

The Origins of Chemical Engineering Education in Canada

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Introduction

There are conflicting claims to the establishment of Chemical Engineering as a discipline in Canadian Universities. The School of Practical Science of the University of Toronto is sometimes credited with the honour of establishing the first program in Chemical Engineering in Canada, although, as we shall see, there is reason to doubt that claim. We have several choices on which to base the claim for being first: the claim could originate as a result of giving a course of lectures, the establishment of a program leading to a diploma or degree, the establishment of a department, the founding of a chair to teach the subject, or the first use of the designation Chemical Engineering. In addition to the University of Toronto, the claimants include King's College, later the University of New Brunswick, which established the first series of lectures in "Agricultural Chemistry" in 1849; McGill University, which announced the first diploma course in Agriculture in 1855, and subsequently established the first degree program in Practical Chemistry in 1874; Queen's University after the arrival of Robert Bell in 1864 to teach Chemistry, Geology and Mineralogy; or École Polytechnique, founded in 1871 as a general engineering school.

The distinction between chemistry and practical chemistry seems reasonably clear. However, in the nineteenth century, almost all chemistry taught in the university was seen to be practical, it was deemed to mean either agricultural chemistry, chemistry as applied to medicine, or the chemistry of geology and mining. The differences between chemistry as a discipline and practical chemistry, out of which grew chemical engineering, were not entirely clear until after the turn of the century. For example, in the session 1904-5, the University of Toronto which had a program in "Analytical and Applied Chemistry," initiated also a "course in Chemical Engineering¹." The designation "Chemical Engineering" had been suggested as early as 1881 in England, but was not popularly accepted. A few schools in the United States began using the designation soon after, including MIT (1888). In Canada it gained acceptance shortly after the turn of the century, possibly beginning with a course at Queen's in the session 1902-3.

We might assume that the first incidence of a program, or course of lectures in the subject area, substantiates a claim of precedence. If we accept this, the University of New Brunswick indeed deserves the honour, with McGill a close second. This does not take into account that at neither school was the program continued without interruption.

Indeed, a Department of Chemical Engineering was not established at the University of New Brunswick until 1961. Although there was a disruption in the program at McGill, it was not for want of a Professor to teach the courses, but rather from a want of students to take them. In what follows, I shall only consider as contenders those schools which are still in the business. We will thus rule out Albert College in Belleville, which established a program in Agricultural Chemistry about 1857, the University of Halifax, a short-lived experiment (1876-81) to unite all the universities in Halifax in the last quarter of the last century, and Regiopolis College, which came and went in Kingston, Ontario.

I have also chosen to delete The University of Guelph from my list. Even though it was founded in 1874 at about the same time as Ecole Polytechnique, it originated primarily as an agricultural college, partly in response to reforms demanded at the University of Toronto for the teaching of practical agriculture. There was no question that for most of its history Guelph did not aspire to teach chemical engineering as a discipline.

The University of Ottawa, founded in 1866, advertised a program in the practical sciences including Civil Engineering in 1874. However, for want of students the program was in a state of suspension up until 1955 with the establishment of the Faculty of Engineering.

King's College and the University of New Brunswick

We begin with King's College, New Brunswick, where the first recorded incidence of a lecture series in agricultural chemistry in Canada was given in 1849 by Dr. James Robb, a graduate of St. Andrews in Scotland, who had been appointed to the Chair of Chemistry and Natural History in 1837. Events leading up to this illustrate some of the difficulties in establishing practical instruction at universities at the time.

Dr. Jacob, the Principal, together with Archdeacon George Best, the first President, established the school firmly in the fashion of the English model as a Church of England denominational college, so setting the stage for thirty years of bitter strife, not only against the denominational aspects, but also against the classical curriculum. There is little doubt that much of the animosity directed at the college over the next thirty years was actually meant for its intransigent head, Jacob.

