Where Chemistry Meets the World: The Environment, Industry, and the Arts

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In the discussion of purposes and aims, one current theme was that chemistry should be made more relevant. For prospective chemists the application of chemical principles in industrial settings should be made evident, and for non-majors the relationship between chemistry and other walks of life should be made clear.

Every citizen in modern society encounters chemistry in his daily living. Some people, such as the industrial chemists, meet it directly in their work. Others encounter chemistry less consciously, perhaps, through their daily use of resources and energy, in their interaction with the environment, and even in their enjoyment of the arts and other cultural experiences.

Papers presented at the Conference gave evidence of the fact that many chemistry educators are cognizant of the need to prepare tomorrow's citizens for their involvement with chemistry. New directions attempted in curriculum and course development were described in various presentations and discussions.

A new course to expose students to the problems and perspectives of industrial chemistry was described by Hazdra (*8*) who believes this interfacing of industry and education will become increasingly important to graduates of bachelor degree programs in chemistry. He advocated the involvement of personnel from nearby industries in the development of such courses and the use of industrial field trips which are carefully planned to be working experiences for the students. Because he foresees a greater percent of chemistry majors going into industry in the future, he believes chemical educators have an obligation to facilitate this transition and to prepare students for the application of the chemistry they have learned to the demands of the work-a-day world.

Laboratory courses built around environmental chemistry were described in papers by Barnes (*1*) and Parravano (*6*). The first of these was designed for the second quarter of the general chemistry course and involved students in the collection and analysis of water and soil samples near local sources of pollution. Using only basic laboratory techniques and analytical methods suitable for the first year chemistry course, the parameters selected to be measured were: (1) acidity (pH), (2) oxidizable organic material, (3) dissolved oxygen (O_2), (4) total hardness, (5) turbidity, (6) total dissolved solids, (7) inorganics: Fe, Mn, CO_2, Na, Cl^-, SO_4^{2-}, PO_4^{3-}. Each student collected his own samples and thus learned something about the problems of sampling, record keeping, and interpretations of data.

The second of these courses (*6*) was designed for the more advanced chemistry students and included both lecture and laboratory work in environmental chemistry. Some of the topics included are (1) the chemical composition of the atmosphere, (2) water sources, and (3) pollutants. At this level, the experiments are more sophisticated and were planned to serve two functions: (1) to illustrate fundamental chemical principles in such areas as kinetics and equilibrium; and (2) to provide familiarity with chemical measurements commonly used in pollution monitoring. The experiments were grouped according to the analytical methods employed; e.g., volumetric, chromatographic, potentiometric, and spectrophotometric. Special attention was given to the placement of monitoring stations, sample gathering, choice of analytical methods, interpretation of results, and reporting.

Based upon field experience in water quality control, Delfino (*3*) provided valuable resource material for chemistry teachers desiring to incorporate water analysis in educational course work. He pointed out certain factors which influence the usefulness of the results of water analysis such as (1) the selection of the parameters to be measured, (2) the sampling, (3) the effect of timing, aging, and storing on certain measurements, (4) the analytical methods chosen, and (5) the relationship of the measurements and their significance for the environmental problem, that is, whether they are made for domestic water sources, recreational water, water used for industrial cooling, or waste waters. Delfino assessed the various water analysis techniques and their applications and provided standard reference materials. These should be helpful to teachers in developing meaningful experiments for course work which will introduce students to modern and acceptable procedures in water chemistry.

Showing that at least one country recognizes the coming importance of the chemistry of the environment to all its citizens, the presentation by Zoller (*9*) outlined an environmentally oriented chemistry-major program. This course of study, to be given at Haifa University-Oranim in the School of Education of the Kibbutz Movement in Israel, is to train secondary school teachers of chemistry. These teachers will contribute to the understanding of the chemical aspects of our world, as well as to an understanding of the problems of the future which will arise in maintaining an acceptable quality of human life. The four-year program includes the basic courses in general, inorganic, analytical, organic, biochemistry, and physical chemistry, together with their supporting courses in mathematics, physics, and biology. It also includes a four-year sequence in environmental studies with supporting course work in geology, natural resources, and food production.

The interdependence of science, art and culture is a reality which is frequently ignored, if not denied, by most citizens in today's society. To bring this reality into focus for students, a course based upon Jacob Bronowski's "Ascent of Man" films was designed as an elective for nonscience students by Brooks and Hostettler (*2*). The cultural evolution of science is the major theme of this two-semester course. The course objectives emphasize the relevance of the course for the nonscience major, namely: to promote an understanding of an appreciation for science *per se,* to develop some comprehension of the relations between science and society, to provide an overall perspective on the arts and sciences, and to stimulate interest in other courses. The course content is organized chronologically according to "ages" and a topic is chosen for each age to serve as a theme through which the course objectives can be realized. These topics focus on the understanding of science *per se,* or on the social aspects of science, or on both. The organization of course content is summarized below.

Content Organization of "Ascent of Man" Course

Age	*Topic*	*Emphasis*
Medieval	Alchemy	Understanding of science
Enlightenment	Chemical Revolution	Understanding of science
Enlightenment to Victorian	Science and the Steam Engine	Social aspects of science
Twentieth Century	Manhattan Project	Social aspects of science
Future	Man Into Superman	Science and social values

Each topic centers around one or two of the "Ascent of

Man" films. Discussions, supplementary readings, guest lecturers from appropriate disciplines, and term papers are utilized to promote the course objectives.

