choices and motivations were often influenced by multiple factors beyond immediate practical concerns. In the case of mining-related literature, only three of the seven volumes on mining and metallurgy were published by John Weale's press after Weale's death in 1862: metallurgy of copper (vol.

29 Grantham's treatise without plates, priced at 2*s* 6*d*, had already been listed in "Mr. Weale's Publications for 1861". The accompanying atlas, containing the plates, was advertised separately on the additional page for £1 2*s* 6*d*. Combined, the total price for both the text and atlas was £1 5*s*, which matches the amount Fryer recorded in his 1868 order.

30 However, a later edition, Grantham 1868, was indeed published by John Weale's successor, Virtue & Co.

31 *The Publishers Circular and General Record of British and Foreign Literature* 1859, 22(528), 465.

1); metallurgy of silver and lead (vol. 2); and electro-metallurgy (vol. 7).[32] The treatise on coal mining (vol. 6), written by the aforementioned Smyth, was published in 1867. Among these, only Smyth's coal mining and electro-metallurgy (vol. 7) found their way into China and were later translated into Chinese as *Kaimei yaofa* 開煤要法 (Essentials to Opening Coal Mines) (1871) and *Dianqi dujin lüefa* 電氣鍍金畧法 (Outline of Methods of Electro-Gilding) (1880), respectively.[33]

Even after realising that some of the series on mining were being continued by the publisher Virtue Brothers & Co., Fryer remained eager to purchase works from Weale's series. My investigation and comparison of Fryer's order list with one of Weale's catalogues suggest that after acquiring Alexander Watt's *Electro-Metallurgy Practically Treated* (published by John Weale in 1860) between 1868 and 1869, Fryer encountered another version of "Mr. Weale's Series of Rudimentary Works", in "A Catalogue of Works" published by Lockwood & Co. in 1859, which was appended to Watt's book.[34] Subsequently, in December 1870, Fryer ordered over ten additional works on shipbuilding, machinery, and construction engineering from Weale's series. In a letter to the Shanghai agency, Machenzie & Co., Fryer noted that these works could be obtained from Virtue & Co. and added, "[i]f any should be out of print, please procure if possible copies of former editions" (Dagenais et al. 2010, 1: 458-9).

The influence of John Weale's rudimentary scientific series on John Fryer's book-purchasing choices is evident, and arguably, provided him with a blueprint for producing Chinese textbooks. This approach was institutionalised with the establishment of The School and Textbook Series Committee (Yizhi shuhui 益智書會, lit. 'Useful Knowledge Book Society') in Shanghai in 1877 (Bennett 1967, 60-2). The Committee aimed to promote elementary science education in China.

In line with this mission, Fryer compiled several elementary science textbooks, including works on mineralogy. These included

32 The originally planned vol. 3, *A Treatise on the Metallurgy of Iron*, was written by H. Bauerman and published by Virtue & Co in 1868.

33 For a brief discussion of Smyth's original work on coal mining and Fryer's Chinese translation, see Wu 2015, 88-9.

34 Fryer's ordering list closely follows the numbering and titles given in the catalogue of Weale's series. For example, he simply quoted the catalogue numbers followed by abbreviated titles, such as "no. 23, 24. Brick making" (Dagenais et al. 2010, 1: 458-9). Notably, the number 53 appears twice in Fryer's list – "53 Laying off ships" and "53 Atlas of large plates" – exactly as it appears in the 1859 edition of "A Catalogue of Works", published by Lockwood & Co. and appended to Watt 1860 ("A Catalogue of Works" 1859, 16-18). This duplication of serial number 53 with identical titles does not appear in any other versions of Weale's catalogues that I have examined. Additionally, Fryer listed "Weale's engineers pocket book, newest version" at the price of 6 shillings. It is likely that this entry was prompted by its advertisement on an extra page of Lockwood & Co.'s catalogue ("A Catalogue of Works" 1859, 14).

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Kuangshi tushuo 礦石圖說 (An Illustrated Account of Mineralogy, 1884) as part of the *Gezhi tushuo* 格致圖說 series (Science Handbook Series), and *Kuangxue xuzhi* 礦學須知 (Mineralogy, 1893) as part of the *Gezhi xuzhi* 格致須知 series (Science Outline Series). These works were carefully adapted to suit the tastes and learning practices of Chinese readers (Chen 2022, 53-4). The broader influence of Weale's concept of diffusing useful knowledge on the general production of Chinese textbooks remains a subject that requires further investigation, though it lies beyond the scope of the present study.

