POLYTECHNICAL EDUCATION AND HERITAGE PRESERVATION ENGINEERING

Douglas Porter

School of Engineering, University of Vermont

341 Votey Hall / 33 Colchester Avenue

Burlington, VT 05405-0156

(802) 656-4027

Douglas.Porter@uvm.edu

ABSTRACT

Modern engineering education originated with polytechnical schools in France at the end of the 18th century. Polytechnical education represented a move from an apprenticeship or shop system of education to an organized presentation of "applied science" involving a standardized curriculum presented in lectures, laboratory, and site work, and which focused equally on theory and practice to yield technological advancements through the application of science to social problems. This new system of education was based on the Enlightenment conviction that reason and scientific thought were the most efficient means of improving the human condition, and on the democratic principal of universal access to a public system of education. This system of technical education was ultimately adopted in much of Europe and the United States, and in its earliest forms there was no gulf perceived between technical education and the culture it served.

THE ORIGINS OF MODERN ENGINEERING EDUCATION

Broadly speaking, engineering education as practiced in most U.S. universities derives from an educational system developed in France during the French Revolution and epitomized by the course of study at the Ecole Polytechnique. This didactic system was pioneered by philosophers, scientists, and academics steeped in Enlightenment philosophy and revolutionary ideals, who believed that scientific knowledge applied in the development of useful technologies and infrastructure was central to securing the happiness and welfare of free citizens in the emerging democracy. In focusing on the 'applied sciences', theory and practice were to be integrated so as to ensure that scientific advances were translated into technological and industrial progress.

At the end of the 18th century, France was trailing England in technological development and struggling with a stalled economy. The Revolutionary Convention undertook studies of public works and public education, and passed the founding charter of the Ecole Polytechnique two months after the overthrow of Robespierre. The charter formulated several teaching goals:

1. To provide education for all engineers at a single school;
2. To resume teaching the exact sciences (after the disruption resulting from the Revolution);
3. To provide training over a broad range of technical disciplines and to enough students to meet the needs of the Republican army, expand public infrastructure, and precipitate industrial development.

The didactic system employed at the Ecole had been outlined by d'Alembert in his preface to the Encyclopedia, a 35-volume compendium of the current state of knowledge in the sciences, arts, and trades authored primarily by d'Alembert and Diderot beginning in 1751 and completed in the 1780s. Following the organization of the Encyclopedia, knowledge was divided into mathematics and methods of computation on the one hand, and physical properties of objects and the principals of their interactions on the other (Pfammatter, p.23). The interconnection of the two types of knowledge and their exploration on theoretical and practical levels to promote the general welfare became the centerpiece of polytechnical education.

Polytechnical education was to be made available to all qualified citizens regardless of religion, gender, ethnic background, or social status, and admissions exams were administered in all of France (including 22 provincial cities). The first faculty of the Ecole included leading experts in descriptive geometry, mathematics, mechanics, chemistry, engineering design, and architecture, and the Ecole quickly became one of the most prominent centers for scientific and engineering training in the world.

Initially, the program of study lasted for three years. Students attended classes for a period of ten months, with a month of examinations and a month of vacation. Course material was presented in lectures, laboratory sessions, site visits, and practicum projects. Faculty wrote their own texts, exemplary student projects were placed on display in an exhibition hall, and proceedings of faculty research were published in a Bulletin sponsored by the Ecole. Ultimately the bulletin appeared as the Journal de l'Ecole Polytechnique and was distributed throughout the world.

By 1800, the Ecole Polytechnique had succeeded in assuring the recruitment and education of a corps of engineers to meet the national need, a body of engineering literature had begun to appear, schools specialized in the advanced requirements of civilian and military engineering were established, France had created one of the first great museums of science and engineering, and was in the process of developing schools for technical training in the industrial arts.