Dr. Edwin Jacob was a stern and uncompromising

master who effected staunch discipline throughout the college and achieved considerable respect in the eyes of his students, most of whom, we should remember, were not only from the elite families, but also were supported largely at public expense at the college. Jacob was most certainly respected by his colleagues, not only by virtue of his position of authority, but also for his scholarship. He was a product of Oxford and thus rigorously grounded in the classics, stressed before that school had reached the depths of decay which were to follow a few decades later. As a member of the privileged church of England clergy; and a scholar in the old world tradition, transplanted to a hostile "frontier" environment, he found it difficult to involve himself in the social strata of the province. This aloofness was interpreted by the populace as further evidence of a scholastic system ill-suited to the needs of New Brunswick. Agitation against the college reached crisis proportions about a decade after King's College had been founded, resulting in a Provincial Act in 1845 to abolish all religious tests, excepting for the Professor of Theology, who was to be retained as head. The act was given Royal assent in 1846, but scarcely stemmed the tide of bitter criticism levelled at the college: it was more an assault on privilege than anything else, with, by now, much of the abuse directed towards Jacob himself. The latter worthy did what he could to fan the flames of dissatisfaction, with public utterances equally condemning the opposition, and proclaiming that the college would not be changed.

Sir Edmund Walker Head was appointed Lieutenant-Governor of New Brunswick, assuming office on April 11, 1848. In the matter of education, it was very clear early in Head's tenure that King's College was in great danger of losing the province's support, having long ago lost the public confidence. Head's other activities included a very strong support of the development of the natural resources and agricultural opportunities in the province. In this endeavour, he had a most able assistant in the personage of Dr. James Robb.

Robb had an excellent idea of the natural resources and capabilities of the province. He had kept meteorological records on precipitation and temperature for various towns over the years, and had made several tours throughout the regions of the province, producing in 1849 a geological map. The map was later incorporated into J.F.W. Johnston's Report of the Agricultural Capabilities of the Province of New Brunswick², in 1850. So great was Johnston's esteem for Head that he dedicated his voluminous work on North America³ to him, with the consequence that most of the work is on or about the Province of New Brunswick. Head worked assiduously to improve the agricultural potential of the province. On February 12, 1849 he addressed a letter to the Colonial Secretary and the College Council, requesting that a series of lectures in agricultural chemistry be given:

"I am extremely desirous that a course of lectures on Agricultural Chemistry should be delivered at Fredericton during the sitting of the Assembly. Dr. Robb, one of the Professors of King's College, is perfectly competent to give

these lectures, and is ready to do so, but in my opinion for such a course some remuneration over and above his salary as Professor of Chemistry and Natural History in King's would be due him, since the lectures, to be really useful, ought not to be confined to members of the College, nor perhaps delivered within its walls."

And further in the communication, *"Should you see no objections to applying the surplus of Mr. Housial's salary in the manner proposed, I will do my best to get it adopted by the College Council, and I will, if possible, stipulate with Dr. Robb, for a repetition of the lectures at some places besides Fredericton. I look upon the diffusion of scientific information relating to Agriculture as a most important object to this Province⁴."*

Perhaps Head had been kept in blissful ignorance of the true nature of the College Council and its Principal. If so, he was very quickly disabused of any notion of the possibility of progressive co-operation in his objectives. Having perceived a mechanism for enhancing the reputation of the college, he now had to contend with the obstinate refusal of the council to embark upon a course conducive to popularization of the institution. The council refused to grant the £25 requested to pay Robb for the enterprise. Finally, long after Dr. Robb had begun to deliver the course of lectures, and with the College Council's total rejection of the entire principle behind the course of lectures on agricultural chemistry, Head ended the matter by paying for it himself⁵.

Rev. Edwin Jacob, Principal of King's, was adamant in his opposition to any technological innovation to the curriculum, and remained so during the ensuing struggle for the survival of the college. Much of his argument was no doubt attributable to his Oxford origins.

