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Some Issues of Mining Education in Britain in the Early Twentieth Century

By
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Abstract

Driven by a sense of crisis that the superiority of British industries was fading, an enquiry into the higher level of technical education which was thought to be a suspect for the deterioration took place at the beginning of the 20th century. Though mining schools in Britain were not so highly appreciated by the contemporaries, they do not appear to have hampered the expanding British mining in the world. After a brief look at the development of mining education and the outline of the enquiring committee, actual views of mining businessmen on mining education are examined based on their evidence given to the committee to reach a tentative conclusion that, despite the spontaneous development, mining education took a rational response to the changing environment by combining theoretical study at school with work experience in overseas British mines. This development was also the process of losing original concept of mining education in the 19th century and of leading to the emergence of a kind of demarcation among mining engineers corresponding with mining schools.

Key Words

Early twentieth century, Technical education, Economic decline, Education of mining,[1] Mining engineer, Royal School of Mines, Camborne School of Mines, Imperial College, Institution of Mining and Metallurgy.

1. Introduction

There has been a long history of discussion about the relationship between British educational system and her economic performance, or more precisely, 'associating Britain's supposed economic failure or falling behind new competitors with defects in education',[2] since the latter half of the 19th century. Being shocked by poor performance in winning prizes in the Paris Exhibition in 1867, a letter of Lord Playfair to Lord Taunton,[3] the chairman of School Inquiry Commission, ignited the series of investigations into the technical education in Britain in comparison with that in other countries, notably Germany and the United States. As Michael Sanderson correctly pointed out, 'there was scarcely a year when

[1] For the sake of convenience, instead of 'education of mining' the term of 'mining education' is mostly used for education and training of engineers of metalliferous mining in this paper.
[2] Sanderson, 'Education and economic decline', p. 150.
[3] Ashby, *Technology and the Academics*, Appendix, pp. 111–3.

somebody was not investigating and reporting on supposed deficiencies in British education"[4] till the early decades of the 20th century. Relatively poor performance, or 'decline' of British economy after the W.W.II gave momentum again to this discussion. While one argues the British educational system was 'long to go to catch up with Germans'[5] in the beginning of the 20th century, the other argues the effectiveness of on-the-job training and education developed in a *laissez-faire* country until 1914.[6] Defects of education usually appear, like 'technological backwardness' or 'entrepreneurial failure'[7] through the people's activity which is hard to explain by a single particular factor. And, in their nature, this kind of discussions tend to be affected by one's political standpoint or by the interests of particular groups, so called 'lobby'.[8] Therefore, the question has become much complicated matter. It is too numerous to list all relevant articles and books here.[9] Though some writers tried to examine into the relationship on empirical basis,[10] there are relatively few empirical works on this subject. As Shin Hirose wrote in his article on education of British engineers, 'the debate is hampered by the scanty nature of evidence upon which it is based.'[11] To overcome this kind of deficiency, the late David Dixon did massive and time-consuming work for his PhD thesis by tracing educational background, careers and activities of 1624 mining engineers who appeared in Obituaries of *Transactions of Institution of Mining and Metallurgy* (hereinafter *Trans. IMM*), 1909–67, and out of which 672 engineers also had records either with Royal School of Mines (RSM) or Camborne School of Mines (CSM).[12] Owing to his work we can get information about engineers' career with their educational background on a massive scale. Therefore, we can discuss the results and consequences of education on some empirical bases. This paper is much indebted to his devoted work.

Sanderson argued that it was not self-evident that there was any close connection between success of certain industries and the extent of their educational support. He took the case of shipbuilding industry as an example. This industry was one of the most successful industries at the beginning of the 20th century in Britain, but its effective training was basically on-the-job training through apprenticeship despite the fact that there were newly established academic departments of this field in universities and colleges. Then he continues: -

> A converse situation appertained in metallurgical mining. This very successful industry had good educational support but not enough of it. The British firms would have been eager to employ more British mining and metallurgical graduates had there been available. Yet this did not seem to hold back the industry: investment in mining and metallurgical education may have been quite limited before 1914,

[4] Sanderson, *Education and economic decline in Britain*, pp. 14–5.
[5] Landes, *The Unbound Prometheus*, p. 144.
[6] Pollard, *Britain's Prime*, Chapter 3, pp. 115–213.
[7] Floud, 'Technical Education', p. 162.
[8] Pollard, *Britain's Prime*, p. 117, Edgerton, *Science, technology*, p. 11, Sanderson, 'Education and economic decline', p. 115.
[9] In addition to works by Landes, Pollard, Edgerton, Floud, and Sanderson which are quoted above, some relevant articles and books can be found in the list of references at the end of this paper; Ahstrom, Albu, Anderson, Barnett, Cardwell, Jarousch, Mokyr, Roderick and Stephens, Rubinstein, Wiener, and Wrigley.
[10] eg. Rubinstein, *Capitalism*, Chapter 3, pp. 120–39.
[11] Hirose, 'Two Classes of British Engineers', p. 338.
[12] Dixon, 'The Results and Consequences'. For his research he made a database of total 1624 mining engineers appeared in 'Obituaries' of *Trans. IMM*, from Vol. 19 (1909/10) to Vol. 76 (1967). The database has been digitised by Mike Gill of Northern Mine Research Society and uploaded to their Web site. <https://www.nmrs.org.uk/resources/obituaries-of-members/>

> but this did not significantly frustrate the activities of those intent on grabbing a big share of the metal mining industry.[13]

In their article on London's dominance in the world metalliferous mining business, Charles Harvey and Jon Press wrote that it is clear that there were many more able and scientifically aware mining engineers and metallurgists in Britain than educational statistics reveal. Though mining engineers' acquiring scientific knowledge through formal education were getting increasingly important since the latter half of the 19th century, the process was 'a gradual rather than a revolutionary', and the British system of apprenticeship continuously produced many engineers well after 1880s. In addition, British international mining companies recruited foreign engineers in numbers, which means that other countries bore their training cost. In this sense, British businessmen 'behaved with impeccable economic rationality in not diverting large sums to mining schools at home.'[14] To some extent it was common with the general scene of British science and technology of the late 19th century as D. S. L. Cardwell pointed out that, as an open society, Britain was accepting inflows of many talent from other countries.[15] The evaluation of this kind of externalisation, such as 'good' for the short-term but 'wrong' for the long-term is another question to be examined elsewhere. It is at least possible to argue that the formal education of mining in Britain was becoming one of the primary sources of engineers not only for domestic mines but also British owned overseas mines, though it was not enough to support the expanding industry and so largely supplemented by apprenticeship and recruitment of engineers educated in foreign countries at the beginning of the twentieth century.

Despite such increasing importance, British mining schools were not universally recognised by the contemporaries. The author of *Mining School in the United States* did not include British schools in the list of schools considered as of the first rank in Europe in 1871, or even worse there was no mention at all about them.[16] Clark. C. Spence, quoting remarks made by T. A. Rickard who was an Associate of Royal School of Mines (ARSM),[17] also wrote as follows.

> Even the Royal School of Mines ... lacked prestige and influence of the major Continental and American institutions.... "The British system of education is in but a small degree better than none." If British technical men held their own, said Rickard in 1904, "it is rather inherited ability than the aid afforded by the miserably financed institutions which do duty for schools of mines in the various states that fly the British Flag." If English technical academies, including Royal School, were "quite behind the times", as another observer noted, and never achieved distinction of their counterparts elsewhere, it was in part because the M.E. degree was less highly valued and the profession itself carried less social and intellectual prestige in England than other areas.[18]

To understand the practical relationship between technical education and industrial performance, some issues of the above stated education of mining at the beginning of the

[13] Sanderson, 'Education and economic decline', p. 167.
[14] Harvey and Press, 'Overseas Investment', pp. 83–4.
[15] Cardwell, *Turning Points*, p. 193.
[16] Church, *Mining Schools*, p. 10.
[17] As for Rickard, Wilson, *The Professionals*, p. 43.
[18] Spence, *Mining Engineers*, pp. 33–4.

20th century will be investigated here, referring to the reports of the Departmental Committee of 1904/06 (hereinafter the Committee) which eventually led to the integration of three colleges in South Kensington, RSM, Royal College of Science (RCS) and Central Technical College of City and Guilds of London Institute (CTC/ CGLI), to form the Imperial College of Science and Technology. Based on the evidence given to the Committee by mining businessmen and engineers, deficiencies and remedial measures in the education of mining to meet the demand from the mining industry will be examined to reach some concluding remarks which suggest spontaneous but rational response in educational system in Britain. Preceding to that, the circumstances of the appointment of the Committee will be explained to grasp the situation of technical education of the time as a whole after a brief look at the history of institutions for mining education in Britain. Since mining engineers often engaged in constructing roads, bridges, and railways from mining sites to shipping ports or transport centres in overseas countries and colonies, they were literally builders of infrastructure of the British Empire. Therefore, this paper will be, in one sense, a study of training and supplying engineers for the whole British Empire.

