directly on the information services industry. The first megatrend affecting this topic is that Americans continue to believe they live in an industrial society, despite the obvious fact that the economy has changed and they now live in one based on creating and distributing information. Many are employed as professionals. Professional workers are almost always information workers—chemists, lawyers, teachers, computer programmers, and others. In an information society like ours, capital is a strategic resource, but information is the key. Access to this information is crucial.

The second megatrend is the duality of a "high-tech" and "high-touch" society. Naisbitt means that each technological application brings with it a need for a compensatory human response. There are two key points: we live in an information-based economy with rapidly escalating technology, yet society demands that technology be balanced with human responses. This represents high tech and high touch.

These megatrends already affect the direction of infromation creation, processing, and distribution. We see it in development of end-user searching, full-text searching, and graphics technology.

Why does the user want to search the literature himself? We believe it is not because of a lack of trust in the information intermediary. Rather, the fancy computer databases represent high tech and the user wants personal interaction with them or high touch. He feels that this personal interaction or manipulation of data will enhance creativity and innovation. The same factors come into play with full-text searching. Additionally, full-text searching expands access to nonindexed information. It speeds access to information by eliminating the need to first locate an abstract and then find the document of potential interest. Full-text publishing additionally can provide more currency to information dissemination since the material does not need to be indexed or abstracted.

Graphics technology provides substructure-search capabilities. It allows data manipulation, such as modeling simulation, and statistical and pictorial representation of data. It is high tech. When a scientist sits at a graphics terminal and uses a light pen or tablet to build a model of interest, it represents high touch. Graphics also enhances electronic publishing and is a crucial link in acceptance of full-text publishing.

In this information-based society with an emphasis on high tech and high touch, will traditional indexing and abstracting survive? Yes—at least for awhile; indexes and abstracts are an important means of communication. They focus on the essence of the work reported in an article. Many scientists are not interested in reading all articles in their field of expertise but choose to stay abreast of technology advancements by reading the author's abstract or one prepared by an information service.

Anyone who has had the opportunity to search a full-text database appreciates the efforts that go into and the importance of indexing. Unquestionably, there is a time and a place for full-text search capabilities, but the need for information manipulation, such as indexing and abstracting, is more important as the volume of published information increases.

Traditional indexing and abstracting will change. The business of information storage and retrieval is growing as rapidly as a snowball rolling down a mountainside. This snowball is increasing dramatically in size and is gaining momentum as it gathers snow and falls farther down the mountain. This momentum brings with it more and more information users. These users, whether they are scientists, government regulatory personnel, or information specialists, are becoming increasingly sophisticated. Their information needs are multidisciplinary. Their time frame for needing answers is short. They want access to more specific information and to data. Some examples include toxicological data, precise testing methods and procedures, reactivity of specific atoms, and the ability to search polymers substructurally. This information needs to be rapidly retrievable. Indexing needs to be expanded and more precise. Technological advancements will help index and abstract more efficiently and effectively.

Types of information requests will continue to vary from bibliographic records containing index terms, to full text, to actual data. Full-text publishing, complete with search capabilities, will not, within the next few years, preclude the need for indexing and abstracting. Searchable databanks with creditable, verified data such as an LD_{50} or specific physical property data will not preclude the need for indexing and abstracting. The ability to graphically search chemical structures is a grand technological advancement but is no substitute for searching index files. All of these retrieval avenues are important. They complement indexing and abstracting. But indexing is the necessary bridge between information generation and effective information utilization.

A Practical Approach to the Use of Literature Early in a College Career†

EUGENE A. KLINE

Department of Chemistry, Tennessee Technological University, Cookeville, Tennessee 38505

Received November 21, 1983

The use of literature in freshman and sophomore chemistry courses can be implemented in the laboratory very easily, especially in Organic Chemistry. Slight alterations of the prescribed synthetic procedures will encourage the student into literature to seek all kinds of necessary information and will play an important part in teaching the need for literature searching.

The importance of professional literature for chemists makes it most worthwhile to examine various ways of stimulating its use by undergraduate chemistry majors in the first 2 years. However, it has to be noted that differences in emphases among departments, abilities of students, and availability of literature demand that several options be considered.

Ideally, the use of chemical literature by undergraduates should commence as soon as possible. There are even Freshmen who can and should be trained to do serious literature searches, and ways should be developed for those freshmen who need special elementary assistance to acquire the knack of such searches. For example, handbooks and

†This paper was presented at the Symposium on Chemical Literature and Information Retrieval in the Chemistry Curriculum, 184th National Meeting of the American Chemical Society, Kansas City, MO, Sept 15, 1982.

