ACS Guidelines for Chemistry in Two-Year College Programs

The following is an excerpt from the *ACS Guidelines for Chemistry in Two-Year College Programs*. American Chemical Society: Washington, DC. 2015.

The complete electronic version of the *ACS Guidelines for Chemistry in Two-Year College Programs* and additional information are available at www.acs.org/2YGuidelines.

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4. Infrastructure

A modern infrastructure is essential for effective and rigorous chemistry-based education. Institutional support for program infrastructure is needed for sustainability through inevitable fluctuations in faculty, leadership, and funding levels.

4.1 Organization of facilities. A program must have appropriate classroom, laboratory, other instructional, office, and common space that is safe, well-equipped, modern, and properly maintained. Laboratory and stockroom space must conform to applicable government standards and regulations. In addition:

- Chemistry classrooms should be reasonably close to instructional and research laboratories. Classrooms should adhere to modern standards for lighting, ventilation, and comfort and have proper demonstration facilities, projection capabilities, and Internet access. Classrooms should be flexible learning spaces that are able to accommodate new pedagogies.
- Faculty offices should be configured for instructional and other professional activities. They should also accommodate confidential discussions with students and colleagues. Offices should have networked computers that provide access to library resources. Faculty offices should be reasonably close to teaching and laboratory facilities and positioned to facilitate student contact. Adjunct faculty members should have comparable offices.
- Laboratories must have properly functioning utilities, fume hoods, safety showers, eyewashes, first aid kits, and fire extinguishers.
- Laboratory capacities should not exceed 25 students.[5]
- Laboratories should be designed to provide at least 50 square feet of net space per student, including lab tables and benches.[7]
- Laboratory facilities must be able to accommodate students with disabilities in accordance with federal and state regulations.
- A properly maintained chemical stockroom should be in the vicinity of teaching and research space. The stockroom must provide safe storage, handling, and preparation areas and permit easy distribution of chemicals to required areas.

7 National Fire Protection Association. NFPA 101: *Life Safety Code*, 2015. http://www.nfpa.org/codes-and-standards/document-information-pages?mode=code&code=101 (accessed Sept 10, 2015)

- Laboratories should have facilities appropriate for the type of work conducted in them. These facilities should permit maintaining experimental arrangements for extended periods of time during ongoing research projects.

The infrastructure for chemistry-based technology associate degree programs is determined, in part, by the needs of the employers. As with other types of programs, the personnel, facilities, and equipment should be sufficient to meet the goals of the program. With chemistry-based technology degree programs, the program partners are sometimes able to provide some of the needed infrastructure.

4.2 Equipment and instrumentation. Programs should have a suite of modern chemical instrumentation and specialized laboratory apparatus appropriate for the courses offered, providing hands-on laboratory experiences in synthesis, characterization, and analysis.

- Programs must have certain essential equipment, such as electronic balances, volumetric glassware, pH meters, colorimeters, thermometers or temperature probes, hot plates and/or Bunsen burners, and filtration equipment.
- Standard items, such as automated data collection devices with associated probes, bench-top centrifuges, melting point apparatus, microscale or full-scale organic kits, gas chromatographs, and UV-vis spectrometers, are highly recommended for programs serving students pursuing careers in science or health.
- Students pursuing chemistry careers should have access to standard chemistry instrumentation, such as FTIR, FT-NMR, and mass spectrometers, etc. If on-site instrumentation does not meet students' educational needs, stable arrangements should be made with proximal sites to provide ready access to the appropriate instruments.

Chemical instrumentation is an evolving area of chemistry. Faculty members should have opportunities to keep abreast of changes and improve the program's instrumentation.

Because chemistry-based technology programs typically must provide a broader range of hands-on experiences, these programs usually need more equipment and laboratory space than transfer and support programs.

Depending on the focus of the program, specialty equipment may be needed; for example, a process technology program may need a pilot plant, but a biotechnology program may need gel electrophoresis equipment. There should be sufficient equipment for all students in the program, space for the equipment, and personnel to maintain the equipment.

4.3 Computer technology and software. Students should have access to computing facilities and software that support laboratory data acquisition and analysis, interactive simulations, and computational chemistry. Software with scientific word processing and illustration capabilities should be available.

4.4 Chemical information resources. Both faculty and students should have access to the chemical literature. Physical and electronic repositories should include current chemistry and related science periodicals and peer-reviewed journals, scientific databases, and other appropriate reference materials, commensurate with the size and nature of the chemistry offerings and the scholarly activity of the students and faculty. Important reference materials, or electronic access to these materials, should be within or near the chemistry facilities and accommodate the following considerations:

- The chemical literature continues to expand at a rapid rate. The library should provide access to journal articles that are not readily available on-site by supplying other mechanisms, such as interlibrary loan, electronic transmission, or document delivery services.
- Instruction regarding the use of information from the chemical literature should be equivalent to that in the institutions to which students commonly transfer. Trained science librarians should be involved in the design and facilitation of these activities.