Beginning early in the nineteenth century, the system of polytechnical education spread rapidly to other parts of Europe. By 1836, Germany had seven polytechnic schools in Berlin (1799 and 1821), Karlsruhe (1825), Munich (1827), Dresden (1828), Stuttgart (1829), Hanover (1831), and Darmstadt (1836). Austria established its first in Prague in 1806, and had added four more by 1844. Switzerland created schools in Lausanne and Zurich in 1855. In Paris, the Ecole centrale des Arts et Manufactures was founded in 1829, and schools were launched in several of the largest cities in France (Addis p.302). Everywhere that polytechnic schools were established, bodies of literature were developed through the translation of existing texts, many of them from the Ecole Polytechnic, into other languages, and the publication of new research and texts for classroom use.

ENGINEERING EDUCATION IN THE UNITED STATES

In the United States, the need to access new territories and energy resources, combined with respect for the ideals of the French Revolution, provided momentum for the application of science to engineering and industrial technology. The need for rapid development of communication and transportation infrastructure created a climate in which entrepreneurial endeavor and invention flourished, and in which technical education was accomplished largely in the workshop. Under this system, mechanical engineers were trained in machine shops engaged in the production of machine tools, agricultural implements, and weapons. Civil engineers were trained on the job, during the construction of the Erie Canal, for example, and railway engineers during the construction of the lines that proliferated beginning in the 1830s.

Workshop innovations resulted in business growth as firms tooled up to meet the new demands for improved products. The "workshop culture" that developed had engineers, technicians, and apprentices working side by side, with small shops partnering to fill large or complex orders, and where the relatively free exchange of information spurred technological development.

The new republic had close connections to Enlightenment France, both philosophically and scientifically, and it was only natural that technical education be developed along somewhat parallel lines. In the US, technical education at the university level at first augmented the workshop culture that helped to precipitate so much industrial activity, but ultimately the apprenticeship-based approach to education was eclipsed by the university programs that were developed in great numbers.

The Military Academy at West Point, founded in 1802, offered the first course of study in the applied sciences. Under the direction of Col. Sylvanus Thayer, the academy adopted the program of the Ecole Polytechnique in 1817, offering training in descriptive geometry, mathematics, physics, chemistry, and engineering design (Wickenden, p.811). Other pioneering institutions included the American Literary, Scientific and Military Academy at Norwich, Vermont, founded in 1820 by Alden Partridge, a former professor at West Point; and the Gardiner Lyceum of Gardiner, Maine, founded by Benjamin Hale (who would later be instrumental in founding a program of applied science at Dartmouth University) in 1821.

Early efforts to provide technical education at the university level were focused on the requirements of farmers and mechanics rather than on engineering. In 1823, Stephen Van Rensselaer established a school at Troy

> “for the purpose of instructing persons who may choose to apply themselves in the application of science to the common purposes of life. My principal object is to qualify teachers for instructing the sons and daughters of farmers and mechanics, by lectures or otherwise, in the application of experimental chemistry, philosophy and natural history to agriculture, domestic economy, the arts and manufactures” (Wickenden p.810).

Under the direction of Amos Eaton, by 1835 Rensselaer had become the first school of civil engineering in the English-speaking world. Franklin Greene succeeded Eaton as director in 1846 and began the reorganization of the school according to the polytechnical model and devoted to all aspects of engineering and architecture (Wickenden, p.812). In 1849, the name of the school was changed to Rensselaer Polytechnic Institute, signaling the new emphasis on engineering education and offering a curriculum based generally on that of the Ecole Centrale. The Institute initially offered a three-year program, which eventually grew to include a fourth year of study.

Several schools followed the example set by Rensselaer: Union College added civil engineering to its science department in 1845; with the involvement of Benjamin Hale (of the Gardiner Lyceum), Dartmouth College added the Chandler Scientific School in 1851; the University of Michigan added an engineering program in 1852, as did Yale University; the Massachusetts Institute of Technology was established in 1860 (in part due to Harvard's sluggishness in implementing a program in applied science).