2. Development of mining schools in Britain

Two streams are observed in the process of formation of mining schools in Britain, though they closely related each other. One stream was the development of Cornish mining schools leading to the establishment of CSM, and the other was the London stream leading to the establishment of RSM which later became a part of the Imperial College in London in 1907. The outline of chronology of the development of mining education is shown in Table 1.

2-a Original concept of mining schools

The concept of mining schools had an origin in 'Prospectus of School of Mines in Cornwall' written in 1825 by John Taylor who was involved in the management of a copper mine in Devon at his young age, and later became the founder of the world renowned mining enterprise.[19] Other than a few exceptions like Freiberg Mining Academy in Germany and École des Mines in France, mining technology had been nurtured by working miners and handed down to the next generation through on-the-job training in European countries until the middle of the 19th century. As one of the major metalliferous mining areas in Europe, Cornwall and Devon, was one of the major suppliers of skilled mining engineers and managers, called 'captain', to mines in other parts of England and overseas countries. But as mining operation was getting deeper and sophisticated while technology and science relating to the mining were making progress, the necessity of systematic instruction in mining technology became gradually felt. From his experience in management of mines Taylor strongly felt it, and he advocated the importance of technical education to working miners. He wrote: -

> ... They hear indistinctly of the progress of others, but, not having the means of judging rightly, they are too apt to fence themselves in with prejudice and conceit, and resist what has not originated with themselves. Nothing, in my mind, could do so much towards the removal of such narrow views as a School of Mining, where young men, whole they could continue their practice underground, might hear

[19] Taylor, J., 'Prospectus of a School of Mines', pp. 1–19, Burt, *John Taylor*, pp. 67–9.

Table 1 Chronology of the Development of Mining Education in Britain

Year	Cornwall	London (including relevant institutions of engineers in italics)
1814		Royal Geological Society.
1818		*Institution of Civil Engineers* (1828 Royal Charter).
1825	John Taylor, *Prospectus of a Mining School in Cornwall.*	
1835		Proposal of Museum of Practical Geology and Mining Record Office by (Sir) Henry T. De La Beche.
1838	Sir Charles Lemon (Royal Institution of Cornwall) privately set up a few courses of lectures in Truro for working miners.	
1840	Sir Charles Lemon's proposal of setting up a mining school with endowment of £5000 to be raised locally but never achieved.	
1843		H. S. Tremenhere, the first Inspector of Mines.
Mid-1840s	John Phillips (mining surveyor), weekly lecture courses at Tuckingmill sponsored by Lady Basset (the mineral owner) but likely short-lived. Robert Hunt, Secretary of the Royal Cornwall Polytechnic Society.	A series of fatal accidents at collieries. Inquiries made by Henry T. De La Beche, Lyon Playfair and so on. Needs for proper mining education advocated. Hunt, Keeper of the Mining Record Office (1845).
1847		*Institution of Mechanical Engineers* (1878 Royal Charter).
1851		Henry De la Beche opened the Museum of Practical Geology on Jermyn Street. Government School of Mines and of Science Applied to Arts (Hunt, Professor of Mechanical Science with its application to Mining).
1853	Discussion about 'the revival of a mining school' by Royal Institution of Cornwall, Royal Geological Society of Cornwall, and Royal Cornwall Polytechnic Society. Hunt was one of the major figures.	Government School combined with the Royal College of Chemistry and renamed as Metropolitan School of Science Applied to Mining and the Arts under the newly formed Department of Science and Art.
1855	A mining school at Truro, three-year trial. Some examinations conducted by W. Warrington Smyth of Metropolitan School of Mines under the Department of Science and Art.	
1859	End of three-year trial because of inadequate financial support. Hunt, President of Royal Cornwall Polytechnic Society. Richard Pearce (former laboratory assistant at Truro class) with support by Royal Institution opened classes Truro, Camborne and Pool. After his return from the study at Mining	

Year	Cornwall	London (including relevant institutions of engineers in italics)
	School in London, another classes at St. Just and St. Agnes. were opened both of which students were examined by Hunt. Miners' Association of Cornwall and Devon was established with the aim of educating miners, Hunt as a founder. Schools started classes in Redruth, Camborne and Penzance, Pearce as one of teachers.	
1863	The schools adopted Department of Science and Art examination scheme.	Changed the name to Royal School of Mines (RSM).
1869		*Iron and Steel Institution* (1899 Royal Charter).
1876	G. L. Basset (the mineral owner), donation of a laboratory to the School at Camborne.	
1880	Students took examinations of the City and Guilds of London Institution.	Department of Mining and Metallurgy (RSM) finally moved from Jermyn Street to South Kensington.
1885	Amalgamation of Miners' Association of Cornwall and Devon with Mining Institution of Cornwall to form Miners Association and Institution of Cornwall.	
1887	John Beringer's lecture on 'Technical Education and Miners' delivered to Mining Association and Institution. New proposal of mining school.	
1888	CSM and Camborne Science and Art School, issued the first prospectus.	
1889		*Institution of Mining Engineers* (1918 Royal Charter).
1890		RSM and Royal College of Science (RCS).
1892		*Institution of Mining and Metallurgy* (1915 Royal Charter)
1907		Incorporation of RSM, RCS and (in 1910) Central Technical College of City and Guilds of London Institution (CTC/CGLI) to form the Imperial College of Science and Technology.
1909	Camborne School combined with mining schools at Redruth and Penzance to form CSM.	
1929		Imperial College finally joined the University of London.

Sources: Compiled from Piper, 'A Short History of the Camborne School of Mines', Reeks, *History of the Royal School of Mines*, Gay, *The History of Imperial College*, Harvey and Press, 'Origins and early history', Buchanan, 'Institutional Proliferation', etc.

> those sciences explained which would be most useful to them, and might devote some of the spare hours which a miner's life affords to seeing and comparing the practice of others in a place where their art has reached the greatest perfection.

For the learning capacity of working miners, he continues: -

> ... Miners in general are a superior class of men, and, in the deep mines particularly, the constant exercise of judgement and thought which is necessary, produces a proportionate degree of intelligence.[20]

And for the teaching of a school he intended to establish, he described: -

> The education desirable for a miner is then a peculiar one, and must be adapted to go with the necessary labour, and not to supersede it; it should explain and make clear the reasons for each proceeding, not make the scholar unfit for his proper duty; it should not tend to the paths of the theory and dispute, but show that good practices depend upon solid and intelligible principle.[21]

Teaching basic science and technical knowledge relating to mining to working miners so that they could properly understand the contemporary mining technology through the combination of practical experience with theoretical instruction was the main concept of his prospectus.

2-b Cornish stream

Though Taylor's proposal of a mining school did not come to existence, the concept of his prospectus became the undercurrent of Cornish stream. After experimental proposals and pioneering schools for teaching working miners shown in Table 1, by the end of 1850s the movement for establishing permanent mining schools got momentum with the establishment of Miners' Association of Cornwall and Devonshire in 1859. Key person of this development was Robert Hunt born in Devonport. When he was working as Secretary of Royal Cornwall Polytechnic Society, in 1845 he was appointed as the Keeper of Mining Record at the Mining Record Office promoted by Henry De La Beche (Later Sir Henry) who was also the founder of the Museum of Practical Geology that became the base of London stream. Hunt himself delivered a lecture on applied mechanics for the newly formed Government School of Mines and Science Applied to the Arts in London in 1851. With his wide acquaintances in London, he probably had a prospect of the network of mining schools in Britain; schools in London and those in mining areas. Then he worked for the amalgamation of above stated Miners' Association with Mining Institution of Cornwall to form Mining Association and Institution of Cornwall which would become the substantial foundation of mining schools in Cornwall. Major concept of Taylor's prospectus, that is, teaching basic science and technology of mining to working miners through the combination of practical experience with theoretical instruction, can be found in a lecture before the amalgamated society's meeting by J. J. Beringer who was an ARSM and one of the devoting promoters for establishing Camborne School of Mines. After explaining the necessity of technical education even for local industrial area confronting the competition from the United States and the European continents where many technical schools were already established, Beringer advocated the importance of financial support to the school by the county council and local people saying that, since expected students would come from working miners

[20] Taylor, J., 'Prospectus of a School of Mines', p. 5, Burt, *John Taylor*, pp. 68–9.
[21] Taylor, J., 'Prospectus of a School of Mines', p. 3, Burt, *John Taylor*, p. 68.

and, like investment in railway, it would take a long time that the achievement of education would be repaid to them. To get such support, a concrete prospect for the school should be required. He explained conditions which gave demand for technical education in three ways; (1) the diffusion of technical knowledge, especially with publication of books and journals, which meant miners had been expected to have such reading ability. (2) the direct application of certain branches of natural science to the industrial area, which required knowledge of pure science to miners. And (3) the increased application of the principle of division of labour. Concerning this condition (3) he mentioned an interesting point as follows.