After 1870, Fryer also began purchasing books for translation from US publishers. By this time, advertising practical and scientific books and distributing the latest catalogues – free of postage – had reached its peak in the long-distance, cross-continental book trade.[35] The free mailing service was facilitated in particular by the expansion of steamship lines after 1869, following the opening of the Suez Canal and the completion of the US transcontinental railroad. This rapid shift significantly broadened Fryer's access to publishers. Fryer subsequently received numerous catalogues from both US and British publishers, as reflected in his ordering lists. His exposure to these catalogues further diversified his selection of books for translation. For instance, Fryer ordered books from the publisher Trübner & Co., and instructed his agent to send the "immediately wanted" books on brass and iron founding to Shanghai, whether from London or the US (Dagenais et al. 2010, 1: 399). Many of the translations on metallurgy (particularly on iron, steel) and mining tools were published by the Jiangnan Arsenal after 1880 (Chen 2022, 49-51). In total, mining-related translations published by the Jiangnan Arsenal accounted for about 6-8% of the entire Jiangnan Arsenal series, depending on how the publications were categorised (Shanghai tushuguan 2011, 79-82). Despite this seemingly substantial output, the fragmented and sporadic nature of these translations created an impression of inconsistency. Even when broadly defined to include mining engineering, mineralogy, geology, and metallurgy, the translations on mining lacked a coherent system or arrangement.

There are additional examples illustrating that the easier movement of books from the West to the East – compared to the pre-1850 era – cannot be taken for granted, despite the flourishing steam-powered publishing industries and advances in transport technology in the West. For instance, Fryer had attempted to purchase John Percy's work, *Metallurgy: The Art of Extracting Metals from Their Ores* (which was published by John Murray in 1861), as noted twice in his ordering lists in March, and July, 1868, respectively (Dagenais et al. 2010,

35 See, for example, the advertisement by the industrial publisher Henry Carey Baird, based in Philadelphia, US, in "New and Important Books for Practical Men" 1868, 25.

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1: 350, 377). It remains unclear whether Percy's work ever arrived in China as expected. However, Percy's works appeared frequently in "books wanted to purchase" notices in British and American publishers' circulars, both before 1868 and well into the 1880s and 1890s.[36]

In another case in 1870, Fryer ordered books on mechanical engineering and emphasised in his letter, "[i]f new copies cannot be obtained, please send second-hand". He also instructed that if second-hand books could not be found immediately but were located later, they should not be purchased, as the books were required urgently (Dagenais et al. 2010, 1: 425). This urgency suggests that Fryer had repeatedly ordered similar books on the same subject. After 1869, Fryer received a wide variety of catalogues, though it remains unknown how many books he ultimately failed to procure.

This tortuous pathway to acquiring 'classical' works illuminates another dimension of the challenges to long-distance, trans-cultural scientific communication in the nineteenth century. These challenges were not related to the accuracy of translations or outdated knowledge but rather to the availability and accessibility of foreign books. The physical movement of books ultimately determined what could be translated and introduced into Chinese society.

4 A Path Not Taken: Mining Education at Guangfangyanguan Around 1870

Mining is a comprehensive engineering science that goes beyond theoretical knowledge or concepts derived from textbooks; no single book can ensure the successful and profitable operation of a mine. Between 1875 and 1876, local Chinese officials in Hubei province gained valuable insights by reading and critically analysing Fryer's translation of Western coal mining treatises (i.e. *Kaimei yaofa* 開煤要法), alongside various newspapers and magazines, as part of their efforts to locate coal deposits. However, by around 1880, Fryer himself complained that these translated works were often useless in actual teaching practice, as no foreign engineering teachers could read Chinese (Fryer 1880, 81; cf. Wright 2000, 310-11). Before 1870, no formal technical schools existed in China for training mining experts. Fryer's early involvement in an unrealised plan for mining education at Guangfangyanguan 廣方言館 (Foreign Language School) around

36 See a few examples I selected from publishers' circulars, where certain volumes of Percy's metallurgy were advertised as "books wanted to purchase": *The Publishers' Circular and General Record of British and Foreign Literature* 1864, 649, 557; *The Publishers' Circular and General Record of British and Foreign Literature* 1867, 712, 306; *The Publishers' Weekly* 1882, 568, 842; *The Publishers' Circular and Booksellers' Record of British and Foreign Literature* 1894, 1446, 300.

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1870 and its subsequent influence on mining education scheme at Shanghai Polytechnic merits our closer attention.[37]

When John Fryer arrived in China in 1861, debates among Qing policymakers about learning Western science and technology had just begun within the framework of the Self-Strengthening Movement. By 1867, a bureau for arts (*yiju* 藝局) was established at the Fuzhou shipyard to train students and artisans. Around the same time, Prince Gong Yixin proposed incorporating mathematics and astronomy into the curriculum at the Tongwenguan in Beijing (Biggerstaff 1961, 19-21; Chen 2023a, 227-34). As the editor of the Chinese-language newspaper *Shanghai xinbao* 上海新報 (English title: *Chinese Shipping List and Advertiser*; published by the *North China Herald* office),[38] Fryer seized the opportunity to criticise Prince Gong's printed official memorial in the newspaper. In Fryer's view, China needed a systematic approach to training students in Western science and the arts, much like Japan had done (Dagenais et al. 2010, 1: 252, 254-5). Unsurprisingly, Fryer's critique caught the attention of Qing reformers. His background made him a credible voice: he had worked at the Tongwenguan in the early 1860s and maintained close connections with missionary educators in Beijing. He was later invited by officials of the Arsenal to teach "ten of the best scholars" selected from the Guangfangyanguan "the principles of the steam engine at the Arsenal". However, Fryer rejected the teaching plan, which he described as "absurd" (337). Nonetheless, this suggests that he did engage in discussions with Arsenal officials regarding the practicality of their proposed teaching plans.