0095-2338/84/1624-0190$01.50/0

reference books in chemistry can easily be added to the usual freshmen course. Familiarity with these sources should be a minimum requirement for all first-year chemistry majors.

INTRODUCTION OF LITERATURE IN ORGANIC LABORATORY

Traditionally, Organic Chemistry has been the first course having a serious introduction to literature. A survey of several freshmen laboratory texts found only two[1,2] that had any use of literature. These included references to the experiments but did not involve a study of the chemical literature. This was in contrast with organic laboratory texts, of which only five[3-7] of 17 texts examined did not have a special section devoted to searching of chemical literature. Everyone taking courses in organic chemistry needs a survey of the basic literature available, its locations on a campus, and the kinds of information that might be found in the literature. There are many ways of accomplishing this, but the most effective one gets the student into the library to find answers to questions designed for that purpose. Questions need to be specific and isolated enough to demand some hunting to find their answers. Furthermore, there needs to be enough different sets like those in Mellon[8] with one item for every three students to be effective. Because more advanced searches would probably require a certain amount of maturity and a commitment to chemistry and/or research, they should probably be put off until the junior year.

A formal use of literature is valuable if it has uniformity in thoroughness and practice. There are ways that literature can be used in the first 2 years to encourage students to explore various possibilities that will match their career interests and abilities. Literature can also provide a great deal of assistance in career planning and can be used in most laboratory experiments, where the working chemist uses it.

In organic laboratory, for example, it is very easy to bypass the exact procedure described in a text in favor of some other reaction that might be more appealing. If the student slightly alters the experiment, it will require him to think through his experiment and require more information from literature, starting with handbooks and proceeding to the more difficult literature and eventually leading him to material that is not covered in literature.

Traditionally, organic chemistry texts have had many common experiments including cyclohexene from cyclohexanol, triphenylcarbinol, adipic acid, isoamyl acetate, aspirin, caffeine isolation, kinetics experiments with ammonium halides, and sulfanilamide. Consequently, all the students do the same experiment, and it is not long before one starts to read the same laboratory reports stocked away in the fraternity files.

LITERATURE IN RESEARCH

Research method requires extensive literature use that should be taught like any other technique, a little at a time. Waiting for a formal course in the junior or senior year is often too late for the serious students to get into good habits for serious research. Thus, when the experiments required for organic laboratory are slightly altered by a Freshman or Sophomore because of his use of literature, he is required to start thinking like a researcher, and he quickly begins to see the need for literature to save him time in minimizing mistakes. He begins to understand research method and is better able to assess his own abilities and desires, to use his time most effectively, and to work in areas having important applications to his choice of career goals.

AN EXPERIMENT REQUIRING LITERATURE

An example of how a more individual approach to organic laboratory can effectively encourage students to search the literature might be found in the synthesis of triphenylcarbinol. This experiment is found in most laboratory texts with a common procedure. One of few examples of a Grignard reaction found in organic laboratory texts, it involves the relatively easy formation of the phenyl Grignard to which is added either benzophenone or ethyl benzoate. At the end of the formation of the Grignard reagent, one of these two reagents is added to the Grignard and is left sitting in the drawer to react until the following week when it is completed. It is a good experiment in that it allows the student to see the Grignard reaction and it yields a solid product, which gives the student practice at recrystallization. The Grignard is one of the most interesting and useful laboratory reactions.

Pedigogically, it makes little difference whether one synthesizes the phenyl or the butyl Grignard, and safetywise, there is very little difference if the substrate is a ketone, an aldehyde, or an ester. However, a great deal more can be learned if the student has thought out a synthesis on his own, one perhaps related to a career aspiration. He must have researched the synthesis for problems and procedures and must have structured the equipment available to carry out the experiment. Especially important to those interested in teaching the use of literature, the student begins to see literature as something essential to a chemist's work.

VALUE TO THE STUDENT

This general approach to teaching literature searching is particularly valuable to the student, who knows where he is going, careerwise. He can get an early start into some area that he thinks he might like and that might be important to him later. He may even find some areas that he will want to completely avoid in the future. The prepharmacy major, for example, often begins to search the pharmaceutical literature for compounds that can be synthesized by a Grignard reagent and that are important in the pharmaceutical industry. The engineering major, on the other hand, is more often interested in polymers and Grignard reagents that might be involved with these. The student, unsure of his career, might alter his experiment to examine some other area of interest that is appealing to him. If requiring the use of literature is overwhelming to the student, he still has the option of following the procedure exactly as in the text, though the instructor's evaluation system needs to recognize differences in effort and results to encourage all to do their maximum. There are some very positive aspects to having all the students doing the same experiment, including lower cost and less need for well-trained instructors. However, there are many advantages to this other system. For example, better prepared students are not held back by less prepared students. Everyone is encouraged to work at his own rate in accomplishing a minimum of techniques and reactions.