> The increased application of the principle of the division of labour has two effects which require consideration. ... In the first place it demands of the labour greater skill in one limited direction; in the second it tends to make his power narrow and restricted... the function of technical school is to supplement, not replace, the knowledge of a profession obtained by actual practice in the workshop or on the mine. In counteracting the narrowing effect of the extreme division of labour the influence of technical school is immediate and direct. A miner, for instance, although he may never equal a professional mine surveyor or assayer, need not be entirely ignorant surveying and assaying if he accesses to a moderately decent mining school. Moreover, many of the sciences, especially mathematics and practical inorganic chemistry, afford excellent mental training, and supply education in the highest and truest sense of the word.[22]

Camborne School developed, being supported by local mining people like Josiah Thomas of prosperous Dolcoath Mine and after his death, his eldest son Charles V. Thomas who later become a principal figure of mining in both Cornwall and Malaya. The school was finally combined with smaller mining schools at Redruth and Penzance to form the Camborne School of Mines in 1909. The school with a mine for practical training named King Edward Mine,[23] became a nationwide school. But it was also the process of losing the original concept of mining schools which was proposed by Taylor, taken over by Hunt and advocated by Beringer, that is, teaching science and technology to working miners through the combination of practical experience and theoretical instruction mainly in evening classes to elevate miners' career. The results of this process are clearly shown in Table 2-a and 2-b. In one sense it was inevitable because the heyday of local mining when the original concept developed had passed long time before and only a small number of mines remained working in the region by that time.

2-c London stream

While maintaining the basic concept of Taylor, the development of mining school in London took somewhat different course from that in Cornwall. Necessity of mining school in London had been discussed mainly from two points of view since the 1840s. One point was for the safety of mining operation, especially reducing the risk of accidents in coal mines. Systematic education of mining technology to mine manager and miners was expected to lessen the risk.[24] The other point was for the promotion of mining industry which was one of the promising industries in Britain of the time. Education of science and

[22] Beringer, 'The Technical Education', pp. 164–9.
[23] Piper, 'A Short History of the Camborne School of Mines', p. 29.
[24] *Report from the Select Committee of the House of Lords on Accidents in Coal Mines*, p. ix.

Table 2-a Origin of CSM Students

Origin of Students	Session 1929/30	Session 1936/37
Cornwall	33	22
Remainder of Great Britain	63	45
Overseas including Colonies	4	18

Table 2-b Schools Previously Attended by Students of CSM, 1929/30

Schools Attended	
Public Schools	38
Secondary Schools	35
Private Schools	16
Technical Schools	5
Public Elementary Schools	6

Source: Piper, 'A Short History of the Camborne School of Mines' p. 29.

technology relating to mining became essential for further development of mining industry along with keeping records of past mining operation so that development of mines could be done based on systematic and scientific information.

One of the enthusiastic promoters for a mining school in London was above mentioned Henry Thomas De La Beche. Though he himself was not educated in Geology, he became the active member of Geological Society and conducted Geological Survey of the British Isles. In the course of the survey, he strongly recognised the importance of practical geology and opened the Museum of Practical Geology with his collection of minerals, and also organised Mining Record Office supported by highly regarded scholars, influential people and the Government. In 1851 with financial support by the fund of the Great Exhibition and Prince Consort, the Museum moved to Jermyn Street in the West End of London and lectures on science and technology of mining were delivered in the premises attached to the Museum. Thus, Government School of Mines and of Science Applied to Arts opened. In his inaugural discourse De La Beche spoke of the importance of proper mining school for miners.

> Although the raw mineral produce of Great Britain and Ireland is valued at £24,000,000 or about four ninths of that of all Europe, ... until now no means in this country for affording needful instruction to those who thus raise so great amount of mineral matter, to be afterwards employed in affording occupation to an additional and large part of our population; all was left to chance, and the result is well known. Many who can afford it to go to other lands to study in the mining schools provided by their governments; some fight through their difficulties at home, becoming valuable and useful men; while the mass of our miners remain uninstructed except so far as they can pick up practical information from each other in the mines, seldom being in conversant but with things as they can find in very limited districts, little aware of what others may be doing in their own calling elsewhere. ... the relative proportions of the annual produce of the different

> European countries, in nearly all of which, except Great Britain, mining schools are established, those states being fully aware of the effective research they promote, and the waste of money they prevent. ... Let those who thus believe visit our mining districts, especially such as metalliferous, where the miner has so often to gain his daily bread by the exercise of his judgement, and they will speedily be undeceived. They still find men as able and willing to profit by instruction as elsewhere in our land.[25]

As a London based institution, the school was affected by the nationwide policy of the Government for technical education. With the establishment of Department of Science and Arts in 1853 it was amalgamated with the Royal College of Chemistry and renamed as Metropolitan School of Science Applied to Mining and Arts to work under the Department to carry out the policy of technical education for the country.[26] Inevitably some conflicts in ideas on the goal of the school occurred; whether the goal should be an independent Mining School or the one of the departments of the Science College under the Department of Science and Arts. Though from 1863 onwards the name of Royal School of Mines (RSM) and the title of Associates of RSM (ARSM) began to be used, the conflict was noticeable in its sluggish move of the mining department from Jermyn Street to South Kensington.[27] This conflict of ideas was finally solved the establishment of two close related but independent school and college; Royal School of Mines (RSM) and the Royal College of Science (RCS) both in South Kensington. With Central Technical College of City and Guilds of London Institute (CTC/CGLI) these two institutions formed the Imperial College of Science and Technology in 1907. Some aspects of this process will be discussed later. In the course of development one of the major points of original concept since Taylor, that is, teaching basic science and technology to working miners gradually diminished though De La Beche opened several evening classes to working people at the beginning.[28] But teaching through the combination of theoretical instruction and practical training was maintained in RSM. It is often said that RSM was eager to teach scientific theories and was less interested in teaching technology essential to mining engineers and, as a consequence, the proportion of ARSM who became academics was rather high in the first few decades.[29] Annual average number of the matriculated students (full time course) was only fifteen during the first two decades since the establishment of the Government School (later RSM). It produced 99 Associates in 1855–75 and 900 in next decades.[30] Their employment by sectors was shown in Table 3. The private sector indicates mainly mining companies including mining consultants. Some Associates were invited as consultants for mining and metallurgy by foreign countries.[31]

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[25] Henry De La Beche, 'Inaugural Discourse', in Museum of Practical Geology, *Records of the School*, p. 14.

[26] Reeks, *History of the Royal School of Mines*, p. 67.

[27] Reeks, *History of the Royal School of Mines*, pp. 111–25. 'First Annual Report of Normal School of Science and Royal School of Mines', *Twenty-ninth report of the Science and Art Department*, Appendix C, pp. 318–9.

[28] Several courses of 'evening lectures' for working men were annually given during the winter months by the professors and lecturers of Normal School of Science (later re-organised as RCS) and RSM. Mining course was not available in 1881. *Twenty-ninth report of the Science and Art Department*, Appendix A, pp. 3–4.

[29] Roderick and Stephens, *Scientific and Technical Education*, p. 103.

[30] Roderick and Stephens, *Education and industry*, pp. 141–2.

[31] eg., William Gowland was invited by Japanese Government and worked as metallurgist, assayer, and so on at Imperial Mint in Osaka from 1872–89. Reeks, *History of the Royal School of Mines*, p. 73. He is also famous for pioneering studies on ancient tombs in Japan.

Table 3 Associates of Royal School of Mines: Employment by Sectors, 1851–1920

	Private Sector	Public Sector	Academics	Military Service	Unknown	Total
1851–1860	8	13	7	1	3	32
1861–1865	7	11	4	0	6	28
1866–1870	9	7	9	0	5	30
1871–1875	21	9	17	0	11	58
1876–1880	37	17	10	3	36	103
1881–1885	35	15	11	1	16	78
1886–1890	67	21	14	9	17	128
1891–1895	76	16	18	4	39	153
1896–1900	65	17	10	13	44	149
1901–1905	79	21	6	31	70	207
1906–1910	96	14	4	63	57	234
1911–1914	68	5	5	56	42	176
1915–1920	17	5	5	15	32	74

Source: MacLeod, '"Instructed Men" and Mining engineers' compiled by MacLeod from the original source, Reeks, *History of the Royal School of Mines*.
Note (by MacLeod): Many entries list more than one profession, and many more have no record of professions. Consequently, the total of 1,072 professions does not match the 1,155 records listed.