Dr. Jacob staunchly refused to consider such instruction as scholarly, or even as bearing on the public charge to the College to provide higher education. Indeed, Dr. Jacob publicly defended the College position⁶.

"For our purposes - they may, I trust, be all comprised in that one word, Duty - the faithful, diligent, and zealous discharge, - more faithful, (if possible) diligent and zealous than ever, of the obligations of our place and time. To those who would make the college a polytechnic institution we may not promise much more in the way of merely practical teaching; we must not listen to the cry which calls us from the pursuit of truth and virtue to the lower paths and grosser occupations of the multitude; we will not yield to the suggestions which would tempt us to pander to the unworthy passions, flatter the prejudices and vain conceits, or court the boisterous plaudits, of factions or the casual crowd."

But Head was firmly convinced that the institution could not exist in the current political climate without addressing the practical needs of a growing colony. He had visited the Great London Exhibition in 1852, a visit which served to convince him that the dawn of the industrial age was

nigh. He returned afterwards in company with Sir Charles Lyell who agreed with Head's assessment of the College⁷. In a letter to the Chancellor⁸, Head speculated on ways the College could be turned to more use: "*The elements of science and natural history, as applied to arts and manufactures, including agriculture, the theory of shipbuilding or navigation, mensuration, surveying, and civil engineering, all these might be offered as being immediately and practically useful in enabling a boy to earn his own bread.*"

It was to Head's further advantage in choosing practical science as the basis on which to save the College, that Robb had travelled extensively throughout the province in connection with his geological and agricultural pursuits. Robb had also actively encouraged application of scientific principles to the solution of practical problems on his tours and was well-known, liked and respected.

By 1854 Jacob's influence had diminished. The College Council agreed to implement a diploma course in Civil Engineering with a lecturer, Thomas Cregan, hired especially for the purpose. With Head's encouragement, Brydone Jack, the Professor of mathematics and Natural Philosophy, and Robb had transformed their courses into a more practical form. By 1853 the regular course of instruction included the following⁹:

By Professor Jack

at 10 a.m.

- I. *Algebra:- on Monday and Wednesday
Geometry:- on Tuesday and Thursday*
- II. *Solution of geometrical problems by algebra:
Construction of algebraic expressions; and analytic geometry:- on Monday, Tuesday and Thursday at 10 a.m.*
- III. *Pneumatics, including the properties of fluids in general, and their application to the construction of the air pump, diving bell, barometer, suction and force pump, fire engine, steam engine, etc.; the relations of air to heat and moisture; and the production and propagation of sound:- on Wednesday and Friday at noon*
- VI. *Astronomy, descriptive and practical, by special appointment.*

By Professor Robb

Course of Chemistry, with its applications to Art and Industry

Matter and Force: Weighing and Measuring.

Heat: Expansion, contraction, temperature, fusion, latent heat, evaporation, boiling, steam, conduction, convection, radiation, incandescence, phosphorescence, combustion.

Light: Theory, spectrum, photography.

Electricity: Galvanism, thermo-electricity.

Magnetism: Electro-magnetism, magnet electricity.

Chemical affinity: Composition of bodies, elements and compounds, nomenclature, laws of combination, equivalents, symbols, formulae, analysis, qualitative and quantitative.

Inorganic Chemistry: History of non-metallic elements and their acids, etc.;

History of the metals and their compounds;

Metallurgy.

Organic Chemistry: Elements of the organic world;

History of vegetable principles and products;

History of animal principles and products;

Metamorphoses of the organic elements:

on Monday, Tuesday, Wednesday, Thursday and Friday at 1 p.m.

The Council had also agreed to the implementation of a course in agricultural chemistry. However, there is no evidence that the course was ever given after 1849.