It is worth noting that around this time, the famous China Education Mission was proposed by Rong Hong (also known as Yung Wing 容閎, 1828-1912). In 1867, Rong successfully persuaded Zeng Guofan 曾國藩 (1811-1872) "to have a mechanical school annexed to the arsenal, in which Chinese youths might be taught the theory as well as the practice of mechanical engineering" (Yung 1909, 168). Rong's official 1868 proposal acknowledged the need for opening mines, but did not directly link the education of mining engineers to the broader educational plan. It was not until 1877, when Rong was serving as the commissioner of the China Education Mission in the US, that Li Hongzhang 李鴻章 (1823-1901) requested him to encourage Chinese students studying in the US to pursue mining engineering. By then, the demand for mining engineers in Chinese industry had become urgent (Chen 2024, 561).

There is no clear direct evidence suggesting Fryer's influence on the development of teaching plans at the Arsenal (although he

37 Guangfangyanguan 廣方言館 was established in 1863, originally named Shanghai Tongwenguan 上海同文館, similar to the other two language schools under the Tongwenguan name in Beijing and Guangzhou.

38 On a brief history of the newspaper, cf. Zhou 2006, 39-42; Mittler 2007, 13-45.

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taught at the French Department). However, as indicated in one of his book-ordering letters, Fryer urged the book trade agent to purchase and send books and apparatus as soon as possible, since a new "Chinese college" at the Arsenal was expected to open in early 1870 (Dagenais et al. 2010, 1: 424). The Chinese college was recorded as a new 'Learning Institution at the Bureau for Manufacturing Machinery' (*zhizao ju xueguan* 製造局學館) in the Qing official documents. It was approved for construction at the Jiangnan Arsenal in 1868, with the building completed by the end of 1869 (Gao, Huang 2007, 188; Wei 1969, 147, 173-4). Additionally, in an 1869 petition, the school (*xuetang* 學堂) was approved to merge with Guangfangyanguan, which was relocated to the Arsenal in the same year (Gao, Huang 2007, 187-8). A closer examination of the 'learning institution' plan reveals that mining-related subjects, essential for supplying industrial raw materials, were a fundamental part of the plan.

In a detailed programme proposal submitted on April 3, 1870 to Zeng Guofan, local officials Feng Junguang 馮焌光 (1830-1877) and Zheng Zaoru 鄭藻如 (1824-1894) presented two sets of regulations for curriculum and activities. The regulations integrated the learning of Western sciences and manufacturing arts with translation, publishing presses, surveying, and above all, education. The general training was proposed to begin with a one-year lower division training programme (*xiaban* 下班), designed to teach students foundational subjects, including international law, mathematical sciences (such as algebra, logarithms, and geometry), physics, foreign languages, geography, astronomy, and drawing. After this, students could choose from one of seven specialised upper division programs (*shangban* 上班), which included:

1. prospecting for mineral ores and metallurgical processes of extracting metals (to supply raw materials to manufacturing industries);
2. methods of metal casting and forging for making machinery;
3. manufacturing wooden and iron objects;
4. design and operation of machines;
5. principles and laws of navigation;
6. naval and land warfare; and
7. foreign languages, customs, and institutions.[39]

The whole set of training programme resembled, and more significantly, broadened, the scope of existing educational models of the above-mentioned *yiju* (bureau for arts), or, school of shipping administration (*chuanzheng xuetang* 船政學堂) at Fuzhou (Giquel 1874, 17-35), which was proposed by Zuo Zongtang 左宗棠 (1812-1885) in

39 Biggerstaff 1961, 167-72; Gao, Huang 2007, 188-202; Wright 2000, 308-9.

1866. The concept of *yiju* was an innovative opening move to establish a model for institutions in technical education. It combined scholarly learning and hands-on training practices (Chen 2023a, 234-9). At Fuzhou, however, no department related to mining or metallurgy was established, apart from a metal-working forge or factory. Clearly, shipbuilding and weapon-making were the primary goals of both arsenals at the time. Mining and metallurgy were crucial for securing industrial raw materials and achieving technological independence.