Table 4 Educational Background of Members appeared in *Trans. IMM* Obituaries 1909–21

	RSM		CSM and Cornish Mining Schools*		Other Institutions (GB)		Other Institutions (Overseas)		Practice** and Unknown		Total
1909/10	7	43.8%	2	12.5%	1	6.3%	2	12.5%	3	18.8%	16
1910/11	2	15.4%	3	23.1%	3	23.1%	2	15.4%	4	30.8%	13
1911/12	7	15.9%	4	9.1%	6	13.6%	11	25.0%	16	36.4%	44
1912/13	5	26.3%	3	15.8%	2	10.5%	5	26.3%	4	21.1%	19
1913/14	2	7.4%	2	7.4%	3	11.1%	4	14.8%	16	59.3%	27
1914/15	8	29.6%	6	22.2%	3	11.1%	6	22.2%	4	14.8%	27
1915/16	20	40.8%	8	16.3%	5	10.2%	4	8.2%	12	24.5%	49
1916/17	10	21.7%	11	23.9%	5	10.9%	10	21.7%	10	21.7%	46
1917/18	8	20.5%	7	17.9%	6	15.4%	9	23.1%	9	23.1%	39
1918/19	6	40.0%	4	26.7%	1	6.7%	1	6.7%	3	20.0%	15
1919/20	9	20.0%	8	17.8%	8	17.8%	8	17.8%	5	11.1%	45
1920/21	8	25.8%	3	9.7%	3	9.7%	12	38.7%	12	38.7%	31
Total	92	24.8%	61	16.4%	46	12.4%	74	19.9%	98	26.4%	371

* Mining schools at Redruth, Penzance, and Henderson's (Truro).
**Personal training (Apprenticeship, Articled etc.).
Source: Compiled and calculated from *Trans. IMM* Obituaries 1909–21, each year.

According to Dixon mining engineers appeared in *Trans. IMM* Obituaries 1907–67, 22.8% of them were Associates of RSM (ARSM) and 18.8% were graduates of CSM and Cornish mining schools against 7.9% from 'practice'.[32] Similar figures except for 'Practice and Unknown' are obtained in Table 4 for engineers who were thought to be active around

[32] Dixon, 'The Results and Consequences', p. 117.

the turn of the century. Since the period of 1909–21 includes the years of the WWI and 'Spanish Flu' pandemic, the mortality rate was unusually high. But so far, we can safely say that, together with overseas mining schools, RSM and CSM/Cornish mining schools already became major sources of mining engineers who had membership of the Institution of Mining and Metallurgy by the time.

2-d Institution of Mining and Metallurgy as an educational institution

Though it was not an educational institution in strict sense, we must mention the role of the Institution of Mining and Metallurgy (the IMM) for training engineers. As Buchanan wrote, 'institutional proliferation' to establish the identity of engineering profession and raise its status was observed in Britain from the mid19th century.[33] For mining there was Institution of Mining Engineers formed in 1889, but it was mainly for coal mining and, in its nature, 'federated' organisation of already existed institutions for coal mining engineers in Northern England. The situation around 1890 was as Garland later said that it is a notable fact that the most important and responsible positions in mining are more and more falling to the scientifically trained man, while the purely practical man who lacks that training is gradually assuming a secondary position.[34] As the sphere of their activities were expanding in the world, formal qualification of engineers and proper information of overseas mining became increasingly necessary. In the course of discussion about the formation of institution of engineers in metalliferous mining and metallurgy, Charles A. Moreing argued in *the Mining Journal* that the institution 'should exist for the good of the profession and not for those who would only use it as a vehicle for their professional advancement. The institution should admit only properly trained engineers and ought to exclude "mere mining captains"'.[35] Also, he added that the institution should help in overcoming the speculative reputation of international mining. The institution formed in 1892 with 113 original members. As reflecting the policy of limiting the membership, only nine Cornish mining captains were allowed to join the institution.[36] Later to fortify this aspect of qualification they sought the Royal Charter granted in 1915.[37] The necessity of the Charter was argued by McNeill in his presidential address.

> We all know instances when a man with little professional training, and with the merest superficial experience, has posed as a mining engineer ...
>
> It is our present misfortune, and it will be our fault, if such conditions with regard to the lack of control which we as an Institution have over those who call themselves 'mining engineers' be allowed to continue. I hold no one should be permitted to style himself a mining engineer, or to practice as such, unless he is qualified to do so; and of his qualification for mining, other than coal, this Institution ought to be the Tribunal.
>
> From this point of view our position as an Institution is not satisfactory. ... We have no authority, jurisdiction or corporate being whatsoever. ...
>
> I thinks I have shown you why we want a Royal Charter.[38]

[33] Buchanan, 'Institutional Proliferation'.
[34] Garland, J., 'Presidential Address', *Trans. IMM*., Vol. V, (1896/97), p. 206.
[35] *Mining Journal*, 20 December 1890, 1515.
[36] Harvey and Press, 'Origins and Early History', p. A173.
[37] A petition for granting a Royal Charter of Incorporation was once made to the Privy Council in 1901, but in this occasion, it was not achieved partly due to the death of Queen Victoria. Wilson, *The Professionals*, pp. 62–5, *Trans. IMM*, Vol. IX (1900/01), p. 235.
[38] McNeill, B., 'Presidential Address', *Trans. IMM*., Vol. XXII, (1912/13), pp. xxxiii and xxxviii.

Table 5-a Membership of Institution of Mining and Metallurgy, 1892–1914

	Honorary Members	Members	Associates	Students	Total
1892	0	117	29	24	170
1896	4	224	117	104	449
1900	7	375	175	174	731
1904	12	571	337	326	1246
1908	11	714	563	511	1799
1912	9	871	828	550	2258
1914	6	961	962	563	2492

Table 5-b Geological Distribution of Members of Institution of Mining and Metallurgy, 1892, 1905 and 1914

	1892	1905	1914
U. K.	119	578	973
Europe	13	70	113
Africa	15	276	467
America	6	169	363
Asia	11	89	220
Australia	6	120	174
Total	170	1302	2310

Source: Harvey and Press, 'Origins and early history', p. A173.

While making effort to establish the status of engineers of mining and metallurgy, members were constantly exchanged their opinions each other based on their research and professional experiences at the meetings and in articles of its *Transactions*. For example, a session for discussing the mining laws in foreign countries was held in 1900.[39] Since the institution had student membership, it functioned as an educational body to instruct the most advanced technology to mining students as well as mining engineers. The development of the institution was shown in Table 5-a and 5-b.

3. Departmental Committee 1904/06

As seen in the previous section, the system of mining education was gradually consolidated by the beginning of the 20th century. As a culmination of the series of official investigation into technical education since the latter part of the 19th century, a departmental committee (hereinafter the Committee) on higher education of technology and science was appointed in 1904. Since the contemporary issues on education of mining engineers can be found through the discussion of the Committee, the Committee's discussion and evidence given to the Committee will be examined. Before that, in order to see the situation of technical education at the beginning of the 20th century Britain, particular reasons for the appointment of the Committee and its final recommendations will be considered first.

[39] *Trans. IMM*, Vol. IX, (1900/01), pp. 2–67.

3-a Circumstances of the appointment of the Committee

The terms of reference, given to the Committee by the President of Board of Education, Marquess of Londonderry, were as follows.

> To inquire into the present working of the Royal College of Science including the School of Mines: to consider in what manner the staff, together with the building and appliances now in occupation or in course of construction, may be utilised to the fullest extent for the promotion of higher scientific studies in connection with the work of existing or projected Institutions for instruction of the same character in the Metropolis or elsewhere: and to report on any changes which may be desirable in order to carry out such recommendations as they may make.[40]

If we interpret the terms of reference literally, they were rather limited ones asking the Committee to examine and propose the most effective use of resources of RCS and RSM in connection with those of other similar institutions in London for the promotion of higher scientific study in Britain. As mentioned above, in the South Kensington site, a concentration of resources for higher education of science and technology, i.e., RCS, RSM and CTC, was observed by the beginning of the 20th century. According to the Final Report (hereinafter *Final Report*) of the Committee in 1906 direct causes which led to the appointment of the Committee were explained as the special combination of circumstances.

(1) The approaching completion, at a cost of over £250,000, of the new laboratories and buildings of the Royal College of Science. If proper advantage was to be taken of the expenditure of this, it had become a pressing question to settle the future scope and the function of the college.
(2) The munificent offer conveyed through Lord Rosebery to the London County Council about two years ago for the provision on the South Kensington site, in immediate proximity to the new laboratories of the Royal College of Science.

In addition to above two main reasons, followings were also expressed.