Dawson and McGill

In 1854 Sir Edmund Head was appointed Governor-General of Canada. This position carried with it the responsibility to act as Visitor to McGill College in Montreal. The College Council, at the suggestion of Head, appointed William Dawson as Principal of McGill College. The appointment was unique at the time: Dawson was the first colonial to be appointed to such a position in Canada. Head had been introduced to the young, largely self-taught, naturalist from Nova Scotia by Sir Charles Lyell, the great naturalist and colleague of Darwin¹⁰. In 1853, Head had appointed Dawson to a commission of inquiry into King's college and been very favourably impressed.

Over the next half century, Dawson (Sir J. William Dawson) proceeded to justify Head's good opinion of him, moulding McGill into the foremost science-based university in Canada. In his inaugural speech in November¹¹, 1855, Dawson announced a course of Civil Engineering lectures (to be given by Thomas C. Keefer). In the speech, Dawson also announced plans to establish two series of courses in practical chemistry, the first to be a popular course of lectures and the second, "--- special courses, each to extend over two years, and to entitle the student, on examination, to a certificate, or diploma." The third in this series was to be a course in agriculture, incorporating English literature, natural history, natural philosophy (physics), surveying, practical chemistry, practical agriculture and farm management. The following

year, 1856, the diploma course in Agriculture was announced¹². Dawson himself taught agricultural chemistry and natural philosophy, while William Sutherland, M.D., taught chemistry. There is no evidence that the diploma course was implemented on a regular basis. However, over the next several years there were a number of diplomas awarded. Dr. Thomas Sterry Hunt was appointed as Professor of Applied Chemistry and Mineralogy in 1862¹³ even though it had become clear that financial exigency had overtaken the university. Dawson continued to teach "practical chemistry," but the university could no longer afford special lecturers such as Mark Hamilton, the professor of Civil Engineering.

In 1871, Dawson, fearing that an engineering program was about to begin in Toronto, convinced the Board to support applied science at McGill. The Department of Practical Science was formed in the fall of that year with a new lecturer in Civil Engineering¹⁴. This became in succession, the Department of Applied Science, and in 1875, the Faculty of Applied Science. At the same time, provision was made to award the degrees of B.A.Sc. and M.A.Sc. in Civil Engineering, Mining and Assaying, Mechanical Engineering, and Practical Chemistry. The first such award was made in 1873. By this time Hunt had been replaced by G.P. Girdwood, M.D. One of the first practical chemistry graduates of this program was Frank D. Adams in 1878, later to become Dean of Applied Science at his alma mater¹⁵. The year 1878 also saw the formation of the Faculty of Applied Science. In 1908 the Faculty changed the name of the program to Chemical Engineering. It was offered together with Civil, Mechanical, Electrical and Mining Engineering as well as Architecture.

Toronto: University College and the School of Practical Science

University College attempted to implement an engineering program as early as 1851 when provision was made for the appointment of a Professor of Civil Engineering. However, the appointment was never made. Following the practice advocated by Dawson at McGill, however, both Civil Engineering and Agriculture were offered as two year diploma courses beginning in 1857¹⁶. It might be remembered that Head, as Governor-General, was also the Visitor to the University of Toronto. It is an intriguing speculation that he was also responsible for the implementation of Civil Engineering and Agricultural Chemistry at University College. In any case, owing to his very great influence in New Brunswick and at McGill, he should be considered as the father of Engineering Education in Canada. For the next twenty-six years University College offered its program in Civil Engineering and Agricultural Chemistry for nineteen of those years. There are records of a few graduates over the years in the Agricultural Chemistry program, numbering two or three a year during the most popular period in the mid sixties. However, the numbers did not warrant any further expenditure on the program.

In 1871 it was proposed to establish a School of

Technology. The scheme was vehemently opposed in the Legislature. The government was defeated in that year, with the result that the school was set up in downtown Toronto primarily as a training centre for artisans¹⁷. The issue of Agricultural Chemistry was settled with the establishment of the Agricultural Farm at Guelph in 1874.