However, the above-outlined specialised educational programs at the Arsenal in Shanghai, including the mining-related category, were not fully implemented in practice. According to Guo Songtao's 郭嵩燾 (1818-1891) diary, Fryer mentioned to Guo during their return journey from an industrial investigation in Europe in 1879 that, in addition to the English and French schools at Guangfangyanguan, the Arsenal housed three external schools or departments (*ju* 局): mining (*kuangxue* 礦學), machinery engineering (*jiqi* 機器), and navigation (*jiashi* 駕駛).[40]

Guo's own observations during his visit to the Arsenal in the same year, however, provide a somewhat different account. He recorded that besides the Chinese, English, and French language schools at Guangfangyanguan, there were three external 'Western learning schools' (*xixue santang* 西學三堂): drawing and design of steamships and machinery (*huatu jian lunchuan jiqi* 畫圖兼輪船機器), mathematics and cannon drill (*shuxue jian yanpao* 數學兼演炮), and shipbuilding (*zhizao chuanwu* 製造船務).[41] Mining was notably absent from Guo's account, and the discrepancy between his and Fryer's descriptions of the school categories appears to have escaped notice.

But according to the official Chinese regulations, by 1881 only three schools – English, French, and mathematics – were in operation at the Jiangnan Arsenal,[42] along with a military school (*wuxueguan* 武學館) and an iron ship building school (*tiechuanguan* 鐵船館).[43] No mining school or department was mentioned in the official records of the Jiangnan Arsenal. A dedicated technical school or polytechnic

40 Guo 1984, 922-3; cf. Wright 2000, 310. Wright mentioned the date as 1880, but it should be 1879.

41 Guo 1984, 927; cf. a slightly different translation in Wright 2000, 309.

42 Biggerstaff 1961, 176-7; Gao, Huang 2007, 204-6. A fourth department, astronomy, was already in existence by 1894, although the exact date of its establishment remains unknown. See Gao, Huang 2007, 206-7.

43 In his book, Biggerstaff notes that "[t]he remaining three, military science, naval architecture, and marine engineering, constituted what must have been a kind of technical school" (Biggerstaff 1961, 176). This statement is based on John Fryer's description of the "subjects" taught at the Arsenal schools (Fryer 1880, 81). The actual names of the technical schools, *wuxue* 武學 (Military Science School) and *tiechuan* 鐵船 (Ironclad Ship School), appear in Qing official reports on the schools. See Gao, Huang 2007, 206, 215.

(*gongyi xuetang* 工藝學堂) was not formally established at the Arsenal until 1898 (Wei 1969, 173-4). This suggests that Fryer or Guo may have confused the military school (*wuxue*) with a mining school (*kuangxue*) during their conversation in 1879. As will be discussed below, Fryer may also have conflated the teaching plan at Shanghai Polytechnic with that of Guangfangyanguan, as the former had indeed advertised courses in the 'study of mining' (*kuangxue*) in the winter of 1879 (e.g. "Gezhishuyuan zhao zhi sheng" 1879, 3). Moreover, Fryer and Guo's differing and somewhat casual descriptions of the schools, particularly their use of varying Chinese terms such as *ju* (bureau) and *tang* (hall) to refer to these institutions, reflect the ambiguous concept of a technical school at that time. This ambiguity suggests that neither contemporary Chinese officials nor Western scholars clearly distinguished a technical school from other forms of learning institutions (*xueguan*).

5 Persistent Efforts in Advancing Mining Education at Shanghai Polytechnic

The seemingly unrealised 1870 mining education plan at Guangfangyanguan was pursued over the next two decades, notably through John Fryer's involvement in establishing China's first Polytechnic in Shanghai,[44] and circulating China's first scientific magazine *Gezhi huibian* 格致彙編 (lit. 'Compiled Works on *gezhi*'), founded by Fryer in 1876. By 1875, mining had emerged as a top priority, alongside machinery manufacturing, in efforts to generate wealth and stabilise livelihoods ("Lun Gezhishuyuan luocheng shi" 1875, 1). *Gezhi huibian* played a crucial role in the burgeoning publishing industry in China, particularly in Shanghai. Through question-and-answer exchanges with readers in the magazine around 1876, Fryer captured the attention of Chinese scholars by introducing Western mining technologies, such as ore composition analysis and machinery for pumping water (Chen 2022, 55; 2024, 557).

From the late 1870s to the 1880s, Shanghai Polytechnic sought, over a period of at least a decade, to integrate mining-related disciplines into its educational framework. A significant example of this initiative was the incorporation of mineral ore specimens ordered by John Fryer from England during 1868-69 (Dagenais et al. 2010, 1: 352, 385). A report on Zeng Guofan's visit to the Jiangnan Arsenal in November 1871 records that Zeng visited Fryer's residence in Shanghai, where he "made several enquires and remarks respecting the different specimens of mineral ores and rocks contained in a cabinet in the

44 Biggerstaff 1956, 127-49; Wright 1996, 1-16; Xiong 1994; Elman 2005.

room where he sat" ("Tseng-kwo-fan's Visit" 1871, 9231; "Summary of News" 1871, 892). These mineral specimens, alongside other types of machinery, tools, and apparatus, were expanded through donations from foreign firms and governments, particularly from British and Belgian sources. They were subsequently displayed at Shanghai Polytechnic and were also intended to populate a museum (*bowuyuan* 博物院) proposed in 1877, which was to be housed in iron-framed buildings. However, due to financial constraints, this museum project was never realised (Biggerstaff 1956, 135-6; Wang 1998, 11-12, 218).

