Trends in the Teaching of Analytical Chemistry in American Universities*

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Received September 29, 1972

The purpose of this paper is to trace the shifting patterns in the teaching of analytical chemistry in the United States over the past several decades. In doing so, I am acting primarily as a reporter and I am not necessarily supporting all of these trends. At the outset, I should acknowledge the help of over 30 of my colleagues in other universities who provided me with information about changes during the past 10 to 15 years, courses being taught at present, and some predictions as to the future.

It should always be kept in mind that American universities are extremely diverse in nature, ranging from institutions that offer little or no graduate work to State supported and private institutions placing...
great stress on graduate and postdoctoral research. Each school is quite free to develop its own curriculum. On the other hand, the fact that most American professors have been connected with at least two or three schools throughout their study and professional work tends to have a unifying influence. In fact, a surprisingly large fraction of staff members have at one time or another been associated with one of the top ten or twenty research oriented institutions so that their influence tends to be enormous. Because of the relative flexibility of courses and curricula, there tends to be a considerable amount of experimentation. This experimentation with courses is stimulated by the fact that the younger staff members are encouraged to develop their own research programs, and there is a natural motivation to introduce advanced courses along the lines of the research. In general, American universities rely more heavily on formal courses at the post-graduate level than European schools do. This, I believe, is a natural outgrowth of the fact that most students change schools between their undergraduate and graduate study. There are many undergraduate colleges, the so-called liberal arts colleges, which offer well-rounded education in science, art, and humanities, but often without the advanced undergraduate courses available at the large universities. Some small colleges, of course, specialize in scientific work but others specialize in arts and humanities and offer only the basic courses in science. Even so, there is a great diversity among American universities in the number of formal courses offered at the graduate level. During the past 10 or 20 years, there has been a general trend toward decreasing the number of course offered and required in all fields, with a corresponding increase in emphasis on research.

Let us begin our survey by looking at the analytical program in a typical large U.S. university at the turn of the twentieth century. European tradition had been strongly influential in setting up undergraduate curricula along the lines of the traditional 4 branches of chemistry; inorganic, analytical, organic, and physical in that order. Analytical instruction consisted of a rigorous practical course in qualitative analysis, exclusively applied to inorganic materials, followed by an intensive study of quantitative methods, largely based on gravimetric procedures. Advanced work consisted of the specialized application of classical procedures to specific types of sample, for example, rocks, ores, metals and alloys, or gases. Depending upon the specialized interests of staff members, courses in microanalysis, microscopy, and the analysis of foods, water, fuels, etc., might have been offered. During the early part of the century, titrimetric procedures increasingly came into use, and later physical-chemical endpoint detection procedures such as potentiometry and conductometry supplemented the use of visual indicators. Understanding of the fundamental principles underlying solution equilibria, precipitation phenomena, reaction rates, etc., enhanced the depth of presentation, but no substantial changes in offerings or course sequences occurred until the 1930's.

Academic analytical chemists had, by and large, neglected the teaching of organic analysis with the exception of an occasional course on elemental microanalysis. Organic qualitative analysis was introduced and taught as a course in organic chemistry not analytical chemistry. The teaching of quantitative functional group analysis lagged far behind the practice in industry. Where this subject was taught at all, it was largely confined to organic laboratory courses. Likewise, biochemical analysis developed largely in the pharmaceutical and clinical fields rather than in analytical chemistry, and most chemistry departments made no effort to enter these fields.

In the 1930's some schools began to introduce physico-chemical or instrumental analysis courses based largely upon spectrochemical and electrochemical methods. Some of the advanced specialized courses began to suffer correspondingly. The next general trend was a decrease in the emphasis on inorganic qualitative analysis by considering it to be a part of the inorganic or general chemistry laboratory rather than analytical chemistry. It began to be considered as a device for the teaching of solution chemistry rather than as a practical means of analysis. By the late 1940's, instrumental analysis courses had become well established in many schools as an advanced undergraduate subject, sometimes at the expense of a semester of quantitative analysis. The trend to decrease emphasis on classical quantitative analysis was started, I believe, by a trading of one half year of the traditional second year quantitative course in favor of the instrumental analysis course to be offered in the third of fourth years. It was strongly encouraged by an action of the American Chemical Society Committee on Professional Training, which for many years has examined undergraduate instruction in chemistry. Although the term accreditation is not used, the undergraduate curriculum is placed on the "approved" list if it meets certain requirements in terms of course offerings, staff, laboratory and library facilities. During the