The School of Technology began classes on 6 May, 1872 with three part time instructors, among them William Hodgson Ellis, Instructor in Chemistry and responsible for teaching Chemistry, Practical Geology and Mining. Ellis was also appointed to be Principal of the school. Thomas H. Heys was also hired to assist in the teaching of Chemistry and to take responsibility for Natural Philosophy. The third instructor was William Armstrong, a graduate in Civil Engineering from Dublin, who undertook to teach Applied Mechanics and Drawing. It soon became clear that something more was needed, and a motion was put to the Legislature to form a "School of Practical Science." This particular name appears to have been coined by Dawson in 1871, who had requested the establishment of such a school at McGill¹⁸. The name was never used at McGill, although the program began that same year.

The School of Practical Science continued as a school for artisans until 1877 when it was agreed to remove it to the campus of the university and to construct for it a new building. The following year the School was opened for the granting of diplomas in Civil, Mechanical or Mining Engineering after three years of study. Two other options were open, Assaying and Mining Geology, and Analytical and Applied Chemistry. The faculty, drawn partly from University College, included H.H. Croft, Professor of Chemistry; E.J. Chapman, Professor of Mineralogy and Geology; James Loudon, Professor of Natural Philosophy; John Galbraith, Professor of Engineering; R. Ramsay Wright, Professor of Biology; and W.H. Ellis as Assistant to the Professor of Chemistry. No students were admitted to the diploma program in Analytical and Applied Chemistry that year.

For the next six years there was some confusion between University College and the School of Practical Science as to which might be offering engineering. In 1880 the controversy overran the Chemistry Department. It was not clear which of the instructors, William H. Pike (who had taken over from Croft), or W.H. Ellis was to be responsible for teaching Chemistry. Pike wanted Ellis declared to be his assistant. However, it did not happen. Ellis was given the main responsibility for Chemistry at the School of Practical Science, and became the Professor of Applied Chemistry and Head of the Department of Analytical and Applied Chemistry, while Pike retained his position at University College as University Professor and Head of the Department of Chemistry. Ellis had a profound influence on chemical engineering education at Toronto¹⁹ and ultimately set it on its present course. With the establishment of the Professional Degree in Civil Engineering in 1884, the controversy came to an end, and University College took little interest in the affairs

of the School from that time on, except in so far as providing instruction as required. The diploma course was continued: the degree could be obtained after three years work in the field, together with some other conditions.

In 1889 SPS gained autonomy from University College as an affiliated institution under the aegis of the University of Toronto, by virtue of the University Federation Act passed that year. A more traditional program was established in five departments:

1. Civil Engineering.
2. Mechanical (and Electrical) Engineering.
3. Mining Engineering
4. Architecture.
5. Analytical and Applied Chemistry.

Eleven candidates were awarded the degree the following year, of which two were for work in the chemical and assaying laboratories.

A program in Chemical Engineering was established at Toronto in 1904²⁰. Over the next few years the program was variously called Analytical and Applied Chemistry or Chemical Engineering. In at least one year both programs were listed¹. In 1906 under the University Act the School of Practical Science became the nucleus for the Faculty of Applied Science and Engineering. Further changes in the act in 1909 resulted in the implementation of a required four year degree program and the cancellation of the diploma program. This helped Toronto to gain greatly in stature since up to this point it had been common practice for students to study for a few years at Toronto before transferring to McGill to finish the degree program.