In the teaching plan of Shanghai Polytechnic, the 1879 advertisement explicitly listed mining as one of the subjects offered at the institute ("Gezhishuyuan zhao zhi sheng" 1879, 3). In the summer of 1890, the chemist Cosmos I. Burton, accompanied by his wife, arrived in Shanghai and was hired to teach six foundational science subjects, including chemistry and mining. Unfortunately, Burton passed away at the age of 28 before his courses could begin. Despite his untimely death, Burton had made systematic preparations for his teaching, including outlining engineering curricula (with mining as a key component), laboratory setups, and other necessary arrangements. It is likely that Fryer assumed responsibility for Burton's planned curriculum and continued to offer courses, including those related to mining, on Saturday evenings, though this began only after 1894.[45]

Thus far, the history of mining education at Shanghai Polytechnic has been simplified by these initial yet largely unrealised plans. The subsequent unsuccessful attempts highlight a critical gap in China's transition to mining education, a transition that was marked by the convergence of both mining practices and educational frameworks. This period reinforces how mining education briefly gained prominence in the late 1880s, just before Professor Burton's employment at Shanghai.

6 Interrupted Convergence of Mining and Educational Practices, 1888-95

John Fryer was never directly involved in the Chinese mining industry, but he maintained close ties with it through his Chinese collaborators in the Jiangnan Arsenal's translation project and through his educational work at Shanghai Polytechnic. Among these scholars, Xu Shou 徐壽 (1818-1884) and his son Xu Jianyin 徐建寅 (1845-1901) were Fryer's early co-translators of mining-related works. Zhong Tianwei 鍾天緯 (1840-1900), a graduate of Guangfangyanguan (studying period:

45 "Gezhishuyuan yanqing huaxueshi" 1890, 3; Biggerstaff 1956, 139-40; Wright 2000, 138-9. On obituary notice, cf. Adams 1890, 654; Wang 1998, 101.

1872-75) in Shanghai, stood out as a notable example of a native Chinese scholar who rose from a declining literati family to become one of the prominent reform-oriented advisors within the officialdom.

After graduating from Guangfangyanguan, Zhong was invited by Xu Jianyin to collaborate at the newly established arsenal in Shandong Province in 1875. In 1880, they both, along with several other diplomats and scholars who investigated Western manufacturing and mining industries in the late 1870s, travelled to Germany.[46] Zhong's two-year experience observing Western industrial nations deepened his perspective on late Qing industrialisation and reforms. Both Zhong and Xu Jianyin played key roles in the development of the coal, iron, and steel industries in the 1890s. However, Zhong's distinctive career also linked Fryer with Sheng Xuanhuai in the initiation of mining education.

From 1882 onwards, Zhong was employed by the Translation Bureau of the Jiangnan Arsenal, where he collaborated with Fryer in translating books and editing magazines that covered a wide range of topics, including Western politics, economics, military affairs, as well as sciences and arts. His contributions quickly gained recognition, and he rose to prominence through his participation in the Prize Essay Contest organised by Fryer and Wang Tao 王韜 (1828-1897) at Shanghai Polytechnic, starting in 1886 (Xue, Liu 2018, 1-2, 205-20; cf. Elman 2005, 346-7). From 1888 onwards, Zhong began serving as an advisor to Sheng Xuanhuai, who was then the Intendant of the Deng-Lai-Qing Military Defence Circuit and the Superintendent of East Customs at Yantai/Chefoo in Shandong (*Deng Lai Qing bingbeidao jian Donghaiguan jiandu* 登萊青兵備道兼煙台東海關監督, from 1886 to 1892).

At that time, Sheng had already witnessed the 'failure' of the Hubei coal mining industry in the late 1870s. However, the unsuccessful coal prospecting efforts led by the foreign mining engineer Samuel J. Morris during this period undermined Chinese officials' trust in Western expertise. Nevertheless, mining expertise in China was shaped by a variety of social and cultural factors, with fengshui disputes playing a particularly crucial, and at times decisive, role in the establishment of mines (e.g. Brown 2023, 158-92). As a result, narratives of 'incompetent' Western engineers became a widely recognised justification for initiating discussions on the need to train China's own mining experts.[47]

The 1887-88 coinage reform, aimed at solving the monetary crisis, acted as a principal stimulus for revitalising non-ferrous mining

46 For an overview of Qing diplomats' visits to the West, see Day 2018.

47 For a detailed investigation of Sheng Xuanhuai's experience with foreign mining engineers in Hubei Province, which ultimately ended in failure and sparked discussions and efforts to establish a mining school in China, see Chen 2024.

industries in Shandong. The sufficient supply of mint metals – copper, lead, and zinc – became an urgent task for local officials like Sheng Xuanhuai, alongside coal and iron. By this time, Qing China had been importing Japanese copper for centuries, and the achievements of Japan's 'modernised' mining and minting industries, particularly in educating and hiring engineers and adopting machinery, began to attract the attention of Qing reformers. As a result, Sheng Xuanhuai proposed the establishment of a mining school in Yantai during 1888-89 (Chen 2024, 562).

