Relevancy of Chemical Literature in the Educational Process[†]

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Received December 21, 1983

Attention is focused on the desirability, if not the necessity, of a positive approach in the chemistry curriculum to motivate students to acquire and maintain an appreciation and knowledge of the chemical literature so they may use it effectively in shaping their careers. The preferable approach is to have a basic course in chemical literature with continuing emphasis on the specific aspects of the literature in each course in chemistry, especially in inorganic, organic, and physical chemistry.

The symposium on "Chemical Literature and Information, Retrieval in the Chemistry Curriculum" was organized and participants were recruited on the premise that using the chemical literature currently and retrospectively is an important and essential operation in each chemist's educational process, not only during the academic years but throughout one's evolving career. May we assume from this premise that chemistry majors are educated in and knowledgeable of the chemical literature? The answer, of course, is NO! Since the 1940s, the trend among the colleges and universities granting degrees in chemistry has been to eliminate required and elective courses concerned with chemical literature.

ACADEME'S REACTION TO THE CHEMICAL LITERATURE GROWTH

The 20th century has been a period in which chemical literature has grown logarithmically. The size and complexity of this literature prompted the educational process to achieve order by splitting science into smaller and more digestible segments of mathematics, physics, chemistry, biology, etc. As the chemical literature doubled at an accelerating rate (currently, approximately every 10 years), chemistry was segmented educationally into inorganic, organic, analytical, physical, physical organic, organometallic, and, more recently, polymer chemistry. Academic science is now highly categorized into essentially nonoverlapping, tidy compartments. This process occurred with the best of intentions and for sound educational reasons. But the process also resulted in an academic departmental structure in which faculty members view science in terms of their own isolated and self-centered units of specialized knowledge. This structure is astonishingly uniform throughout the many colleges and universities granting degrees in chemistry. Division of science into disciplines and subdisciplines is good, and even necessary, up to a point. Beyond a certain point, however, the process separates areas of knowledge that should be connected and produces graduates overloaded with segmented facts with only a bare appreciation of science or even their discipline as a whole.

Chemists who hope to assume a professional role in the world of science and technology have a need for symmetry and wholeness in what they do and think. They need to know how to participate in the systems of communication that determine the reach of the foundation of chemistry and the cooperation within the family of scientists and technologists. It is difficult to maintain a fulfilling scientific interest in a fragment, even a relatively large one, without uniting it with the whole of a discipline, and preferably of science.

An educational legacy that lasts a lifetime must be based on a grounding in the literature, history, philosophy, and ethics of chemistry. To include this grounding at the undergraduate level appers to be very difficult. It does not fit into the well-established curriculum for chemistry majors. It interferes, in terms of available time, with the teaching of the fundamentals of inorganic, analytical, organic, and physical chemistry. Courses in the literature, history, philosophy, and ethics of chemistry have been considered dull, and they can be painfully dull when presented as so many items in a collection or as so many chemists who did what. A course in the literature of chemistry that includes history, philosophy, and ethics can be an exciting challenge when the why's and so what's are explored within the evolving traditions of chemistry. Unfortunately, such courses up to now have had a severe image problem. They have been without a critical mass of faculty support. Indeed, there is a disheartening paucity of qualified faculty members who care about or profess an interest in such a course, let alone being able to teach it.

The status of such a course among the graduate schools of chemistry is particularly discouraging. Of the faculties in the 300 plus universities granting graduate degrees in chemistry described in the publication *Directory of Graduate Research 1981* (Americal Chemical Society, Washington, DC), only a very small number, barely a dozen or so, lists any activity or publication in some area of chemical information retrieval, nomenclature, history of chemistry, or computer science. Graduate schools surely cannot assume that their entering students know how to search the chemical literature or even know there is a literature.

According to the introduction to the *Directory of Graduate Research*, "Undergraduate education prepares the student to bring to bear on a problem the *accumulated knowledge* of mankind and to apply all available information toward its solution. Graduate education prepares students to solve problems when *sufficient information is not available*, by themselves extending mankind's knowledge."

VALUES OF THE CHEMICAL LITERATURE

The chemical literature is the "accumulated knowledge of mankind", and knowing how to use it permits us to "apply [the retrieved] information to solve problems". It is more: the chemical literature comprises systems of communication by which we learn the values of and sources of authority in chemistry and from which we organize our knowledge. It is a rich and multilayered paradigm for communicating chemistry as it has evolved and is evolving.