Queen's

At Queen's, as at other schools, a program in Civil Engineering and Surveying was offered as early as 1865²¹. There is no evidence that the course was ever given, even though there was a trend towards practical instruction. One of the reasons for the advertisement might have been that the eminent geologist Robert Bell, C.E., had joined the Faculty in 1864 to teach chemistry, geology and mineralogy. However, the man who probably had more than anyone else to do with the establishment of engineering at Queen's was Nathan Fellowes Dupuis, a mathematician, appointed in 1868 as Professor of Chemistry and Natural History. It was Dupuis who gave the opening address for the session at Queen's on 2 October, 1872, remarking²²: "... it is not a matter of choice with us, whether we will have scientific teaching or not, but a matter of necessity ... if our universities will not make provision ..., schools of technology, established for the purpose, will." He had clearly an eye to the movements in that direction south of the border, and was probably aware of the growing importance of the Mechanics Institutes which had sprung up across the country to fill a gap not addressed by

anyone else. However, due to a disconcerting lack of funding it was several years before the need could be met.

Rev. George Munro Grant, appointed Principal of Queen's, in 1877, was a close associate of Sanford Fleming. In 1872 he accompanied Fleming's Canadian Pacific Railroad survey expedition through the Rockies as its secretary²³. Grant, like Dawson, was born in Canada but educated in Scotland.

Sometime in 1887 the Eastern Ontario communities began agitating for a school of mining. It was established in 1893 in association with Queen's to "...give a complete scientific education of both a theoretical and practical character to young men studying mining engineering and to provide theoretical and practical instruction in subjects pertaining to modern agriculture²⁴." The staff included Dr. William L. Goodwin, Professor of Chemistry, Willet G. Miller, Professor of Geology, and William Nicol in Mineralogy and Assaying. Professor Nathan F. Dupuis taught mathematics. And here we find a curious development. The calendar for Queen's for the session 1894-5 announced the establishment of a new Faculty for instruction in: Chemistry and Mineralogy, Mechanical Engineering, Civil Engineering, Electrical Engineering, Mining Engineering, and Biology leading to Medicine. Dupuis was named as Dean of the new Faculty. All of the practical subjects were taught by instructors from the School of Mining, even though the degree of B.Sc. in the chosen discipline was granted from Queen's. The first degrees in the program were awarded in 1898.

There was a great deal of rancour in Toronto over the establishment of the School of Mining because of the provincial aid given to the school, the common epithet calling Queen's "a one horse institution²⁵." In 1902, a degree program was established covering the disciplines of Chemistry, Mineralogy, Mechanical, Civil, Electrical and Mining Engineering. According to the Calendar of the School of Mining, there were two programs in applied chemistry, Chemistry and Mineralogy, and Chemical Engineering²⁶. Queen's University thus became the first Canadian School to actually use the term "Chemical Engineering" to describe the program. The School of Mining was affiliated to Queen's University and grew side by side with the Faculty of Applied Science, although all degrees were awarded through the University. The School of Mining and the Faculty of Applied Science were not amalgamated until 1916.

École Polytechnique

École Polytechnique lays claim to being one of the oldest engineering schools in the country. It was established in 1873 on a site now covered over by the Place des Arts in Montreal. At the outset the course was intended to be of four years' duration, the first graduands emerging in 1877, consisting of a class of five students. Initially commissioned as l'École des Sciences Appliquées aux Arts et à l'Industrie, École Polytechnique changed its name to the present one in 1875. By 1887 it was decided that affiliation with a chartered

institution might prove to be of mutual benefit. Hence, in that year, École Polytechnique was affiliated with Laval University²⁷. École Polytechnique was ranked as one of the three most successful engineering schools of the era by 1890. The others were Toronto and McGill, the latter with 61 full time engineering students in that year. École Polytechnique continued its arrangement with Laval until 1920 when the school became aligned with the Université de Montréal instead. Since then, the latter arrangement has continued, with a move to a shared campus in 1955. Strictly speaking, although chemistry was taught as part of the regular engineering program, it was not until 1958 that Chemical Engineering was recognized as a discipline at the school. Up to that time École (Université de Montréal) granted degrees in general engineering or Civil Engineering²⁸.