In seeking teaching staff, Zhong Tianwei played a key role in negotiating with Max Goebel (in Chinese: Gu Beier 古貝爾), the Consul-General for Belgium in Shanghai, and John Fryer (Chen 2024, 565). Sheng and Zhong were looking for a qualified teacher (*jiaoxi* 教習) for the proposed mining school in Shandong, someone who would ideally be able to conduct field surveys as a mining engineer (*kuangshi* 礦師). This rudimentary idea for establishing a mining school reflects how late Qing reformers envisioned such institutions. By that time, the first generation of five students who had studied mining engineering in Europe had returned to China, and several returned students from the US had also been hired by Qing reformers for various industrialisation and modernisation projects (561).

Another key source of potential candidates for the mining school's teaching staff was the technical schools, including Shanghai Polytechnic. Zhong Tianwei recommended several talented graduates from Guangfangyanguan to Sheng Xuanhuai as candidates for positions in Chinese, English, and mathematics at the proposed mining school. Among them, Xu Huafeng 徐華封 (1858-1928), another son of Xu Shou, distinguished himself and received high praise from Zhong. According to Zhong, Xu Huafeng was Fryer's favourite student and possessed extensive expertise in manufacturing industries, especially mining. Zhong also noted that Xu was well-equipped to manage mining operations and could even replace a foreign engineer, taking on the role of supervisor (*tidiao* 提調) at the planned school (Xue, Liu 2018, 386).

After extensive discussion, Sheng and Zhong concluded that it would be nearly impossible to hire one individual capable of both conducting field mining surveys and teaching at the school. As a result, they decided to hire two separate mining engineers. Since Fryer was travelling in the US at the time (1888), he agreed to assist Zhong and Sheng in recruiting a mining engineer from a US university, such as the University of California, San Francisco (cf. Chen 2024, 565). Fryer particularly emphasised the advantages of mining education in the US, given the country's rapid advancements in mining technology compared to Britain. This judgment was likely based on Fryer's personal communication with a mining engineer on their shared trip to Japan in 1888, whose father was also a mining engineer hired in

Japan. However, Zhong and Sheng were skeptical of Fryer's connection and urged him to write to the *Jiujinshan dashuyuan kuangwu xuetang* 舊金山大書院礦務學堂 (likely the College of Mining, University of California, San Francisco) to enquire about potential candidates, offering a monthly salary of 200 taels (Xue, Liu 2018, 402). It took a considerable amount of time for Fryer to receive a response.

Since Sheng and Zhong were also seeking mining engineers from Belgium, Fryer planned that, if they found suitable candidates elsewhere, the mining engineer from the US he was in search of would be hired by Shanghai Polytechnic. With Goebel's help, Zhong Tianwei eventually found a Belgian mining engineer, Emile Braive (in Chinese: Bai Naifu 白乃富), at a monthly salary of approximately 500 taels (Chen 2024, 565). Despite these efforts, the proposed mining school in Yantai was not approved by Li Hongzhang due to its inconvenient location. Instead, Zhang Zhidong adopted the plan in Hubei, which later became the foundation of the renowned Hanyeping Company (568-9).

Regarding Shanghai's mining education, by the end of 1888, Fryer had secured funding through a donation of 1,000 taels per annum from Liu Mingchuan 劉銘傳 (1836-1896), then the provincial governor of Taiwan, who was also promoting various industrialisation projects, including a telegraph school. This funding was intended to support five students to study mining engineering at Shanghai Polytechnic. Additionally, a limited number of student candidates would be allowed to enter the mining engineering programme at Shanghai through government stipends (Xue, Liu 2018, 411).

However, this plan did not materialise, as the recommended mining engineer from the US requested an annual salary of 10,000 *yuan* (far above the 2,400 *yuan*, or 200 taels per month, offered by Fryer). Moreover, this 23-year-old engineer had a young family to support and had to consider his future career options after leaving the US university system (Xue, Liu 2018, 429-30). After this unsuccessful attempt to hire a mining engineering teacher from the US in 1889, it is highly likely that Fryer eventually recruited Burton from Great Britain by 1890. Despite Burton's untimely death, which hindered further educational efforts, the mining educational scheme in Shanghai continued, at least in their teaching plans.

