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Committee on Professional Training

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The CPT Library Survey

In November 2000, CPT undertook a survey to learn more about chemical information resources in undergraduate programs at approved institutions. The survey was sent to all 617 ACS-approved schools. The number of surveys completed and returned was 408, which represents a 66% response rate. The high level of response reflects the level of importance that institutions attribute to these issues and suggests that this survey touched on a timely topic of substantial concern in academic institutions. This survey has generated considerable food for thought for CPT in terms of access to and use of chemical information in approved undergraduate programs.

At least part of the prevailing unease about the state of chemical information can be ascribed to the evolution of electronic forms of chemical journals and databases and the rapidly shifting landscape dictating access to these media. Indeed, changes are taking place so rapidly in electronic forms of chemical information that some of the data collected in the CPT survey last fall were out-of-date prior to being compiled. Thus, this survey will not provide as complete a picture of the chemical information situation as CPT had originally hoped. Nonetheless, an analysis of the data suggests some very interesting and significant trends in chemical information holdings and access in chemistry programs that call for the community's further consideration. CPT is carefully considering these data and plans to publish a full report on valid results in the next *CPT newsletter*.

Mentoring

The economic growth of the United States will depend less on the exploitation of natural resources and more on the development of human resources, which are the basis of a technology- and information-driven economy. To sustain economic growth, the United States will require a greater commitment to the equity and effectiveness of its educational system than in the past. Such is the promise of mentoring in the chemical sciences. Mentoring should be defined in terms of the unique character of a relationship and the function it serves rather than in terms of a set of specific formal roles (Shirley Peddy, 1998). Thus, those who seek mentors, or those who desire to become mentors, need to know the essential elements that characterize a successful relationship between a mentor and a protégé. This article highlights the need for a professional relationship in which the mentor helps the protégé succeed within the chemical sciences. Given the dearth of science majors in the general student population, especially the low numbers of students from underrepresented groups, it imperative that students and faculty alike be made aware of how to establish or improve current or pending mentor–protégé relationships (National Academy of Sciences, 1997).

Mentoring Guidelines

Mentors perform an immense variety of functions while working with a protégé, including teaching, guiding, advising, counseling, sponsoring, role modeling, motivating, protecting, communicating, advocating, and promoting. The responsibilities are equally varied. First and foremost, a mentor must be readily available to assist the protégé. The mentor must provide guidance, both solicited and unsolicited, related to skills development, potential problems, career interests, and career planning based on a candid, critical, and ongoing assessment of the protégé's potential for and commitment to succeeding as a scientific professional. Thomas Dortch (2000) suggests that an effective mentor builds a relationship to make the emotional investment necessary to have a serious or profound impact. Many of the key mentoring functions are outlined below.

Training and Development

- Stimulate the acquisition of knowledge
- Provide information about educational programs
- Develop an understanding of the requirements, expectations, and organizational imperatives or demands of the profession
- Provide emotional support and encouragement
- Assist in the development of a personal and professional work ethic

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- Instill an understanding of the requirement for successful maneuverability within organizational systems and cultures (e.g., colleges/universities, laboratories, and corporations)
- Aid in the development of coping strategies while training to become a professional

Networking

- Involve the protégé in the mentor's own professional and social network to facilitate the development of contacts requisite to career advancement
- Write letters of recommendation and make contact for career development opportunities
- Provide informal instruction about etiquette and appropriate dress for social occasions

Confidence Building

- Discuss the process of creative insights
- Share professional experiences and professional and personal goals
- Discuss experiences in dealing, successfully and unsuccessfully, with professional challenges
- Encourage and challenge the developing professional
- Provide praise and acknowledge growth
- Establish a relationship of mutual trust as a precursor of scholarly pursuits and other activities in which the mentor may be involved
- Do a reality check

In summary, what is required to be an effective mentor or protégé?

Effective mentors provide advocacy for creating, maintaining, or enhancing opportunities, and they take sincere pride in their protégés' accomplishments. Relationships flourish when protégés learn from their mentors and find appropriate ways to express their appreciation. Remember, a telephone call goes a long way!

Besides the need for more resources, as a scientific community, we must focus on more effective ways to support young people's efforts to develop careers in the chemical sciences. Effective mentoring is a crucial activity that is necessary to ensure the future success of many bright and talented young people in the chemical sciences.

Important References

Shirley Peddy, Ph.D. *The Art of Mentoring: Lead, Follow, and Get Out of the Way*. Bullion Books: Houston, TX, 1998.