Royal Military College

RMC was founded by an Act of Parliament in 1874 somewhat along the model of West Point Academy in the United States²⁹. It was clear from the outset that the program was aimed as much at civilian life as the military. As a result, it proved to be popular, an average of twenty students a year entering between 1876 and 1890. Diplomas were issued for successful completion of the four year program in Civil Engineering. However, it was noted that the program would equip the graduate for work in other disciplines.

The first class entered on 1 June, 1876, and were graduated four years later, not without some worrying moments for the future of the college. The change in Government in 1878 almost caused the demise of the college because the French Canadian contingent were not sympathetic to a non classical education. Also, for the first few years, the only way that the entry level classes were maintained at sufficient numbers was by lowering the entrance standards. The only one of the first year's crop of cadets to achieve military distinction, Lieutenant-General Sir William Throsby Bridges, chief of the Australian General Staff, and founder of the Royal Military College at Duntroon, Commander of The

Australian Imperial Forces in 1914, was, ironically, required to withdraw in 1877³⁰. Thirteen of the first graduating class of eighteen entered civilian life, some achieving distinction in that sphere.

Dr. Herbert A. Bayne was appointed Professor of Experimental and Natural Sciences in 1879. This included responsibility for physics, chemistry and geology. A founding member of the Royal Society of Canada, Baynes died in office in 1886, allegedly of overwork³¹. He was succeeded by J. A. Waddell, B.A., Ph. D., D.Sc., who retained the post until 1897. For a time the standards of the institution floundered. By 1921 graduates of the four year program were accepted into the third year of chemical engineering at both Toronto and Queen's. McGill required economics in addition to the regular program for admission³². However, the chemistry option was eliminated in 1925. It was not until 1962 that the first degrees were awarded in engineering.

Conclusions

Although there is little doubt that McGill's program should be ranked as the first in Canada. This is entirely due to the efforts of Sir. J. William Dawson, to whom Canada owes so much for the establishment of engineering education. Dawson adopted the Scottish model of practical education

rather than the German or French models, as in the United States, or the English model, which was much behind developments in North America.

The Father of Engineering Education in Canada was Sir Edmund Walker Head. Head used the concept of practical education in Civil Engineering and Agriculture as a means to save King's College (the University of New Brunswick) from closure. It was at his suggestion that Dawson was chosen as Principal at McGill, with the immediate development of engineering education at that school. And finally, one can conjecture that as Visitor, Head also supported practical instruction at Toronto.

The honours for the first Chemical Engineering Degree program go to The School of Mining of Queen's University. And the first course in Agricultural Chemistry, one of the predecessors of Chemical Engineering, was given at King's College, New Brunswick, later the university of New Brunswick.