(3) The rapid growth of the gold-mining industry in South Africa and the insufficient provision for the education of the British mining engineer as compared with his foreign competitors have forced attention upon the condition and equipment of the Royal School of Mines, and it has become evident that large sums would be necessary to restore this old established and famous school to its relative position, a position corresponding with that held by this country in the mining industry of the world. In this connection the usual inquiry into the necessities of an Imperial School of Mines was undertaken about three years ago by the Institution of Mining and Metallurgy.
(4) The resources of the recently inaugurated Bessemer Memorial Fund will be made available for the purpose of such a school.
(5) The centre of gravity of the South Kensington site has been to some extent affected by installation, in 1900, of the central offices of the University of London in the buildings of the Imperial Institute.[41]

Though the mission of the committee derived from rather practical reasons, they extended the scope of discussion to the progress and problems of technical education in

[40] The Preliminary Report of the Committee (*Preliminary Report*), [Cd. 2610], p. 5.
[41] *Final Report, Vol. I*, p. 23.

Britain as a whole in comparison with those in other countries; Germany, Belgium, France, the U. S. A. and Canada.

There were mainly two reasons to do so. The one reason was sluggish development of technical education despite the consolidation of the legal framework. The Technical Instruction Act of 1889 and its amendment of 1891 enabled local county councils to levy a local tax up to 1 penny per 1 pound for private property to support schools of technical education affiliated by the Department of Science and Art. The Local Taxation Act of 1890 provided funds from so-called 'whiskey money' to county councils for technical education.[42]According to these acts local governments became responsible for promoting the technical education formally though, for a while, local county councils were not so eager to raise money for it by taxation. London County Council established Board of Technical Education to supervise the technical education in London. Civic colleges and universities like Birmingham, Manchester and Leeds were being equipped with science and technology curriculum. University College and King's College in London, which had established in the early part of the19th century and eventually became major components of London University which was transformed into an institution with educational function from merely examination body in 1898, were already teaching science and technology subjects. Even in Cambridge and Oxford introduced mathematics and science subjects by the beginning of the 20th century.[43] Despite these movement the process for establishing the substantial system of technical education in whole country was slow. On-the-job training such as apprenticeship still remained an effective method of technical instruction in Britain.

The other reason came from a pessimistic view that British industries were falling behind those of other countries, notably Germany. Reflecting this feeling, E. E. Williams' book, *Made in Germany* (1896), became one of the bestselling books. 'German threat' was getting popular topics of daily conversation. As usual, many people attributed this poor performance of industries to the deficiency of technical education. They constantly referred to nice-looking technical education in other countries, especially in Germany which had College of Applied Science at Charlottenburg (Technische Hochshule in Charlottenburg) alongside the University of Berlin. A pessimistic current of discussion on education since Playfair's age in the latter part of the 19th century was reinforced again. Establishing Charlottenburg like institution in London which was expected to become the centre of technical education in the British Empire became the theme of discussion.

In the meantime, a letter from Lord Rosebury, the Chancellor of the University of London, to Lord Monkswell, the chairman of the London County Council, was published in *Times* newspaper in June 1903. In the letter Lord Rosebury, while appreciating the Council's effort to construct the framework of education of science and technology, quoting the report of the Technical Education Board of the Council, he wrote: -

> In the striking report presented to the Council by its Technical Education Board last July, on the application of science to industry, it is clearly shown that several of our industries have suffered, and are still suffering, from our failure to organise, not so much technical education of the ordinary type as the more advanced

[42] Roderick and Stephens, *Scientific and Technical Education*, p. 58, *Education and industry*, pp. 73–4.
[43] Roderick and Stephens, *Education and industry,* Chapter 5, pp. 83–114.

> instruction in scientific technology and facilities for original research. The report points out that on other countries special attention has long been paid to the highest technical training of those who will become, if not the captains of industry, the skilled lieutenants and confidential assistants in every branch of commerce or manufacture. Perhaps the most perfect instance of such provision is the great College of Applied Science at Charlottenburg, alongside of the University of Berlin, erected at an outlay exceeding £500,000, and costing £55,000 a year. From its portals there issue every year some 1,200 young men of 22 or 23 years of age, equipped with the most perfect training that science can give, as experts in chemical technology, electrical engineering, metallurgy, shipbuilding, &c. Of these the ablest are eagerly sought after by the great industrial combination of the German empire, which owe their remarkable success in no small degree to the quite exceptional wealth of scientific knowledge and training which is thus placed at their disposal.
>
> It is clear that in spite of all that has been done in various directions, London is still very inadequately provided with educational opportunities of this advanced kind. For lack of such opportunities, our London young men often find the highest places filled by the better educated Germans; and scientific researches, even when carried out here, now often benefit our rivals.

Then he told his ambition in rather emotional tone.

> It is little short of a scandal that our own able and ambitious young men, eager to equip themselves with the most perfect technical training, should be compelled to resort to the Universities of Germany or the United States. It is not right that picked students from Canada, Australia, South Africa or India, should be unable to find within the Empire the educational opportunities that they need. The time has come for making London, at any rate so far as advanced work in scientific technology is concerned, the educational centre of the Empire.

And he made a practical proposal.

> It is proposed that the institution, whilst working in close co-operation with the Royal College of Science, the Central Technical College, and other branches of the University should be organised as a distinct "school" of the University under the management of its own committee, a committee on which I hope the London County Council will consent to appoint representatives.
>
> An offer has been made by Messrs. Wernher, Beit, and Co., to place a large sum of money in the hands of trustees to be applied as a contribution towards the cost of building and equipment, and further offers of the same kind have been made by other public-spirited London citizens.

Also, he expressed a careful consideration to other similar institutions already exited.

> It would be, of course, direct its attention from the first, not to duplicating any provision now existing in London, but to supplementing that provision by taking up subjects as yet undealt with, or only inadequately dealt with.[44]

His letter ignited a discussion of the questions as to what kind of institution would be required for higher or the highest level of education of science and technology in London, and as to who would take initiative of this matter.

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[44] *The Times*, 29th June 1903, p. 13.

Apart from the problem of technical education in general the mining industry was facing its own problems of technical education at the beginning of the century. A. G. Charleton, the president of the IMM, spoke of the particular needs of the professional education of mining engineer in his presidential address in March 1902, saying that it was not merely 'a matter of choice' but was forced upon him by 'stern necessity' caused by followings.

(1) the rapid increase in the number and improved equipment of mining schools in our Colonies and elsewhere, which, with more and more liberal endowment, are turning out a larger number of men who have adopted mining engineering and metallurgy as professions; bringing into direct but friendly competition engineers trained in different countries and various schools, under different systems.
(2) The need that has arisen for reducing the cost of production, so as to enable lower and lower-grade and more refractory ores to be worked at a profit, without raising the price of metals to such a point as would materially restrict their uses; which, as a natural consequence, calls more and more improved organisation, mechanical appliances, and metallurgical methods of treatment.
(3) The increased amount of money, more particularly British, which has found an outlet for profitable employment in mining, and has become directed by companies capitalised on a far larger basis than was formerly the rule, with a corresponding increase in the technical and business responsibilities to their management.[45]

The mining industry itself eagerly wanted to improve mining schools to meet the needs of the time.

3-b Reports of the Committee

The Committee was appointed in such situations. It submitted *Preliminary Report* (1905) and subsequently *Final Report* (1906) after 17 meetings at which 21 witnesses were examined in 1904. Before submitting the recommendations in *Final Report*, they pointed out conditions to be fulfilled for establishing the highest level of technical education as the best use of resources at South Kensington in *Preliminary Report*.

(1) The gift of a large capital sum (say not less than £100,000) for building and initial equipment.
(2) The gift of a considerable additional site (say not less than 4 acres) at South Kensington.
(3) The willingness of the Board of Education to allow their College of South Kensington to be brought into a scheme of common government and administration.
(4) The similar willingness of the City and Guilds of London Institution in respect of their College at South Kensington.
(5) The continuance of the Government contribution including the necessary provision for the maintenance of the new laboratories and other buildings of the Royal College of Science, now approaching completion.
(6) The continuance of the support given by the Corporation and Livery Companies of the City of London to the Central Technical College.

[45] *Trans. IMM*, Vol. X, (1901/02), p. 328.

(7) The Provision (in the proposed College of applied Science at South Kensington) of instruction in certain departments of Engineering either by new foundation or by transfer and enlargement of the part of the work of some existing College or Colleges (e.g., University College or King's College).
(8) The co-operation of the University of London.
(9) The assurance of a sufficient maintenance fund.[46]

They also made a special mention on the mining education that the central school of mines with a full course of instruction of the Mining and Metallurgy to meet the needs of the whole British Empire mining should be situated in London.[47]

In *Final Report*, after rather long investigation into the development of technical education in Britain and in other countries (section 2), the conclusion and recommendations were given as follows.