ADDITIONAL INSTRUCTION

Since there are few references to the literature in organic laboratory texts to help the student in this kind of approach, time is required in class to introduce each experiment. It is important to explain the various applications of a particular reaction that might be used in expanding the original reaction or procedure to something more interesting and useful. For example, there are many references on Grignard reactions that can be used by the student including Grignard Reactions of Nonmetallic Substances,[9] Organic Syntheses,[10] Synthetic Methods of Organic Chemistry,[11] A Textbook of Practical Organic Chemistry,[12] and Organic Reactions.[13]

The possibilities for this approach are not limited to this one Grignard reaction. Many reactions essential to an introductory laboratory course include electrophilic aromatic substitution, free-radical chlorination or bromination, synthesis of an alkene, esterification, and multistep synthesis. All can be used with equal success. These all have many interesting possibilities that offer no greater danger, cost, or difficulty, and there would be reactions applicable to each career that could still be used to meet the requirement for the laboratory while also encouraging literature searching. Equipment unavailable to all students due to limited supply is only issued to those students who find a way in their study to use that equipment. Everyone will benefit from seeing each others' different apparatus and techniques, which often includes vacuum distillation, motorized stirring, and unique distillation setups.

COMPUTER SEARCHES IN THE FIRST 2 YEARS

The use of computers to search literature is most helpful to research and is becoming increasingly valuable in uncovering data that are difficult to find by conventional methods. However, in the first 2 years of the chemist's training, there is probably little need for such exercises and the costs are generally prohibitively high. But a way that the serious younger student can gain access to the computer is by working with a faculty member active in research and having the need and funding for computer searches; together they can search a particular topic. However, there are still problems for many chemists because computer data only go back to 1967. Computer searching is still a specialized field, and only time will change its cost and availability.

TIME AND EFFORT

Both the younger student and the instructor must decide how much extra time and effort they want to put in the individual laboratory approach described in this paper, as there are no limits to the amount one might do.

However, because not all students care to put extra effort in the laboratory, it is logistically possible for the instructor to handle those who do. There is no question but that this approach increases interest and gets the students into literature earlier and more thoroughly. A class of 100 students, as long as they do not use the library all at once, presents no severe logistical problems for the librarian. Classes of 300-500, however, might begin to create problems at the library's reserve desk. More qualified instructors are also required in this approach to answer the greater variety of questions and to handle the extra chemicals needed for the many experiments.

SUMMARY

In summary, the question of a formal course in literature for all Freshmen and Sophomores is ruled out in most cases because of impossible logistics. The unsettled nature of the first-year students and the questionable value it would hold for the majority of the students are other good reasons why a separate course is not appropriate until the junior year when it will be most beneficial. However, there are things that can be done even though there may be a reluctance to adopt a formal course.

REFERENCES AND NOTES

(1) West, Phillip W.; Bustin, Roberta "An Experimental Approach to Experimental Chemistry"; Macmillan: New York, 1976.
(2) Birdwhistell, Ralph K.; O'Connor, Rod, Eds. "The Freeman Library of Laboratory Separates in Chemistry"; W. H. Freeman: San Francisco, 1971; Vols. 1 and 2.
(3) Fieser, Louis F.; Williamson, Kenneth L. "Organic Experiments", 4th ed.; D. C. Heath: Lexington, MA, 1979.
(4) Helmkemp, George K.; Johnson, Harry W., Jr. "Selected Experiments in Organic Chemistry", 3rd ed.; W. H. Freeman: San Francisco, 1983.
(5) Swinehart, James S. "Organic Chemistry: An Experimental Approach"; Meredith: New York, 1969.
(6) Todd, David "Experimental Organic Chemistry"; Prentice-Hall: Englewood Cliffs, NJ, 1979.
(7) Wilcox, Charles F., Jr. "Experimental Organic Chemistry—Theory and Practice"; Macmillan: New York, 1984.
(8) Mellon, M. G. "Chemical Publications—Their Nature and Use", 4th ed.; McGraw-Hill: New York, 1965.
(9) Karasch, M. S.; Reimuth, O. "Grignard Reactions of Nonmetallic Substances"; Prentice-Hall: New York, 1954.
(10) *Org. Synth.* **1921**, *1*.
(11) Thielhiemer, William, Ed. "Synthetic Methods of Organic Chemistry"; Karger: New York, 1946; Vol. 1.
(12) Vogel, A. I. "A Textbook of Practical Organic Chemistry", 4th ed.; Longman: New York, 1978.
(13) "Organic Reactions"; Wiley: New York, 1942: Vol. 1.