FOOTNOTES

1. C.J.S. Warrington and R.V.V. Nicholls, A History of Chemistry in Canada, Sir Isaac Pitman and Sons, Toronto, 1949, p456. See also the Calendar, University of Toronto, 1906-7, listing six departments, Civil Engineering, Mining, Mechanical and Electrical, Architecture, Analytical and Applied Chemistry and Chemical Engineering. A diploma was offered through the School of Practical Science after three years work. The degree of B.A.Sc. was available from the University of Toronto in Civil, Mining, Mechanical, or Electrical Engineering after a further year of study. It was not until the session of 1912 that the diploma option was removed and all candidates were required to enter a four year program.
2. James F.W. Johnston; Report of the Agricultural Capabilities of the Province of New Brunswick, 1850; see also: Richard A. Jarrell, Science Education at the University of New Brunswick in the Nineteenth Century, *Acadiensis*, July, 1973.
3. James F.W. Johnston, Notes on North America, 2 vol., Wm. Blackwood, 1851.
4. Letterbooks of the Lt. Gov.: Sir Edmund Head, 1849-54, New Brunswick Provincial Archives, Fredericton, N.B.
5. Head's letterbooks, op. cit.
6. Edwin Jacob, Encaenial Address, June 26, 1851, UNBA. Jacob's attitude can be attributed to his own training. As Katherine MacNaughton in The Development of the Theory and Practice of Education in New Brunswick, 1784-1900, UNB Historical Studies, No. 1, 1947, observed, such education as he received was aimed at keeping the masses in ignorance rather than otherwise in order to control them. She goes on to say that for Oxford graduates: "--- there was practically no instruction in English language, literature, history, geography or civil government. The entire scholastic effort was expended on learning the Latin grammar, writing Latin prose or verse and translating Latin classics, or in similar exercises in Greek." This was the educational system Jacob attempted to impose on King's College.
7. Head to the Chancellor, King's College, 28 September 1852, printed in Journal of the House of Assembly under date of 10 March 1854. Well Head might have perceived the danger to King's. After Johnston's report, the proposition was made in the Legislature to convert the college into an agricultural school with a model farm attached. The purpose of the farm would have been to train prospective immigrant farmers.
8. Mrs. Lyell, editor: Life, Letter and Journals of Sir Charles Lyell, John Murray, London, 2 vol., 1882.
9. University of New Brunswick Archives
10. Sir Charles Lyell was one of the great naturalists of the nineteenth century. Lyell first made Dawson's acquaintance during Lyell's North American tour of 1841-2. They communicated regularly thereafter, especially on geological matters.
11. J.W. Dawson: On the Course of Collegiate Education, adapted to the circumstances of British America, Inaugural Discourse, November 1855, Montreal.
12. Calendar of McGill University, 1856.
13. p 417.
14. Stanley Foster Brice, McGill University for the Advancement of Learning, McGill-Queen's University Press, 1980, Vol. 1, p 274.
15. Graduates of McGill University corrected to July, 1909.
16. Calendar of University College, Toronto, MDCCCLVII-MDCCCLVIII, Henry Rowsell, Toronto, 1857, p 14. There were a few diplomates in Agriculture in each year during the following decade.
17. Engineering at Toronto is chronicled in: Early Engineering in Toronto, 1851-1919, by C.R. Young, University of Toronto Press, 1958; and Cold Iron and Lady Godiva: Engineering Education at Toronto, 1920-1972, ed. by R.S. Harris and I. Montagnes, University of Toronto Press, 1975.
18. Young, op. cit., p43.
19. L.W. Shemilt, "A Century of Chemical Engineering Education in Canada," in History of Chemical Engineering, Edited by William F. Furter, Advances in Chemistry Series 190, American Chemical Society, 1980.

20. Calendar of The School of Practical Science, 1904-5.
21. Calendar of Queen's University, Session 1865-6.
22. See Queen's University at Kingston, 1841-1941 by D.D. Calvin, p 205.
23. George M. Grant, Ocean to Ocean, 1873.
24. A.L.Clark, The First Fifty Years: A History of the Science Faculty at Queen's University 1893-1943, Queen's University, 1943, p 9.
25. Clark, op. cit., p 21.
26. Calendar of the School of Mining (Affiliated to Queen's University) 1902-3. There is a descriptive footnote in the Calendar to describe the Chemical Engineering Program: "(The) course (Chemical Engineering) provides for the education of a class of engineers of growing importance. Owing to the widespread use of mechanical and electrical processes on a large scale, managers of such works must be acquainted not only with chemistry, but also with this kind of engineering."
27. Robin S. Harris, A History of Higher Education in Canada 1663-1960, University of Toronto Press, 1976, p 168. Harris' work is a very substantial chronicle of events and trends in the Universities, and includes several sections on engineering education.
28. See Glenn A. Morris, Structures and Levels of Technological Education Case Study for Canada, monograph of the Engineering Education Section, UNESCO, 1984, p 10, for a comparison chart of the founding of the engineering disciplines at the various Universities in Canada.
29. Ibid., p 173.
30. Richard Arthur Preston, Canada's RMC, A History of the Royal Military College, The university of Toronto Press, 1969, p 61.
31. *ibid.*, p 83.
32. *ibid.*, p 235.