[Conclusion]
(1) That the position of this country makes further provision for advanced technological education essential.
(2) That students, by whose advanced technological education the nation would profit, are not actually obtaining it to the extent, which is desirable, this is due to: -
  (a) The lack of facilities for instruction in certain important subjects; -
  (b) The absence of such co-ordination among existing institutions of technological education as would permit concentration of the more advanced courses in a limited number of institutions; -
  (c) An insufficient appreciation, especially on the part of the employers, of the value of such education.
(3) That the opportunities for research in our technological institutions are inadequate to the industrial needs of the Empire, owing not to any want of ability on the part of professors, but to the fact that much of their time is frequently absorbed in the giving of comparatively elementary instruction in Pure and Applied Science.
(4) That in any institution in which the highest technological education is given, the equipment should be adequate for the purpose, and the staff should include, at the head of the several specialised branches of the work, men of the first rank in their profession.

[Recommendation]
That the present combination of conditions at South Kensington points to the desirability of so utilising the resources there available, and of making additions to these, as to form on that site an institution of the highest standing, as institution which, with the staff, equipment, and students that it will command, would go for towards remedying the above mentioned defects.[48]

They recommended the Government to make every effort to integrate RCS, RSM and CTC at the South Kensington Site into one institution under one governing body as the

[46] *Preliminary Report*, p. 6.
[47] *Preliminary Report*, p. 8.
[48] *Final Report Vol. I*, pp. 23-4.

conditions given in *the Preliminary Report* were being fulfilled. According to the recommendation the Imperial College of Science and Technology was established in 1907. But details of the governing body and its relationship to the University of London were left to further discussion.[49] The Council of the IMM itself already discussed re-organisation of the RSM and submitted the report saying: -

1. That the Royal School of Mines should be endowed and equipped in such a way that it will not be surpassed in its training efficiency by any similar school in the world.
2. That it should retain its identity and remain an absolutely distinctive entity in any combination of co-ordination of Colleges.
3. That the diploma of "Associate of the Royal School of Mines" should be maintained.
4. That the direct management of the School should be entrusted to a Committee which the Mining and Metallurgical Industries should be substantially represented, subject to the general control of the Central Governing Authority.[50]

To some extent the independency of each institution remained such as a title of ARSM for the graduates of RSM. Most of the requests of the IMM were included in the recommendation. The discussion about the relationship between the College and University of London continued till the 1920s.[51]

4. Some issues of mining education: evidence given to the Committee

The Committee invited a wide range of people as witnesses to be examined. They were Dean and professors from RSM/ RCS, Secretary and council members from the IMM, the chairman of the Board, Principal and a professor from CSM and so on. Among witnesses from the IMM, A. G. Charleton, C. A. Moreing, E. Taylor, and R. T. Bayliss, were mining entrepreneurs who employed a number of graduates of mining schools both in Britain and foreign countries for conducting their internationally expanding business of mining. Therefore, they were able to give evidence, comparing mining education in Britain with that in other countries from the viewpoint of employers. Their evidence along with other relevant evidence given to the Committee will be examined to understand the problems of mining education of the time.[52] And also, possible remedial measures of the defect of education they discussed will be investigated.

According to McDermid, Secretary of the IMM, one third of Council members of the IMM were RSM graduates (ARSM).[53] Six out of twenty-one witnesses were ARSM such as Charleton, Gowland and Beringer. Taylor was not ARSM, but he studied mining technology

[49] Royal Commission discussed the matter and made a recommendation, but it was not materialised. *Final Report of Commissioners*, 1913, Hall, *Science for Industry*, pp. 33–7.
[50] Report of Council, *Trans. IMM*, Vol. XV, (1905/06), p. 390.
[51] Gay, *The History of Imperial College*, pp. 84–8.
[52] Minutes of evidence, appendices were published as *Final Report Vol. II*. Hereinafter references to evidence will be given in the following format; name of witness, number of relevant questions like 'Moreing, qq. 819–20'.
[53] McDermid, q. 661.

Table 6 Employees of Technical and Semi-Technical Characters in Bewick, Moreing and Company, classified by Salaries and Origin of Training (excluding Accountants and Purely Commercial Agents)

Class	Trained in Technical Schools				Trained in Practice	Total
	America	Australia	England	Total		
More than £4000	5	0	0	5	0	5
£1200 - 4000	9	1	2	12	5	17
£800 - 1200	4	8	1	13	6	19
£480 - 800	3	19	3	25	37	62
£240 - 480	1	18	2	21	248 (148)	269 (169)
Total	22	41	8	76	296 (196)	372 (272)

Source: Moreing, q. 819.
Parentheses: Hoover, 'The Training of the Mining Engineers', p. 716.

at RSM.[54] Most of the witnesses highly appreciated RSM's contribution to mining education in Britain as the pioneer of mining school. Charleton who studied at Freiburg Mining Academy as well as RSM did not make one-sided argument on the defect of British mining education, while showing characteristics of each country's educational system in a balanced manner.[55] Despite those appreciation, many of them told the Committee the shortage of fund and equipment of RSM to meet the needs of the time. The statement of the IMM sent to the Committee also pointed out that the defect of RSM to become 'the Central School of the Empire' were largely due to its inadequate endowment and inability to adapt itself 'to altered circumstances and requirements'.[56]

There were also unflattering comments to mining schools in Britain and their graduates. Moreing whose company had interest in the management of thirty-two mines in Australia, New Zealand and elsewhere presented a memorandum prepared by him with his company's engineers including Herbert Hoover (later the President of the U. S. A.).[57] Since the content of memorandum was almost same as that of Hoover's article in *Science*, it is likely that the memorandum was written under the strong influence of his opinion.[58] In the memorandum a table of employees of the technical and semi-technical character in his company, classified by salary and educational background, was supplied. The salary linked with the rank of engineers from the mere technician or 'skilled artisan' to the general manger. As shown in the Table 6, fourteen out of twenty-two engineers of two highest paid ranks were educated in America. English mining school graduates tended to be at rather lower ranks than American counterparts. The table also indicates that people who were trained in technical schools and colleges occupied the higher position than those of 'trained in practice'. Referring to the table, Moreing said that, 'very few of these men come from England, and, as we are an English firm, it is not from any want of willingness on our part to

[54] Taylor, q. 914.
[55] Charleton, q. 1011–3.
[56] 'A statement of the IMM Council', McDermid, q. 661.
[57] Moreing, q. 819. As for Hoover as a mining engineer, see Nash, *The Life of Herbert Hoover*, Mouat and Phimister, 'The Engineering of Herbert Hoover'.
[58] Hoover, 'The Training of the Mining Engineer', p. 716.

employ them, but because we do not get them'.[59] This statement suggested a possible defect of education in British mining school. Training not only technical skills but also a kind of management sense would be required in mining education. As will be seen later, he put stress on theoretical education at the school combined with practical training by apprenticeship in commercially active mines after completion of the course of the school.

Bayliss who had experience in the management of a mine for thirteen years in the U. S. A. employed engineers from mining schools both in Britain and America. He told the Committee that the teaching method and contents were rather obsolete in British schools. He even asked the people from the British schools to forget some parts of what they had learned at school. He emphasised the importance of practical side of training at school.[60] Taylor who operated mines mainly in India stated before the Committee that his company employed many men from CSM and Cornish schools as well as self-educated men. Only ten out of about two hundred people who supposed to be drawn from mining schools were graduates from the School of Mines.[61] This may have suggested that the required type of engineers varied according to the metal they mined, the location of mines such as America, Australia, India, and the method of mining they employed. But all of them had a shared view that the education of Mining school in Britain should be improved to meet the needs of the time.