National Academy of Sciences. *Adviser, Teacher, Role Model, Friend: On Being a Mentor to Students in Science and Engineering*. National Academy Press: Washington, DC, 1997.

Thomas W. Dortch, Jr., and the 100 Black Men of America, Inc. *The Miracles of Mentoring: The Joy of Investing in Our Future*. Doubleday: New York, 2000.

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Chemists and Mathematicians Discuss Curriculum Needs

At the invitation of the Mathematics Association of America (MAA), a group of chemists was invited to Macalester College in November 2000 to talk about mathematics needed in a modern chemistry curriculum. The meeting was part of a series hosted by the MAA in which mathematicians met with people representing disciplines that require significant mathematics, including biology, physics, engineering, and business. The chemists attending the session included CPT representatives Norm Craig (Oberlin College) and Royce Engstrom (University of South Dakota). Other chemists in attendance were Ronald Christensen, William Coleman, Glenn Crosby, Peter Jurs, Joseph Lagowski, Truman Schwartz, and Theresa Julia Zielinski. The discussions occurred over a three-day period. After the meeting, the chemistry group prepared and submitted a report summarizing the discussions. The highlights of the report are presented here.

The chemistry curriculum presents special challenges in terms of mathematics. Chief among those is the fact that practicing chemists vary widely in the amount and level of mathematics they actually use. Those working in the area of organic synthesis, for example, may use fairly basic mathematics, while theoretical chemists may use exceptionally sophisticated mathematics. Others may rely heavily on statistics, and research chemists likely encounter a wider variety of mathematical needs than others.

The chemists categorized into six thematic areas the special nature of mathematics preparation needed by today's students:

- **Multivariable relationships.** Almost all problems in chemistry, beginning from the routinely used ideal gas law on up, are multivariate. Calculus courses typically do not address multivariate systems until well along in the curriculum, so the chemists recommended greater attention to multivariate systems from the beginning of the calculus course.
- **Numerical methods.** As the power and availability of computers have grown, chemists have made rapidly increasing use of numerical methods. Chemistry students would benefit from additional exposure to numerical methods in the mathematics curriculum.
- **Visualization.** Many areas of chemistry rely extensively on the visual representation of concepts and data. Increasing emphasis on sophisticated visualization techniques, particularly multidimensional, will be required.
- **Scale and estimation.** Chemists are constantly called upon to make comparisons of quantitative measures, and the vast range of the size of numbers dealt with by chemists requires continued emphasis on developing a "feel" for quantitative relationships. Furthermore, chemists and mathematicians need to be diligent in their efforts to develop estimation skills in students, so that the "reasonableness" of quantitative answers is apparent.
- **Mathematical reasoning.** Students need to develop a sense of quantitative relationships and translate between physical reality and the abstract concepts represented by mathematical equations. Chemistry students are routinely called upon to apply logical, multistep mathematical reasoning to solve chemical problems. The use of and translation among different dimensional units is a part of mathematical reasoning.
- **Data analysis.** It goes without saying that chemists rely critically on large amounts of quantitative information. The ability to collect, condense, summarize, and express the reliability of data is integral to contemporary chemistry.

The chemists conveyed their thoughts to the mathematicians on where in the curriculum various mathematical concepts and skills should be taught. Responsibility for certain topics resides within the K–12 preparation of students, while the university mathematics curriculum should cover certain areas, and other more specialized areas should be the responsibility of the chemists themselves. In reality, many concepts and skills would be the combined responsibility of all three. For instance, students should enter college with solid foundations in algebra, scientific notation, introductory graphing, basic geometry, fundamental functions, and logarithms. On the other hand, unit conversion, elementary statistics, and spatial representation would be mathematical concepts that are best taught in the context of general chemical principles. Fundamental calculus concepts would quite clearly be taught in mathematics courses, as would the concepts of operators, three-dimensional surfaces, fundamentals of numerical methods, and conversions among coordinate systems. Finally, the advanced chemistry curriculum would be a logical place to teach group theory, chemometrics, and the specifics of numerical methods.

The topic of technology in the math and chemistry curriculum was discussed at some length. The graphing calculator, rather popular within the mathematics community, finds relatively little use by chemists, the latter relying more heavily on graphing packages contained within computer-based spreadsheets, for example. Computing permits many mathematical approaches to become routine for chemistry students, or at least feasible in an undergraduate setting. Thus, the idea of iteration and visualization is readily accessible because of technology. Likewise, the handling of large and complex data sets is manageable, with the extraction of information from otherwise intractable signals commonplace through various transforms and averaging techniques. Pattern recognition, combinatorial approaches, and, of course, information retrieval are all mathematical approaches that are regular parts of the undergraduate curriculum because of technology.