If we are to close the gap between the undergraduate chemist and his/her literature, the first step is to make the student aware that every course and textbook in the chemistry curriculum are recapitulations of segments of the chemical literature. What one learns in any course is that part of the

† Lead paper in the symposium on "Chemical Literature and Information Retrieval in the Chemistry Curriculum" presented before the Divisions of Chemical Information and Chemical Education, 184th National Meeting of the American Chemical Society, Kansas City, MO, Sept 15, 1982.

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0095-2338/84/1624-0095$01.50/0

literature the textbook author and professor evaluated and repackaged as being relevant and pertinent at that time. In reshaping the past to render as much coherence to the information as possible, considerable information and values must be left out, and some information may even be distorted by the interpretations.

The educational process from elementary grades to well into college conditions students to focus learning on individual textbooks and teachers. As their degree of learning is evaluated by a series of tests, students realize that information, like health and money, is most important when they do not have it, especially during a test. There is a great difference, however, in information to a student for a test and information to a scientist for investigating the secrets of nature. The seeking of information, whether in the laboratory, in the literature, or from a colleague, is a vivid personal matter to the scientist. Just as an adult is more than an enlarged child, a professional chemist is more than a student of chemistry, not in size nor in total information but in differentiation. The difference between recapitulation and seeking of information is considerably more than the techniques, skills, and total recall of what one learns in college. The difference lies in the knowledge of how chemistry evolved into a science, technology, industry, and a professional way of life, what and where the literature is, who made and are making the literature, and why the literature is the mortar that holds chemistry together. Whereas the student of chemistry hopes that chemistry has a future, the professional chemist knows it has a great future because it has had a great and brilliant past.

Although a relatively small number of chemists affect the literature as authors, all professional chemists are affected by the literature as readers and users. Reading and using the literature are a tradition within the community of chemists for maintaining scientific growth, for continuing self-education, for seeking new ideas and relating existing information, and for establishing background information on initiating new research programs. What we learn and are trained to do in college are but the first stage in the shaping of a professional career. Those who leave academe with the belief that education in chemistry is finite court technical obsolescence within a decade and could find themselves in a career of the past. Much has been said and written lately on the observation that too many students enter college deficient in mathematics and language skills and in knowledge of science. We should also be concerned about college graduates who are scientific illiterates, including too many who majored in one of the disciplines of science. Along with the what to learn, the educational system needs to place more emphasis on the how to learn. Knowing how to learn is a legacy that lasts a lifetime and that enables graduates to generate their own futures.

SHAPING A CAREER

It is in the industrial world that over two-thirds of the chemistry graduates develop and shape a career. Only a relatively small number of these graduates, including Ph.D.'s, will have a career in the laboratory that continues into retirement. The majority will evolve careers in areas quite unrelated to the supply and demand concepts of the academic world. Some of the nonlaboratory careers graduates may metamorphose into are sales, marketing, purchasing, health and safety, quality control, information science, energy, materials, and environment. Some may also end up in the supervisory and management ranks. Those whose careers are continuously in the laboratory experience many radical departures from their training and education. In many chemical companies, a majority of Ph.D. organic chemists whose educational background was centered on synthesis and reaction mechanisms now think of themselves as polymer chemists or material scientists, yet they never had a course in what they do today. Their transition from organic chemist to polymer chemist was made possible because they are readers of the current chemical literature and know how to use the chemical literature for retrospective searching. They know how to seek information in the laboratory, in the literature, and from colleagues. Through continuing self-education, they are broadly educated and are able to structure their own careers. They are literature chemists.

Literacy in chemistry is more than the ability to extract data and information from primary and secondary sources. It is this and knowing how to discover meaning and knowledge in the literature. It is having the desire to read and study and taking pleasure in these activities. It is having a direct and lively interest in the chemical literature and in those who made and are making the literature.

PUTTING CHEMICAL LITERATURE IN THE CURRICULUM

On the basis of my previous publications relevant to this subject[1-8] and the arguments advanced in this paper, I think it is time for academe to take a positive approach toward motivating students to acquire and maintain an appreciation and knowledge of the chemical literature. In addition to having a basic course in chemical literature relatively early in the curriculum, there are valid reasons to incorporate in each chemistry course, viz., inorganic, organic, and physical chemistry, those aspects of the chemical literature that are specific to each course. In view of the fact that chemical information science is a discipline of chemistry, one in which several thousand chemists are shaping meaningful careers, we should expect some graduate schools to conduct research in this discipline, preparing students for potential careers as chemical information scientists. Most importantly, however, students of chemistry, undergraduate and graduate, need to be comfortable and competent in using the chemical literature as they metamorphose into professional chemists.