In 1895, John Fryer published a set of engineering curricula focused on Western learning, or concrete learning (*shixue* 實學), at Shanghai Polytechnic. Mining (*kuangwu* 礦務) was listed as the first subject in the curriculum, followed by five other subjects: electrical engineering (*dianwu* 電務), surveying (*cehui* 測繪), civil engineering (*gongcheng* 工程), steam engines or machinery (*qiji* 汽機), and mechanical engineering or shipbuilding (*zhizao* 製造) (Fu 1901, 1) **[fig. 2]**.

As shown in figure 2, Fryer's mining curriculum at Shanghai Polytechnic consisted of one general course and three specialised

courses, covering various aspects of mining. These included: (1) mining affairs (17 lessons); (2) opening coal mines (22 lessons); (3) opening metal-related mines (21 lessons); and (4) mining machinery (16 lessons) (Fu 1901, 3). How these courses were implemented, particularly after Fryer's departure in 1896, remains unclear. Not coincidentally, Sheng Xuanhuai established China's first engineering university around the same time, in October 1895, featuring departments similar to those listed by Fryer.[48] Mining, at last, found its place in China's educational system.

7 Conclusion

This article uncovers previously overlooked connections between translation projects and emerging challenges in mining in China, including textbook acquisition and pedagogical strategies. It seems obvious to ask how the Western books found their way into hands of Fryer and missionaries in China, given that books and periodicals on 'advanced' science and technology (e.g. military and navigating techniques, coal-fuelled steam-engines, railways and telegraph) were readily available in the industrialised centres of Europe (as well as US). This seemingly straightforward question, however, prompts a deeper examination of how China was dis- or re-connected with the West through cultural practices in its pursuit of industrial power and wealth. The failed attempts to acquire books and hire qualified teachers underscore two significant obstacles in the cross-cultural transmission of knowledge from the West to China.

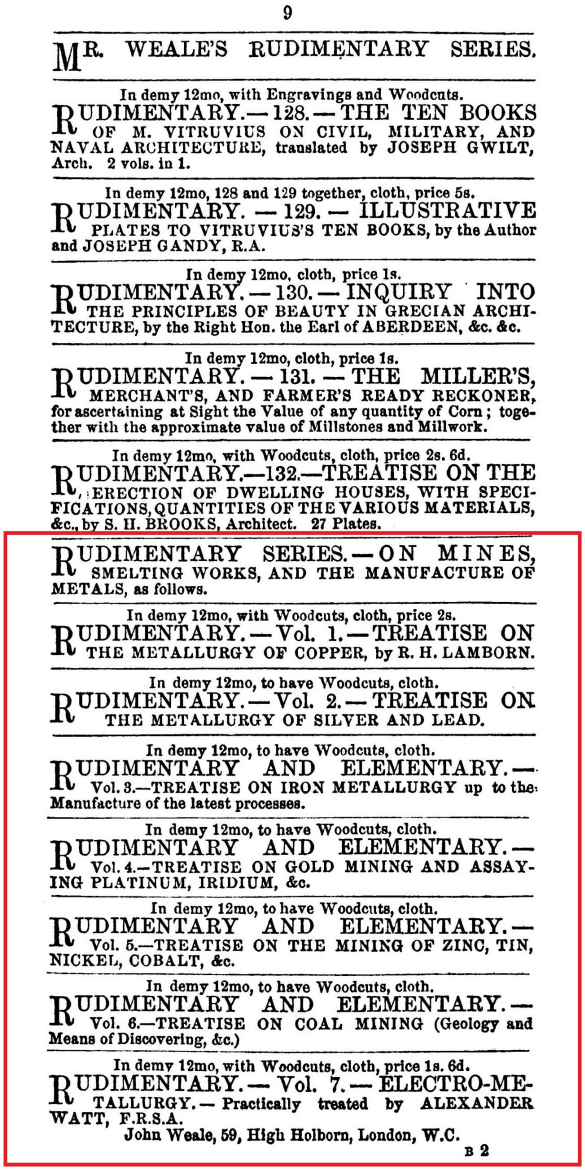
Book catalogues, largely neglected in translation and transfer studies, provided late Qing China, with mediation by John Fryer and other foreigners, a crucial link to the print industry culture of Europe and the US. This article sheds light on these overlooked catalogues, particularly John Weale's rudimentary scientific series, which were less frequently discussed as communication media in Sino-Western exchanges. These rudimentary series of 'classical' Western scientific and industrial works, including mining, played a significant role in inspiring China's textbook production after 1870. However, access to books was far from guaranteed. Fryer's seemingly arbitrary choices of works for translation reflect his limited access to book traders and other overseas trade agencies in the late 1860s. Even for trade agents, overseas book purchasing posed reliability challenges in both commissioning and shipping, challenges that likely shaped the evolution of their businesses, whether as news agents or booksellers, and merit further study.