The session provided a welcome exchange of ideas among chemists and mathematicians, and similar discussions should be encouraged even within the bounds of individual instiutions. The mathematics community is to be commended for its efforts to deliver a stronger and more relevant curriculum to the other disciplines.

The full report by the chemists to the MAA can be found on the MAA Web site maintained by Bowdoin College.

Chemistry Degree Programs for Blind Students

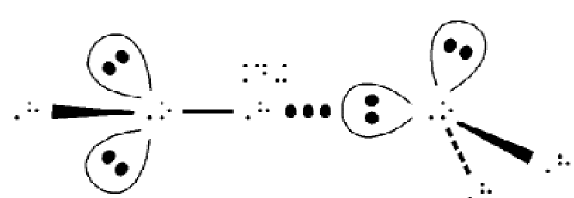
Students who are blind or visually impaired have traditionally been discouraged from studying science and engineering. It was often assumed that the visual nature of mathematical graphs, chemical structures, and technical drawings was too difficult to convey to a braille reader. Additionally, mathematical and chemical expressions are written in a special braille called Nemeth Code. Manual production of Nemeth Code is time-consuming, making it expensive. As a result of these impediments, there are very few college-level textbooks and related materials commercially available.

In the early 1990s, Purdue University had two blind students enroll in general chemistry. When confronted with this reality, a concerted effort was made by the chemistry department to provide the best possible educational experience. A group of graduate students, professional staff, and faculty was formed. Originally called the VISIONS lab, the group took four important steps. First, a protocol was developed for using undergraduate assistants in the laboratory to help with any aspects requiring sight. The blind students performed all other manipulations, data recording, and report generation, giving them a genuine laboratory experience. The second step involved the use of commercially available capsule paper to generate raised lines and textures, which can be tactilely “read” to convey chemical structures, graphs, and technical drawings. The availability of such material dramatically enhanced student understanding. The third step involved the development of a computer program that could automatically convert *WordPerfect* equation graphics into Nemeth Code. This reduced the time for production, so that exams and quizzes could be converted into braille in less than one day. The last step was the creation of tactile models to convey information that was difficult to translate into a two-dimensional drawing. Examples are space-filling hydrogen orbitals and crystal-packing structures.

While solving local problems, the chemistry group was asked to help prepare tactile material for other courses across campus. By 1996, the number of blind students had expanded beyond the capability of the chemistry department to provide the required level of service. At this time, the group was expanded and made a university organization called TAEVIS (Tactile Access to Education for Visually Impaired Students, http://www.purdue.edu/odos/TAEVIS/index.htm). This new organization serves the needs of all visually impaired students in any major. Currently, material is provided for students working on degrees in pre-law and liberal arts. Two new students majoring in pre-law and aerospace engineering are expected this fall. TAEVIS has also provided chemistry, math, and general science materials for other educational institutions.

One of the original students decided to major in chemistry. This required the adaptation and extension of the freshman protocol to all advanced courses, including the laboratory. The success of the program is reflected in the graduates. Since 1998, two braille readers have received bachelor’s degrees and have gone on to pursue graduate studies—one in inorganic chemistry and the other in business administration.

— Prepared by Fred E. Lytle, Professor, Purdue University, and Sue A. Wilder, Director, TAEVIS



The figure depicts hydrogen bonding. The oxygen and hydrogen atoms are written in braille. The lone pairs of electrons are drawn as two large dots within the outline of the sp^3 orbitals. The braille above the central hydrogen is Nemeth code for δ^+. When transferred to capsule paper, all inked lines and dots will become raised about a millimeter. The student can then read the braille and, with instructions, interpret the remainder of the diagram.

Safety and Safety Education Supplement

Safety is critical in all laboratory settings. Therefore, safety education must be an integral part of the chemistry curriculum. Discussion of the hazards involved in specific experiments should prepare all students for their coursework. As students progress through their program of study, they should develop a high degree of safety awareness, build a health and safety information knowledge base, understand safety procedures and processes, and gain experience in handling hazardous materials safely.