On introducing the chemical literature course, much thought must be directed to who should teach it and what its content should be. Ideally, it should be taught by a mature and literate chemist who has a deep and abiding interest in the literature and those who made it and in the historical, philosophical, and ethical aspects of chemistry. It would be advantageous if the teacher understands the challenges of and opportunities in the chemical industry for chemists, both in laboratory and nonlaboratory careers, and how careers shift in this environment.

The content of the course obviously must be concerned with what the literature is, where it is, who made it, and how it is evolving and what historical, economic, and political factors influenced the growth of chemistry into a profession and an industry.

Rewards to the students can be many. The most important may be the ability to learn how to learn in chemistry and thus be prepared for technological and career changes.

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Cost-Effective Operation for an Agricultural Information Center[†]

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Received September 8, 1983

The recent economic climate for the industrial world requires that all facets of operation be examined and honed to greatest efficiency. Information services must respond to an increasing demand to provide more services for an expanding research and development staff and maintain reasonable budget increases in spite of recent sky-rocketing costs of information products and services. Unit cost reduction methods have been developed and implemented to control escalating operating costs. Methods for cost control and cost reductions are described, specifically, systematic review and control of subscription renewals and book acquisitions and an innovative procedure for closer control of on-line database usage to countermand rapidly rising costs of scientific databases.

INTRODUCTION

Information is expensive. If you have it, it is expensive to process. It is also expensive to maintain so that it is easily accessible to users. If you do not have the needed information readily available, it may be even more expensive to acquire and usually impossible to obtain on short notice.

The success of any technical information service function is measured in a large part by its ability to provide high-quality services and products in spite of increases in the cost of products and operations.[1] This paper discusses how we are dealing with this problem in Technical Information Services, referred to as TIS, at American Cyanamid's Agricultural Research Division in Princeton, NJ. But first, some information about the Agricultural Research Division, its client/user population, and its mission.

AGRICULTURAL DIVISION—ITS CLIENT/USER POPULATIONS

At the Agricultural Research Division, referred to as ARD, we have scientists, managers, and support staff involved in research and development of products for animal health and nutrition and also of products related to plant science; these are insecticides, herbicides, and plant-growth regulants. Research and development responsibilities of ARD are worldwide. Our development staff is responsible for both domestic and overseas research in the Americas, Europe, Africa, the Middle and Far East, and Australia. The TIS user community also includes the administrative group of the Agricultural Division, who handle domestic and overseas marketing, technical services, and sales.

In general, the principal users of technical information and our library collection are bench scientists and other scientists, who comprise about 60% of the total research and development population. Many requests made to TIS by ARD personnel may originate outside our division from persons in the development or marketing groups or from our patent attorneys.

FACILITIES AND COLLECTION

The Agricultural Research Division is housed in a facility built in 1961. The Library contains literature, patents, company research and development reports, and laboratory notebooks necessary to support the work of the Agricultural Center. These resources are enhanced by our use of five major computer systems that collectively provide access to more than 150 databases relevant to our work.

TIS STAFF AND FUNCTIONS

TIS staff is comprised of information scientists, librarians, and support staff. Our three areas of responsibility include Library Operations, Patent and Literature Services, and Research Information. Our information scientists are either graduate chemists or graduate biologists with advanced degrees or advanced training in their subject field and in information science.

The mission of TIS is to provide informational support to ARD through acquisitions and maintenance of the Library collection and, most importantly, by responding to daily requests for specific information (Figure 1). The results of these requests take the form of products that vary with the nature or complexity of the question. For example, searches are usually very complex, may cover more than 10 years of literature, and may take many months to prepare.

About 2 years ago, we discontinued our current awareness bulletins called "Items of Current Interest" (ICI). These were a cut-and-paste operation of references and abstracts selected by the information scientists from Library periodicals. These current awareness bulletins were time and labor intensive and expensive.

We now have a computer-generated current awareness service, Selective Dissemination of Information (SDI), on selected topics. These SDI's arrive via mail from the supplier and are circulated to interested persons. SDI's are obviously more efficient, and recipients are very pleased with them. At

[†] Presented before the Division of Chemical Information, Symposium on Cost of Providing Information from an Industrial Information Center, 185th National Meeting of the American Chemical Society, Seattle, WA, March 23, 1983.