4.5 Chemical safety resources. The program must be conducted in a safe environment with adherence to federal, state, and local regulations regarding chemical storage, hazardous waste management, and laboratory safety.

The following are required by federal law;[8] there may be additional federal, state, and local requirements:

- A written chemical hygiene plan consistent with U.S. Occupational Safety and Health Administration (OSHA) and state standards, as well as a mechanism for aligning this plan with all teaching and any research activities
- Personnel designated to coordinate all aspects of the chemical safety program in cooperation with institutional and other departmental safety programs
- Regularly tested and inspected eyewashes, shower stations, and fire extinguishers in all areas where such safety equipment is mandated
- Training for all laboratory personnel in the appropriate use of personal protective equipment and all safety equipment available onsite
- Segregated storage areas designated for acids, bases, reducing agents, oxidizing agents, and toxic materials. Cabinets and refrigerators that store flammable materials must meet the OSHA and other appropriate federal and state regulations. National Fire Protection Association (NFPA) and Globally Harmonized System (GHS) labeling codes must be used on all reagents and storage facilities.

The following are recommended practices that support a safe learning and working environment:

- Proper facilities and personnel for chemical waste disposal aligned with OSHA and state regulations
- Laboratory safety plans that recognize the specific hazards encountered in chemistry laboratories
- Standard operating procedures (SOPs) for the storage, use, and disposal of any particularly hazardous materials
- Safety information and reference materials, such as safety data sheets (SDSs), and personal protective equipment readily available to all students and faculty

8 Occupational exposure to hazardous chemicals in laboratories. *Occupational Safety and Health Standards*, Standard no. 1910.1450, 1990. https://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=STANDARDS&p_id=10106 (accessed Sept 10, 2015). Also, Fire Protection. *Occupational Safety and Health Standards*, Standard no. 1910.157; U.S. Department of Labor, 2012. https://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=STANDARDS&p_id=9811 (accessed Sept 10, 2015). See also, The Uniform Fire Code (UFC) Section 80.301 (n) and the National Fire Protection Association (NFPA) comments following section 4-3.1.

- A policy regarding maximum stockroom chemical holdings, including small quantities for especially hazardous materials
- Personal protective equipment available to all faculty, staff, students, and visitors
- Optional safety equipment, aside from the federally mandated eyewashes, shower stations, and fire extinguishers, that is inspected and maintained as appropriate
- Regularly tested and inspected fume hoods in all laboratories that involve the use of volatile or potentially hazardous materials
- Regular inspections of all laboratories and systematic review of safety protocols and procedures. Safety incident reporting system accessible by all faculty, staff, and students: Incidents should be reported within 24–48 hours, and close calls and nonreportable incidents should be included.
- Safety incident investigation system to collect reports, investigate incidents, and report effective practices and lessons learned to all faculty, staff, and students. Investigations should be considered learning opportunities, and information should be shared freely without fear of retaliation.[9]
- Safety incident database that contains information about safety incidents, investigations, near misses, and nonreportable incidents—this database should be used to identify trends, address challenges, and highlight effective practices.

4.6 Student support services. An institution must have support services in place to help students move toward attaining their goals. Student support services must be appropriate for the student body and be consistent with the institutional mission. Support services should include:

- Advising staff who work with the faculty to enable students to achieve their academic goals
- Staff specialized in helping students with career and transfer resources
- Academic and personal support for students with physical, communication, learning, and other disabilities

9 While egregious incidents may result in punitive action, it should be noted that OSHA prohibits retaliation for reporting safety issues. OSH Act of 1970, Section 11 (c) https://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=OSHACT&p_id=3365 Moreover, punitive action will drive faculty and staff to stop reporting incidents.

- Tutorial services for students to improve their study skills and become more effective learners
- Open and reliable access to technology, such as computers
- Programs and organizations to support and engage targeted communities of students, such as student clubs
- Programs that increase the participation of underrepresented groups
- Assistance for students in acquiring financial aid

4.7 Transferring students. Faculty, counselors, and advisers from two-year chemistry programs should be in regular communication with their counterparts at institutions that accept a significant number of transfer students to ensure that the curricula of both institutions are appropriately coordinated. Two-year programs should convey the educational backgrounds and academic goals of their students to the receiving institutions. Both transferring and receiving institutions should assist students in making a successful transition.

Although specific courses are most commonly articulated by two-year and four-year institutions, it is recommended that program articulation be used, as appropriate, to better serve students. All transferring students, including chemistry-based technology students, should be counseled to take the full general chemistry course sequence, full organic chemistry course sequence (if appropriate), cognate mathematics and physics courses, and general education courses in patterns comparable to the course work of freshmen and sophomores at the institutions to which the students plan to transfer.

In addition, mentoring and other types of academic support should be provided to help students prepare for the challenges inherent in transferring to new programs and environments. Support can be offered in a variety of forms including, but not limited to, transfer-specific orientation workshops, bridge classes, transfer success courses, peer mentoring, leadership retreats, field trips, student clubs, and ACS student chapters.