Safety Awareness

Safety awareness, demonstrated by always taking safe actions and developing a positive attitude toward safety, is very important for students. Faculty, staff, and students need to understand that safety is their individual responsibility to themselves, to others in the laboratory, and to the environment. Faculty and staff members exemplifying good safety practice in the laboratory are an effective means of instruction. Because safety is an integral part of scientific education, questions related to safety should appear in examinations. Additionally, safety awareness programs and reminders, such as signs, safety instructions, and presentations, help promote a safety culture and encourage students to work safely. Student participation in safety committees, safety reviews, risk assessment, and development of safe procedures provides valuable experience and reinforces safety consciousness.

Health and Safety Information

The major safety topics that chemistry majors should understand are:

Hazard identification

Specific examples of common laboratory chemicals and their hazards should be discussed. Both health and physical hazards will be encountered in the laboratory. Health hazards include exposure to substances that produce acute or chronic toxic effects, corrosives, sensitizers, irritants, carcinogens, reproductive toxins, and materials with target organ effects, which damage specific body organs or systems. Physical hazards include explosives, pyrophoric materials, strong oxidizers, organic peroxides and peroxide formers, flammable liquids, water-reactive materials, unstable chemicals, compressed gases, lasers, and radiation. Other common physical hazards are activities that can cause cuts, burns, or electrical shocks and the overpressurization of vessels.

Methods to minimize exposure or reduce risk

Work with hazardous materials in the laboratory can be done safely. Students need to know methods to minimize exposures and reduce risk by using safe procedures, fume hoods, shielding, spill protection, gloves, and other types of personal protective equipment. Students conducting research should understand hazard evaluation and risk-reduction methods. Students should know how to read and understand Material Safety Data Sheets (MSDSs) and understand the concept of the Chemical Hygiene Plan. Individuals should not carry out experiments involving hazardous materials or procedures while alone. Students should know what to do when emergencies occur, including knowing escape routes, emergency phone numbers, and the location and use of emergency equipment (e.g., alarms, eyewashes, showers, fire extinguishers, and spill kits).

Hazard and risk information

A very important part of safety education includes learning the sources of information about hazards and how to obtain, read, and understand this information. Students should be introduced to available resources for obtaining data on the hazards they will face during their careers. The following are some useful resources:

Reference books

Prudent Practices in the Laboratory, National Research Council, National Academy Press
Safety in Academic Chemistry Laboratories, ACS
The Merck Index, Merck & Co.
Matheson Gas Data Book, McGraw-Hill Professional Publishing
Sax's Dangerous Properties of Industrial Materials, John Wiley & Sons
CRC Handbook of Chemistry and Physics, CRC Press
CRC Handbook of Laboratory Safety, CRC Press
Hawley's Condensed Chemical Dictionary, John Wiley & Sons
Handbook of Chemical Health and Safety, Oxford University Press
TLVs and BEIs, American Conference of Governmental Industrial Hygienists
Journal of Chemical Health and Safety, Elsevier

Internet

MSDS Directory (http://www.ilpi.com/msds/index.html)
National Institute for Occupational Safety and Health (NIOSH) Pocket Guide to Chemical Hazards and International Chemical Safety Cards (http://www.cdc.gov/niosh/npg/npg.html)
Safety reference books/directory (http://www.lib.uchicago.edu)
SAFETY Listserv (SAFETY@uvmvm.uvm.edu), archives on http://hazard.com

Safety Procedures and Processes

Throughout their studies, students must experience safety procedures and processes. Students, faculty, and staff should participate in appropriate safety training on a regular basis. Safety committees or teams can be a valuable asset and serve as an educational resource. All students should have access to information (MSDSs, books, etc.) and know about the hazards of the substances they handle and be prepared to respond in emergencies. For students conducting research, thorough risk assessments must be carried out to evaluate potential hazards associated with planned experiments. In the event of an accident, formal review of the incident and appropriate follow-up actions must occur.

A safe environment must be provided in all classrooms and laboratories. Recognizing that the ultimate responsibility for safety within an institution lies with its president and administration, safety procedures and policies that determine accountability should be established. An institution's chemical hygiene/laboratory safety plan should include standard safety rules and procedures, descriptions of safety committees, and emergency procedures. An emergency reporting system that is easily accessible at all times to persons working in laboratories must be maintained. Periodic inspections should be performed, and problems must be addressed. Laboratory-specific safety rules, such as eye protection, should be posted and rigorously enforced. Appropriate facilities for safely handling and storing chemicals must be available. Laboratory operations, safety-related equipment, and the disposal of unwanted hazardous materials must be in compliance with governmental regulations.