48 On the history of China's first engineering university in Tianjin, especially on the setting up of mining engineering department, see Chen 2023b.

In parallel with translation efforts, this article also presents a new roadmap, illustrating how Fryer, alongside several reform-oriented scholar-officials and their advisors (notably Zhong Tianwei), planned and advocated for mining education in Shanghai. Although the need to train China's own mining experts emerged in the late 1870s, it took more than two decades for Qing reformers to prioritise mining education. Fryer's 'invisible' involvement in two unrealised mining education plans, from the 1870s Jiangnan Arsenal project to efforts to hire mining engineers from the US for Shanghai Polytechnic in 1888-89, underscores the gradually evolving intellectual and political climate for mining educational reform among Chinese scholars and officials.

The challenges in transmitting Western scientific and technical knowledge through Shanghai Polytechnic's educational programs were clearly articulated by Fryer in 1895, who identified three key obstacles: (1) the intellectual climate for promoting Western science was not conducive for decades (*fengqi weikai* 風氣未開); (2) insufficient funding impeded the establishment of sustainable training programs (*jingfei buzu* 經費不足); and (3) the scarcity of proper teachers (*wu heyi zhi shi* 無合宜之師).

The notion of a 'proper' teacher in the context of mining engineering reflected the complexities of late Qing China's path to establishing mining education. This term encompassed not only the well-known issues of language barriers and reliance on translated textbooks, but also practical challenges in recruiting foreign instructors. These teachers needed to be not only qualified engineers, but also affordable, physically able to work in China, and willing to relocate. Much like the unexpected difficulties in obtaining key Western mining texts, the obstacles to hiring competent foreign mining experts, which represents a critical in-person aspect of knowledge transfer or science communication beyond book knowledge, further impeded the development of mining education in late Qing China.



9

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B 2

Figure 1
The planned seven volumes in Weale's Rudimentary Series on mines, smelting works, and the manufacture of metals. Source: "Mr. Weale's Publications for 1861", n.d., 9. Advertisement. Appended to Weale, John (1860). *Rudimentary Dictionary of Terms*. 2nd ed. London: John Weale (Digitised by Google Books)

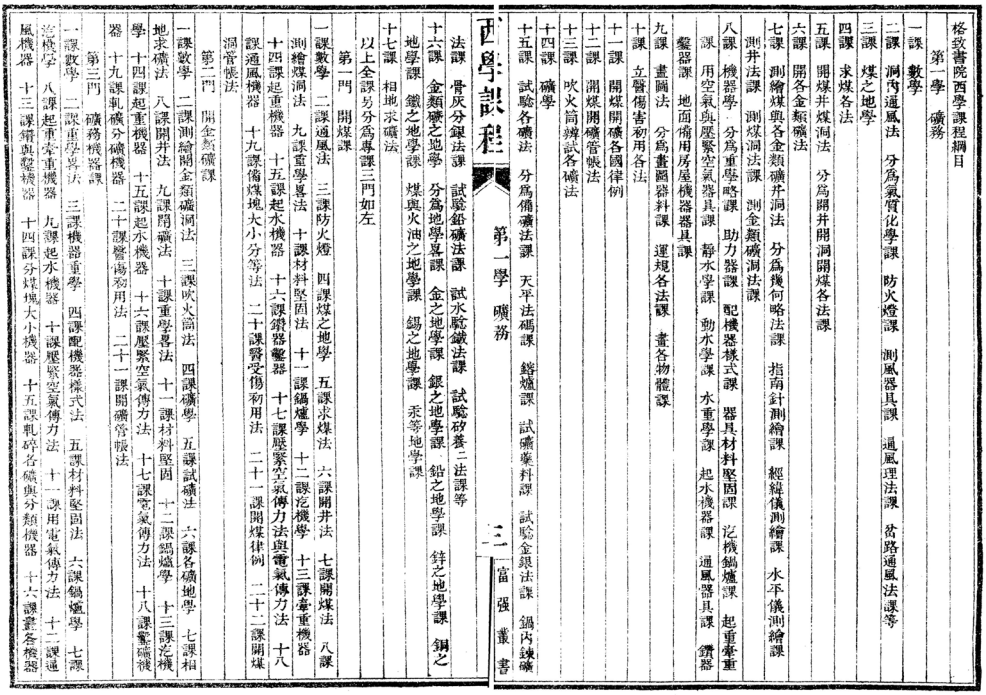

Figure 2 John Fryer's 1895 Mining Curriculum for Shanghai Polytechnic. Source: Fu Lanya 傅蘭雅 1901, 3. *(Gezhi shuyuan) Xixue kecheng* (格致書院)西學課程 (Curriculum on Western Learning at Shanghai Polytechnic). Yuan Junde 袁俊德 (ed.), *Fuqiang zhai congshu xu quanji* 富強齋叢書續全集 (Sequel to the Collected Works from the Studio of Wealth and Power). Shanghai: Xiaocangshanfang

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