While this curriculum development based on Bronowski's films was for a year-long course, a recognition was given to the fact that the "Ascent of Man" films could be used as a basis for a minicourse, for an individual lecture topic, or for a lecture aid. These efforts could enlighten and brighten conventional chemistry courses and aid in the understanding of the interdependence of science, art, and culture.

A course entitled Chemistry for Artists and Art Buffs is another attempt to bridge the cultural gap between scientists and artists. This course, designed and described by Denio (*4*), is a three-credit course over one semester and with a weekly two-hour laboratory. There is no prerequisite of high school chemistry and a nonmathematical approach is used in teaching this course—both of these factors being desirable in order to reach the targeted audience.

Art applications of chemistry are emphasized throughout the course. The first half is a basic introduction to chemistry and includes conventional topics such as atomic structure, chemical bonding, molecular structure, chemical reactivity, and weight and energy relationships. Examples from the artists' world are used to develop understanding of chemical concepts. The second half deals mainly with the application of chemistry concepts to the artists' world and includes topics such as the behavior of metals, dyes, fibers, plastics, pigments, paints, ceramics, and glass. Laboratory experiences give students hands-on exposure to the chemical and physical processes utilized by artists.

This course has helped to increase the chemical awareness of a group of art students, as well as students in a variety of other nonscience areas. The relevance of chemistry in the cultural experiences of today's citizens becomes more evident.

While some educators have approached innovative curriculum and course development through emphasizing a particular course content, other chemistry teachers provide their students with meaningful educational experiences through emphasis on the laboratory approach to science teaching. Two examples of this approach were given by Scaife (*7*) and Nagel (*5*).

The philosophy underlying Scaife's laboratory course is encapsulated in a quotation from Roger Bacon "of the three ways of acquiring knowledge—authority (the lecture), reasoning (the discussion), and experience (the laboratory) the last is most effective." Assuming that this is true today, Scaife has designed a ten-week laboratory course for nonscience majors which has particular emphasis on developing and understanding the thought processes and methods utilized in answering specific chemical questions. The 4-hr weekly laboratory meetings are designed to maximize opportunities for students to work with some independence in a learning-by-doing atmosphere, while at the same time being assisted by pertinent questioning and demonstrations of techniques by the instructor.

The course content is very specific and involves the study of the properties of various cations and anions in salts and in aqueous solutions by means of simple chemical tests and instrumentation. Through a series of experiments, students learn to identify assumptions, investigate factors, interpret results, and justify and explain conclusions. Students then are led into situations which cause them to develop imagination, creativity, and scientific thinking.

A laboratory approach to chemistry teaching on the high school level has been utilized by Nagel (*5*) to arouse student interest in chemistry and "to lure them into learning." By organizing the study of chemical principles around the laboratory preparation of familiar products such as paints, scented soaps, mirrors, glue, and dye, students have been motivated to a high level of performance. By total involvement in the production of a product which they recognize and which they will test for quality, the students are motivated by something more than a debatable quest for knowledge.

The course is designed around approximately 4-wk laboratory projects. As each project unfolds, the need to know becomes apparent and the principles of chemistry emerge in supporting class sessions, along with relevant terminology and concepts. All the principles presented in a standard Chem Study course are incorporated in this program, but the context in which the information is presented is new.

This program has evolved over a number of years and has been compiled in study guides. Success with diverse student populations has been achieved because of flexibility in the direction and depth of both class and lab work. Favorable preliminary reports have been received from teachers who have field tested the project units during the past academic year.

Annotated Bibliography

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A program utilizing environmental problems in a general chemistry course laboratory.

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A two semester course for nonscience majors organized around topics and themes of Ascent of Man films and designed to show the interdependence of science, art and culture.

(3) Delfino, Joseph J., **The Role of Chemical Analysis in the Interpretations of Water Quality,** Laboratory of Hygiene, University of Wisconsin—Madison, Madison, WI 53706

Data and methods in water analysis.

(4) Denio, Allen A., **Chemistry for Artists and Art Buffs,** Department of Chemistry, University of Wisconsin-Eau Claire, Eau Claire, WI 54701.

A one semester, three-credit course with laboratory for nonscience majors with emphasis on art applications of chemistry.

(5) Nagel, M. C., **A Vocational Approach to Chemical Principles,** Avon High School, Avon, CT 06001.

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(6) Parravano, Carlo, **The Design of a Laboratory Program for General Chemistry,** Department of Chemistry, State University of New York, College at Purchase, Purchase, NY 10577

An advanced laboratory course in environmental chemistry.

(7) Scaife, Charles W. J., **Scientific Creativity: A Chemistry Course for Nonscience Majors that is Entirely Laboratory,** Department of Chemistry, Union College, Schenectady, NY 12308.

A ten week laboratory course with emphasis on developing thought processes and understanding scientific thinking.

(8) Wesolowski, Wayne E., and Hazdra, James J., **An Introduction to Industrial Chemical Processes: An In-Depth Study Approach,** Department of Chemistry, Illinois Benedictine College, Lisle, IL 60532

The contents of a one-semester course for upper division students in the chemistry major program to orient them to the problems of industrial chemistry.

(9) Zoller Uri, **Chemistry of Man's Environment—A Cornerstone in Chemical Education: An Undergraduate Chemistry Teacher Training Program,** Division of Chemical Studies, Haifia University-Oranium, The School of Education of the Kibbutz Movement, P.O. Kiriat Tivon, Israel.