Guidelines for the Teaching of Professional Ethics

The ACS Committee on Professional Training recommends that instruction in professional ethics be part of the undergraduate chemistry curriculum. This instruction may help students achieve the following results: (1) Ethical sensitivity: Students should understand that science is filled with ethical judgments, and they should be able to recognize the ethical component of complex situations. (2) Knowledge of relevant standards: Students should learn the professional standards of chemists as articulated in the ACS Chemist's Code and in relevant works on scientific ethics. (3) Skill in ethical decision making: Students learn to analyze complex ethical problems and design appropriate solutions. (4) Ethical actions: Often the most ethical course of action is difficult. By education and example, chemistry faculty can help students to act ethically in difficult situations encountered later in their professional lives.

There are many important and interesting questions in professional ethics. The following could profitably be part of any program of instruction:

- Responsible treatment of data: Since no scientist uses or reports all the data, students need to learn when data can be discarded. They also need to learn how to use and report data.
- Reporting scientific information: Science is based on a principle of open communication. Students must learn the standards related to publication of scientific results, including questions of intellectual property.
- Responsibilities of the peer review system.
- Conflicts of interest: All scientists have conflicts of interest. Some involve financial interests; others do not. Students should learn to recognize a conflict of interest situation and how to deal with it.
- When and how questions of possible ethical misconduct should be raised.
- Use of animals and humans in scientific research: While the use of animals and humans is relatively rare in chemical research, at least a brief discussion of these questions is important.
- Relationship of chemistry to society: What are the responsibilities of a chemist to society both as a chemist and as a citizen?

Strategies for Instruction in Professional Ethics

Strategies for offering ethics instruction in chemistry include a guest lecture program, a separate course, or integration of ethics broadly into the curriculum. The most effective choice depends on the goals and resources of the particular institution. A guest lecture program may be the simplest. Experts in professional ethics can be invited to give lectures in appropriate courses or as part of a regular departmental seminar program. The advantage of this approach is its simplicity; it does not require significant changes in curriculum, nor does it ask often overburdened chemistry faculty to learn a new field. The disadvantages are that it is difficult to ensure that all the relevant issues are covered, and that a guest lecture program can send the subtle message that ethics is just for a few experts and not important to the working scientist. Finally, it may be difficult to find and schedule speakers on a regular basis.

An attractive alternative is to create a separate course or to incorporate ethics as a significant part of an appropriate existing course, such as a capstone course or a seminar for chemistry majors. Such a course might also be offered in conjunction with other science departments. Descriptions of such courses have appeared in *The Journal of Chemical Education*, among other places. The advantage of a separate course is that coverage of relevant topics can be assured. The disadvantage is that it is often difficult to add a separate course to an already crowded chemistry curriculum. Finally, it can be difficult to find someone willing and able to teach such a course.

The third possibility is integration of ethics into the curriculum by raising and discussing ethical questions in all courses. The advantages are that the questions can be discussed in context, so that ethics will be seen by students as integral to the practice of science. The disadvantages are that it is difficult to coordinate instruction that is spread among a variety of courses and that all, or at least most, of the chemistry faculty need to be trained in the teaching of professional ethics. There are, however, some simple strategies for introducing professional ethics into any chemistry course. One is what is sometimes called the "ethics moment," which is merely raising a question of professional ethics, such as proper use of evidence, when it arises in context. A second is the "ethics homework problem." Here students are asked to write a brief essay concerning a question of professional ethics that arises in the course. Finally, discussion of appropriate hypothetical or real ethics cases can be incorporated into the course. Good ethics case materials are increasingly available.

Sources of Materials

Two booklets, *On Being a Scientist* (National Academy Press, 1995) and *Honor in Science* (Sigma Xi, 1991) provide a good introduction and overview. Several longer works include *The Ethics of Science: An Introduction*, by David B. Resnik (Routledge, 1998); *Research Ethics: Cases and Materials*, edited by Robin Levin Penslar (Indiana University, 1995); and *Scientific Integrity: An Introductory Text with Cases*, by Francis L. Macrina (ASM Press, 1995). Since these works focus mainly on academic science, it may be useful to also consult works such as *Engineering Ethics: Concepts and Cases*, by Charles E. Harris, Jr., Michael S. Pritchard, and Michael J. Rabins (Wadsworth, 1995), which more fully discuss the issues of the professional working in an industrial context. A collection of cases written specifically for chemists entitled *The Ethical Chemist* is available from the author, Jeffrey Kovac of the University of Tennessee, Knoxville, for a nominal charge.

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