The Genesis of Laboratory Work in American Science Education

In 1860 there was no laboratory work in American high school science education; by 1900 it was everywhere. How this came to be was the subject of a presentation, "A History of High School Laboratory Work in Chemistry and Physics," to the Physics and Chemistry Teachers Clubs of New York at New York University on 12 January 2007 by Keith Sheppard, of Stony Brook University, and Gail Horowitz, of Yeshiva University.

Sheppard traced the role of laboratory work in science education to Justus von Liebig, who, Horowitz point out, was Professor of Chemistry at Giessen, now in Germany, from 1824 until 1852. He thus became the "father of laboratory work in science education" as well as the "father of organic chemistry," although it was the latter title, because of Liebig's fame in chemical research, which enabled him to influence science education and thus acquire the former title.

Horowitz explained that Liebig trained businessmen as well as academics, from the U.S. as well as from Europe. His three-step training method consisted of 1) fundamental laboratory techniques, 2) chemical analyses (of what eventually became the contents of 100 bottles), and (eventually) 3) chemical research. In turn, Liebig's students imported his methods into their own institutions. Several notable Americans in this category, Sheppard said, were Eben Horsford, Oliver Wolcott Gibbs, Frederic Genth, and Jonathan Porter.

Sheppard continued that Horsford was most influential in transplanting Liebig's methodology to the United States. He had returned to accept a professorship at Harvard and quickly persuaded a local manufacturer to donate money to establish a scientific school modeled along Liebig's lines. In 1847 the Lawrence Scientific School opened and initiated the first laboratory course in chemistry.

Two years later, Charles Eliot began his studies at Harvard, just as Josiah P. Cooke was hired as Instructor of Chemistry. Cooke set up a private laboratory at Harvard emulating Horsford's laboratory at the Lawrence School, and Eliot began volunteering in Cooke's laboratory and witnessed firsthand the use of the laboratory method. After graduating, Eliot remained at Harvard and began to co-teach a chemistry class with Cooke and oversaw the laboratory work. But Eliot's appointment was short-lived; and when he was not offered the professorship which Horsford had just vacated, he disappointedly went to study in Europe.

After two years studying the organization and methods of instruction of universities in France, Germany, and Italy, Eliot was enticed to accept a position at the newly-founded Massachusetts Institute of Technology. At MIT he began teaching chemistry, using the laboratory method. Realizing that no adequate textbooks existed, Eliot co-authored the first English language chemistry laboratory manual. Its objective was "to facilitate the teaching of chemistry by the experimental and inductive method." The text revolutionized chemistry teaching in the United States, by promoting laboratory-based instruction.

After working at MIT for just two years, Eliot was elected president of Harvard University in 1869. In selecting Eliot as its first scientist president, Harvard made a significant break from tradition. Eliot would serve as Harvard's president for forty years. The directions that he took and the changes that he implemented while serving as Harvard's president revolutionized the teaching of science in the U.S.

Almost immediately, Eliot broadened Harvard's admissions policy. First, physics was added as an admissions option; then a mandatory science entrance requirement was implemented. In 1886, a new policy regarding laboratory work was initiated. Completion of specific high school science experiments would entitle entering students to receive admission credit. Eliot had Cooke prepare a list of approved chemistry experiments and Edwin Hall prepare a comparable list of physics experiments. (Hall is best known for his discovery of the Hall Effect, an electric potential difference set up across a wire by an electric current passing through it when a perpendicular magnetic field is present.) Given Harvard's influence, high schools created new laboratory courses to feature individual laboratory work.

Sheppard also pointed out that Eliot's impact on high school science was not limited to Harvard's sphere of influence; it also extended to the *national* level. There was widespread dissatisfaction with the high school-college interface, which led in 1892 to the formation of the first national education committee, the Committee of Ten (CoT), which was chaired by Eliot and was charged with restructuring high school study.

In the late nineteenth century, mental discipline and training were seen as the purpose of education. Certain subjects, notably Latin, Greek, and mathematics, were believed to strengthen the faculties of memory, reasoning, and imagination. Eliot argued for the place of science in the curriculum because in the science laboratory a student "exercises his powers of observation and judgment [and] acquires the precious habit of observing appearances, transformations, and the processes of nature." A major reason why the sciences were able to break into the then classics dominated curriculum was because of the Physical Science subcommittee's and Eliot's advocacy of the laboratory method.

In 1895, Sheppard went on, the Committee on College Entrance Requirements (CCER) was established to implement the CoT recommendations. The science sections of the CCER reiterated the importance of laboratory work and specified that laboratory work should be performed individually in well-equipped laboratories, with each student having his/her own set of apparatus. If these conditions were met, then "all colleges must give admission credit for the subject." Having been instrumental in ensuring that the sciences and science laboratories were incorporated into high schools and colleges, Eliot also contributed significantly towards raising the status of science, further ensuring its prevalence and prominence in educational institutions.

At the time, the status of a subject in high school was directly correlated to its degree of acceptance by colleges. In 1877 Eliot launched a movement to standardize the college entrance examinations, which further consolidated the role of laboratory work. In 1900, Nicholas Butler of Columbia University established the College Entrance Examination Board (CEEB) -- "Eliot's idea and Butler's triumph." The fist examinations (later known as achievement tests and now as SAT II tests) were given in 1901. The subjects tested were those defined by the CCER. In science, initially, there were physics and chemistry examinations. Subjects that were tested became acknowledged as college entrance subjects.

The CEEB published syllabi for the courses it tested, outlining what curricula high schools should follow to prepare students for the CEEB examinations. The first CEEB syllabi in physics and chemistry exhibit the importance that the CEEB gave to individual laboratory work. They required laboratory work to be performed in the schools and sent in to be graded by an examiner. The practice of requiring laboratory books to be assessed externally continued until 1909, when it was replaced with certification by science teachers. To this day, New York State continues to require teacher certification of student laboratory work. The current New York State Regents requirement in chemistry is that high school students complete at least 1200 minutes of laboratory work.

Making his mark on the educational scene, Andrew Carnegie established a ten million dollar pension fund for college professors in 1905. Named for Carnegie was the "Carnegie unit," defined as 120 60-minute hours spent in class. It was universally adopted, and Sheppard noted that double periods for labs counted as a single period. This two-tier system, better known for assigning credit in college courses, has continued to this day, and Sheppard observed that NSTA's 15 December 2006 draft position paper on the role of laboratories in science education did nothing to challenge this. Sheppard himself felt that the additional time spent on laboratory work in science courses merits additional credit for them.