4-a Facilities and equipment

Poor facilities and equipment were one of the fundamental problems. For RCS there was an improvement of these things as the result of the tactical effort by the principal, Thomas H. Huxley, to gain the state money under the name of training science teachers. Along with Huxley's RCS, RSM also improved some facilities and equipment but it was not enough. Sometimes RSM had to find lodgings for their laboratories and offices nearby the school.[62] Now such a deplorable state was improving as the formation of Imperial College. Wernher, Beit and Co., a prosperous diamond mining company, was prepared to donate large sum, and Bessemer Fund became available to improve the facilities and equipment. The Government, London County Council and CGLI promised annual financial support to the College. Therefore, limitation due to the shortage of fund to improve the facilities and equipment was to ease gradually.[63]

4-b Practical training

As for teaching method, insufficient practical training was also a problem. The term, 'practical', was sometimes used in different way among witnesses. On one occasion, the term was used as 'practical' or a laboratory work in the curriculum as distinguished from ordinary lectures. On the other occasion, it meant working experience in active mines during or after the study at school.[64] The latter was mainly discussed in the Committee. As stated above, Moreing put stress on practical training for two years through apprenticeship after finishing the course at school.[65] Taylor thought that the whole process of engineers'

[59] Moreing, q. 819.
[60] Bayliss, qq. 951, 964–5.
[61] Taylor, q. 923.
[62] Reeks, *History of the Royal School of Mines*, pp. 140, 147 etc.
[63] Hall, *Science for Industry*, pp. 32–3.
[64] Taylor, q. 918.
[65] Moreing, qq. 819, 822.

education should not be carried out solely by school but through on-the-job training as well. He said that graduates of mining schools may have been in the more commanding position at the starting point of their career than the people without mining school education, but afterwards self-education based on the accumulation of experience would become far more important than school education. He proposed an idea of 'junior' engineers such as 'junior reduction officers' and 'junior underground agents' for the graduates instead of apprenticeship. Probably this reflected the fact that relatively large number of self-educated engineers were employed by his company. While appreciating theoretical instruction at school, he suggested his intention of employing more graduates if more practical training would be introduced into school.[66] Bayliss who emphasised practical training proposed working experience before matriculation like Freiburg in Germany. Or he alternatively suggested a sandwich course of theoretical education at school and working experience in mines. He thought that alternate training of studying and working would certainly help students to find their aptitude as mining engineer and to choose the suitable department of mining operation for each person.[67] Charleton expressed his opinion that mining school would nurture basic capacity of engineers to understand a wide variety of practices employed in mines of various countries in the world.[68]

One of the means to make up the shortage of practical training in the curriculum at school was to work in mines during the vacation. In America working experience during the vacation was integrated into the curriculum as Hoover experienced at Stanford University.[69] There were many commercially active metalliferous mines in the U. S. A. On the other hand, those in Britain were diminishing in number, so students may have found difficulty to find a suitable metalliferous mine for their working experience during the vacation.[70] Since in Germany the secondary education was conducted more systematically than in England and the academic level of incoming student was not so varied, it was possible to have working experience before matriculation.[71] Despite this disadvantage, compulsory six-month vacation work which consisted of training at a colliery for three months and at an ore mine for the rest months was introduced in 1903/04 term curriculum at RSM.[72] Vacation work at CSM was also recommended in *Final Report*.[73] Later, for vacation work, many students of Imperial College went to Rio Tinto copper mine in Spain with which the College had some connections.[74]

But it was not enough for training engineers and the question how to reinforce practical training still remained. There were many British owned mines in overseas countries and colonies. They could become the mines where graduates of mining schools were trained. The IMM proposed one-year training in such mines under the supervision of professors at home school after the completion of three or four-year theoretical course.[75] Actually, the IMM offered post-graduate working experience in South African mines (Transvaal) for the

[66] Taylor, qq. 928, 930–7.
[67] Bayliss, qq. 955, 960.
[68] Charleton. q. 984.
[69] Though it was not for mining but geology. Nash, The Life of *Herbert Hoover*, p. 31.
[70] Bayliss, q. 951, Gowland, q. 349, Moreing, q. 861.
[71] Judd, J. W. (Dean of RMS and RCS), qq. 123–7.
[72] Judd, q. 300.
[73] *Final Report Vol. I*, paragraph 108.
[74] Gay, *The History of Imperial College*, p. 166.
[75] Charleton, qq. 1001–2, McDermid, q. 661 etc., *Final Report Vol. II*, Appendix VI, pp. 179–80.

students of RSM.[76] Charlton and Taylor basically supported the idea. Moreing insisted two-year genuine apprenticeship which was not under the supervision of professors after four years of theoretical study at school. His company offered a grant for giving an opportunity to work in their South Australian mines on pay for two years to RSM graduates.[77]

Most of witnesses were not so interested in possession of own training mine like CSM's King Edward Mine. All agreed the necessity of a training mine for 'practice' in the curriculum but did not recommend having a mine for working experience because training in one particular mine could result rather narrow experience to students. And they thought that non-commercially active mine was not suitable to nurture the sense of management which was required to mining engineers. Moreing said, 'we do not believe in any attempt to reproduce actual working conditions' and 'our requirements are not only technical, but also commercial'.[78] Imperial College purchased Tywarnhaile Mine in Cornwall in 1909 mainly for the purpose of training of mine surveying.[79]Learning theoretical subjects at school together with some 'practical' and working in overseas mines as work experience after graduation would be the best combination for training engineers. Because this scheme reflected the international expansion of British mining, it should be the rational choice and the British way of education of the time.

4-c Motivation of students

Above stated British type of education and training system was establishing with ample endowment, but the question as to whether it worked practically well or not was an entirely different matter. For example, as far as Moreing's scheme of working in Australian mines was concerned, only one student had applied for it until 1904.[80] Problems probably lay in the motivation of the students. Bayliss pointed out that the American student took 'his work more seriously' and he went 'into a technical institution as a means of making money'.[81] Therefore, they sometimes started working upon finishing the secondary education and, after working for several years, entered the technical college to raise their position and get good pay for their work. In other words, they had a strong sense of purpose to enter the mining school. On the contrary in Britain 'many parents are indisposed to let their boys of sixteen or seventeen go out into the world, as they call it, and rub shoulders with working men and that sort of thing'.[82] According to Moreing American engineers who had professional education supported by education of the fundamental humanities were generally eager to raise their position by working in various departments of the work to get the final position of the general manger. British graduates from the mining schools were relatively reluctant to experience wide range of work in various departments of mines. They soon wanted to get a high position in mine management.[83] In one sense this attitude was in common with what Floud once wrote that in Germany the entire system of technical

[76] *Trans. IMM*, Vol. XV (1905/06), p. 389.

[77] *Trans. IMM*, Vol. XV (1905/06), p. 389, Vol. XVI (1906/07), p. 248. But this offer was withdrawn later because of his worsening relationship with the IMM, therefore, no mention was found in *Trans. IMM*, Vol. XVII (1907/08), pp. 356–7.

[78] Moreing, q. 819. The importance of sense of management was emphasised by Hoover too. Hoover, *Principles of Mining*, Chapters XVI–XX, pp. 161–93.

[79] Reeks, *History of the Royal School of Mines*, p. 68, Gay, *The History of Imperial College*, pp. 166, 191 (footnote 92).

[80] Moreing, q. 858.

[81] Bayliss, qq. 948–50.

[82] Bayliss, q. 950.

[83] Moreing, q. 896.

education was designed to fit each worker onto a rung of the job ladder from which he would not move, in France and the United States it was concerned to confer status on those destined for the upper rungs of the ladder, while in Britain it was designed to permit and encourage vertical job mobility[84] Similar thing mentioned by Curle saying that British engineers had tendency to stick to one department and were lack of motivation to become the manager to supervise the whole mining operation.[85]

4-d Status of mining engineers

Above lack of motivation closely related to the social value system in Britain and the structure of governance of mining companies. Curle properly pointed out this problem by using the term, 'caste system'. He wrote: -

> In America, engineering is an honoured profession ... In England, on the other hand, we are dominated by the caste system, and caste declares that an engineer is to rank far down in the social hierarchy. ... it would never occur to him to make his son a mining engineer. ...
> ... The London School of Mines will not take its proper position, either separately, or as part of a technical university, until it receives as good a type of man as the American universities, and until the degree of mining engineer shall be highly valued, and shall carry the social and intellectual prestige it carries in America.
> ... On the other hand, it is considered quite the right thing to be a director of a mine, even if you are merely a dummy put in by a company promoter, and have got to do as he tells you. It has come about, therefore, that the lords, or other titled people, retired generals, civil servants, and the like, have crowded thickly on to the boards of most of our mines, and are there with the one and only idea of grabbing the fees pertaining to such posts.[86]

Similar argument was found in Spence's book quoted before, and Hoover also wrote by using the term, 'social dignity'.