Growth in the mining industry and in the country's rail system provided additional incentive for the development of new educational programs. Railroad construction, particularly with regard to bridges, placed increasingly greater demands on the technical skills of engineers, and railroad construction appears as an area of specialization in some of the early university curricula (e.g., Rensselaer's 1850 curriculum in Wickenden, p.813). Responding to rapidly developing mining industries in the mid-Atlantic region and the West, Columbia University opened the first US school of mines in 1864, borrowing liberally from the program at the Ecole des Mines in Paris (Wickenden, p.817). The Columbia program became a prototype for most of the other university programs in mining and metallurgy established during the 19th century.

The Morrill Land Grant Act of 1862 created opportunities for a more comprehensive system of public education throughout the United States. Sponsored by Vermont senator Justin Morrill, under the Act the federal government granted tracts of land to individual states to be mined or farmed in order to finance the creation of new schools. Initially presented in 1857, the Act was successfully opposed by southern conservatives but was finally passed during the Civil War. Within twenty years, the federal government made grants having a combined area larger than Great Britain to establish schools of agriculture and the mechanical arts (Wickenden, p.816); by 1896 the number of engineering colleges had risen from 6 (in 1862) to 110 (Wickenden, p.547). The Sibley College of Engineering at Cornell University was one of the most influential of the land grant schools and modeled its curriculum on European examples (Wickenden, p.818)

By 1870, the general availability of new engineering programs was having a noticeable impact on the profession. Prominent engineers were assuming leadership roles in educational programs, a body of engineering literature was being developed, and the accelerated rate of industrial expansion continued to draw people to the field (Wickenden, p.818). During this period of expansion, laboratories came to play a more prominent role in engineering education, with state-of-the-art facilities established at MIT, Cornell, and the Stevens Institute. Another early feature of the American programs was the combination of scientific and technical study with the liberal arts, which continues to be typical of engineering education in the United States.

COLLOQUIUM GOALS

In 1930, the Society for the Promotion of Engineering Education published its comprehensive study on the improvement of engineering education in the United States. In the forward to their report, director W. E. Wickenden commented:

"The engineer of tomorrow will not rise to leadership by abandoning his distinctive role or by permitting it to become ill-defined. He will do so by remaining essentially an engineer, by becoming a more competent engineer, by extending the reach of engineering methods and ideals to larger realms of life…If engineering education is to serve these ends, it must safeguard all the distinctive qualities and virtues of its past and add to them a more generous humanism." (W.E. Wickenden, A Comparative Study of Engineering Education in the United States and Europe. 1929. p.53)

By 'humanism', Wickenden is referring to the social goals and objectives to which engineering can be applied in order to effect human progress. We have brought you all here to discuss how to preserve the strengths of our current curricula while adding "a more generous humanism" through the education of engineering students in the preservation of built heritage. That there is a role for heritage preservation in engineering education finds precedent in the abbreviated history we've just considered. The earliest polytechniciens (faculty and students from the Ecole Polytechnique) were directing archeological excavations as well as surveying and documenting historic sites. In the early 19th century, a group of 39 polytechniciens were among the scholars that produced 3000 documentary panels organized in 10 folios under the title “Description d’Egypte” published in 1802.

Incidentally, polytechniciens also participated as leaders in the Revolution of July 1830, helping to bring about the defeat of the French monarchy. At the time, their participation was celebrated in an open letter written by students at West Point, and the popular image of the engineer in France and the US was elevated to a degree every bit as heroic as the image of the engineer promulgated in Dave Fischetti’s new book.

Until recently, the role of engineering in historic preservation practice in the United States has not been well defined. This is changing as the field becomes more complex technologically, as our scope has broadened to include natural and cultural landscapes, and as our focus on late 19th and 20th century architecture has brought larger and more highly engineered buildings under the purview of preservation design specialists. This trend has been accompanied by increased participation of engineers in historic preservation projects, and the development of a body of literature devoted to preservation engineering issues:

- ICOMOS has convened the International Scientific Committee on the Analysis and Restoration of Structures of Architectural Heritage (ISCARSAH), which has developed a series of Principles defining the roles of engineers in heritage preservation.
- International EU Congresses on Construction History and the Structural Analysis of Historic Construction, in which our colleague Paulo Lourenco has played such

a pivotal role, are helping to organize the effort of heritage preservation engineers in Europe.