> Another matter which enters into the great English question is that social dignity does not attach to the position of engineer. In the English social mind, the engineer is still an artisan or a trades man, and the distinction of the engineer as a professional man of equal rank and personal attainments to any other profession has but few advocates in this country. The consequence is that the young men of better families, looking about for a profession, must choose either the law, the church, the army, the navy, medicine or the civil service if they hope to attain social dignity. The result is that it would be very difficult to draw the average brains of the country into the technical branches, where I think the feeling in America is quite to the contrary.[87]

In addition, a sceptical attitude to technical education, more precisely engineering education, in the late nineteenth century may still have had influence in social mind of British people. For example, though it was not a comment to technical education but to the relationship between research of pure science and that of technology, Alfred Wallace wrote

[84] Floud, 'Technical Education', pp. 156–7.
[85] Curle, *The Gold Mines*, pp. 18–9.
[86] Curle, *The Gold Mines*, pp. 17–20.
[87] Hoover, 'The Training of Mining Engineer', p. 719.

about the question as to whether scientific research should be supported by public money in 1870: -

> The only logical foundation for advocating the furtherance of scientific discovery by the expenditure of public money, would be the belief that science can be most successfully pursued by those whose chief object is to make practical and valuable discoveries; whereas the whole history of the progress of science seems to me to show that the exact opposite is the case, and that it is only those who in a noble spirit of self-sacrifice give up their time, their means, even their lives, in the eager and loving search after the hidden secret of Nature, who were rewarded by those great discoveries from which spring a rich harvest of useful applications.
> ... I do not admit that it is just to tax the community for all the Government institutions ... some of these institutions require modification. ... As an example, I may indicate that a detailed survey, like that of the large scale Ordnance-maps, being primarily a boon to the landowners of the country, should not be wholly paid for by the public.[88]

As stated above, the IMM was eager to establish the social status of mining engineers. But even within the academic world such a sceptical attitude was possibly observed. Final year students who passed the associateship examination to get Associate's diploma like ARSM from newly formed Imperial College had to take another set of examinations to gain the degree of the University of London until the late 1920. Though complicated factors such as political motivation and vested interests may have been involved in establishing the relationship between the College and the University, it cannot be denied that there was a kind of scepticism, that is, the question as to whether engineering education should be included in university academism.[89]

While suggesting that it would be possible to improve 'more or less hand-to-thumb methods' of British technical training by introduction of American way of training, Hoover wrote about skills required to engineers and the necessary reorganisation of the method of administration in British industries.

> English industries, however, are conducted under two bureaus of administration – commercial and technical. The attitude of commercial direction always tends towards the greatest immediate result, which usually takes the form of the least outlay of capital. The tendency of the engineer is to get the minimum production cost per unit, which involves large outlay of capital. Neither side is entirely right, and in America this has been successfully overcome by educating commercial bureau as engineers. In other words, our engineers are administrators instead of consulting men, so that any in improvement English industries must come by a reorganisation of their method of administration, as much as by superior education of their men, and this is a matter which can not be accomplished by technical education, and, in any event, would be of very slow growth.[90]

Several witnesses also emphasised the introduction of more commercial subjects into

[88] Wallace, A. R., 'Government Aid to Science', *Nature*, (20 January 1870), p. 315.
[89] Details for the relationship between Imperial College and the University of London, Gay, *The History of Imperial College*, pp. 84–8.
[90] Hoover, 'The Training of the Mining Engineer', p. 719.

mining schools' curriculum. This was realised in Imperial College curriculum. Though it may have had a long way to establish 'social dignity' of engineers, the reputation of mining school education in Britain was gradually improving in the early part of the twentieth century. RSM was taking more students from public schools who were considered to belong to 'better families' than before. According to a witness from CSM same tendency was observed for CSM students in 1903 too.[91]

4-e Characteristics or two tiers?

Apart from the social value system in Britain, though obscure, a kind of demarcation between RSM and CSM was observed among mining engineers. As mentioned above, Taylor employed comparatively large number of CSM graduates in his companies. But Moreing gave evidence suggesting two tiers of mining engineers. He said: -

> I should like to see a school (RSM) that would train high class engineers, as distinguished from a school that only trains foremen. You have several times referred to the Camborne School of Mines; the Camborne School of Mines I consider trains surveyors, assayers, and mining foremen, and trains them very well, but it does not turn out high-class engineers. It has not got the proper course. What want is a school that will turn out engineers, not only surveyors and assayers.[92]

According to McDermid the integrated education of RSM with CSM such as 'a half-year special work' at CSM for RSM students was never discussed by the IMM council.[93] In *Final Report* of the Committee CSM was only described as a proposed site for vacation work of RSM students.[94] This must have been a disappointing result for CSM witnesses who were expecting secure relationship with RSM.[95]At the early stage of the development of mining schools, enthusiastic promoters envisaged a network of mining schools for education of working miners. As stated before, one of the original concepts and purposes of education, that is, education of working miners, were being gradually lost. And once systematic education established, the demarcation among schools may have appeared. Dixon found that there was a slight difference in their working countries between ARSM and graduates of CSM.[96] Whether we call it as the emergence of two tiers of engineers or simply the characteristics of each school is a further question to be examined.[97] Investigation, based on Dixon's database, into engineers' career paths at mining companies, such as managing directors, assayers, surveyors and so on, by their educational background will be one of the possible themes of next study. So far, we can at least identify the difference in their origins. RSM started in the atmosphere of the West End of London where a wide variety of societies

[91] C. V. Thomas (Chairman of the Committee of Management, CSM), qq. 1262–5, and also see above Table 2b.
[92] Moreing, q. 866.
[93] McDermid, q. 772.
[94] *Final Report Vol. I*, paragraph 108.
[95] Wilson, *The Professionals*, p. 62, C. V. Thomas, qq. 1310–2, W. Thomas (Lecturer of CSM, the manager of the King Edwards Mine) once wrote a 'general view' to RSM, proposing closer relationship or amalgamation with RSM. W. Thomas, qq. 1471–2.
[96] According to Dixon's tables of aggregated years of experience and career invested which are aggregated figures of years of experience of each man in the area, for graduates both of RSM and CSM/Cornish schools, South Africa was the most common working place with 22.3% and 22.2% of total aggregated years respectively. For graduates of RSM, U. K. (19.6%), South America (9.6%), and Far East, excluding China, Japan and Korea, (9.0%) followed, while for those of CSM/Cornish schools Western and Central Africa (16.2%), U. K. (15.4%), and South America (11.6%), came the second, third and fourth. Dixon, 'The Results and Consequences', pp. 158–60.
[97] Though the mining method was much different between Cornwall and Nigeria, CSM students might have felt an affinity to tin field in Nigeria, Western Africa.

and activities relating to science were flourishing in the upper class community, on the other hand, CSM originated from practical mining area in Cornwall.[98]

5. Concluding remarks

Having been driven by a sense of crisis that the superiority of British industries was fading at the turn of the century, an enquiry into the higher education of technology which was thought to be a possible suspect of the deterioration took place. It aimed to establish the central institution of technical education to meet the demand for engineers from the whole British Empire, referring to cases of the other countries, notably Germany and the United States. Mining education to train mining engineers was not an exception of the enquiry. Mining schools in Britain were not so highly appreciated by the contemporaries while the demand for engineers of metalliferous mines was growing to support internationally expanding British mining business. But, as preceding studies have suggested, the deficiency of domestic mining education does not appear to have hampered the development of mining industry. No significant shortage of mining engineers was felt by employing those who were educated in other countries under the 'gradual process' of substitution of engineers from on-the-job training to school education. As a matter of facts, how did mining entrepreneurs think of the mining education in Britain at the early decades of the 20th century? An investigation into this question, mainly based on evidence given to the Committee, was made above.

All witnesses from the mining business had a common opinion that the facilities and equipment of RSM were in poor condition due to the lack of investment. They also drew attention to the dwindling opportunity of practical training at the school because of diminishing number of active metalliferous mines in Britain. On the formation of Imperial College, the shortage of endowment appears to have eased by the donation and financial support from public fund. As for practical training, vacation work was introduced in the curriculum of the college. And also, the combination of theoretical study at school with working experience at British owned overseas mines after the graduation was proposed. This educational scheme was truly rational development reflecting the worldwide expansion of British mining.

Most of them argued lack of motivation of British students. This may have derived from the low status of engineers in social thinking of British society. Governance structure of the mining company may have practically aggravated the problem by confining the role of mining engineers just to technical work. The dignity of engineers was required for schools to attract more people. The effort for establishing the professional status of mining engineers made by the IMM was essential for overcoming this problem.

Of course, had there been more systematic development of mining education, it would have contributed more vigorously to the development of mining industry. But spontaneous development of mining education is not so blamed as what critics of education argued. They

[98] Similar theme is discussed about the different culture of three component colleges of Imperial College, especially between RCS/RSM and CTC. Gay, 'East End and West End'.

took a rational choice in the process of adaptation to the changing environment with the creation of combination of theoretical study at school and post-graduate work experience in British owned overseas mines. In other words, mining industry itself made mining education.

The process of establishing mining education was also the process of losing the original concept of mining education in the early part of the 19th century. The establishment of professional education meant the divorce from the education for working miners. In one sense, it was inevitable because domestic mining population had decreased drastically by the beginning of the 20th century in contrast with growing demand for engineers working overseas. Once professional status of mining engineers established, demarcation among engineers appeared. More empirical study of the question as to whether it was the emergence of two tiers of engineers corresponding with characteristics of education of each school will be needed, taking over the Dixon's study.

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