- The National Center for Preservation Technology and Training is hosting a Summer Institute for Architecture and Engineering Training and is one of the principal funders of this colloquium.
- The Association for Preservation Technology has established a Preservation Engineering Technical Committee that has resulted in the publication of more articles in the APTI Bulletin on the subject of preservation engineering, and inclusion of an engineering track in recent APTI conferences.
- More U.S. historic preservation programs are offering engineering-oriented courses, focused on materials and structure

The application of engineering techniques to buildings and sites, and archaic materials and structural systems presents a number of unique challenges that are seldom addressed in university engineering programs. Many of these challenges are characterized by concurrent commitments to the authenticity and historic integrity of the sites on the one hand, and to public safety on the other. I'm guessing that this is a theme that will be repeatedly explored in the discussion sessions later.

With regard to the current state of heritage preservation engineering education, to some extent we are repeating our historical process. Nearly all of us practicing in the area of heritage preservation engineering have relied on workshop culture to complete our educations; we are training on the job. American universities have been slow to develop curricula focused on heritage education for engineering students. But if we are to achieve the desired levels of expertise and to produce qualified engineers in sufficient numbers to address the need, it is vitally important that universities take the lead in teaching, research, and field projects focused on heritage preservation.

The School of Engineering at the University of Vermont (UVM) is gradually adopting heritage preservation as an area of focus for its undergraduate and graduate programs. Our efforts so far have focused on the use of historic sites for student research and thesis projects, senior capstone design projects, and service-learning projects in the Geotechnical Design course. Here are a few examples:

As a part of the process of broadening our focus to include historic structures and sites, this colloquium has been organized to define the needs for curriculum development in heritage preservation engineering education. The colloquium is focused on modifying existing curricula to include heritage preservation topics and develop a series of modules that can be added to existing courses progressively. It is not our intention to restrict the discussion to courses at UVM, but rather that the results of the colloquium be adaptable to engineering programs anywhere in the US. For this reason, colloquium topics address a broad engineering spectrum that includes sustainability issues, ethics, structural analysis of existing construction and design of alterations, materials characterization, energy, heat and moisture transfer in buildings and components, fire safety of archaic assemblies, disaster preparedness, documentation, NDE and remote monitoring platforms, and the history of technology.

Once again, we'd like to thank The National Center for Preservation Technology and Training, the Getty Conservation Institute, and the Colloquium Steering Committee for their support.

This morning's plenary session will be followed by a series of discussion sessions that will occupy us for the next day or so. In a few minutes we'll break into four discussion groups each working on a different topic; there are twelve topics in all. It is intended that each of you will participate in three of these discussion groups.

Discussions are organized around position papers written by the discussion moderators. Position papers address the development of course modules related to the topic, and copies have been distributed to each of you electronically; paper copies are available on the table at the back of the room. The discussions will provide opportunities for you to respond to the papers. This is the real work of the colloquium and we hope the discussions are lively.

Rapporteurs will record the discussions, and moderators and rapporteurs will deliver short, informal summaries of their discussions at the end of each session. The colloquium proceedings will be published; position papers, discussion notes, and plenary papers will constitute the main body of the publication. We expect that these will be available on the colloquium website later this summer, and are exploring the possibility of a paper publication. It is our intention to use colloquium results in developing curricular modules to be added to courses at UVM.

During the discussions, we ask that each of you be mindful of the following:

- The current state of knowledge and essential competencies
- Research questions and potential funding
- Experiential learning opportunities – internships, service learning projects
- What curriculum additions are necessary to cover the material in sufficient depth?

  Does the topic lend itself to curriculum modules and/or new courses
- Should the material be presented at the undergraduate and/or graduate level