VIII. Planning Your Learning Space

A well thought out and organized science classroom and laboratory helps provide a safe and effective educational experience. Whether you have a hand in the room's original design or the ability to rearrange it, this section of the Ward's Science Laboratory Manual will help you provide a safe and successful science lab. The ideal situation would be to incorporate all of the following recommendations, in addition to the requirements. As this is rarely the case, however, science teachers should develop a good chemistry safety-sense. Consider this information, incorporate the required features, and include the recommended features where possible. A Ward's Science *Room Inventory Checklist* is included at the end of this section to assist you in determining what you have and what you need in your learning space.

"Due to the basic nature of science, science classrooms and laboratories are among the most hazardous instructional areas in the school environment, so safety for those who will be using the facilities should be a prominent concern for facility planners." [2]

Before the school year begins, science teachers should review their surroundings and assess the space available for science classroom/laboratory utilization. As part of any school design, provisions for a science lab are generally included. If your building was built without a lab, you will have to do some planning. Science can be taught in a wide range of settings, from a regular classroom to a state-of-the-art facility. Labs with inadequate resources, however, will be more limited as to the number of students that can function in them safely. Differences aside, there are some common features all learning environments must maintain to facilitate quality science instruction.

Due to concerns regarding student supervision, quality of education, and safety, the National Science Teachers Association (NSTA) recommends a maximum class size of 24.[3] This limitation can be increased if the number of science teachers available for the class increases. Ward's Science defines the requirements and recommendations found in this section based on this recommended class size. The following information was compiled from the Occupational Safety and Health Administration (OSHA), Health Canada, National Fire Protection Agency (NFPA), and recommendations of The National Science Teachers Association (NSTA).

The Prep Room

An analysis of the layout of your classroom/laboratory should include chemical preparation and storage areas separate from the instructional area. Where possible, a separate room should be dedicated for each purpose. According to the National Science Education Leadership Association (NSELA), "*A lab prep room should be next to the science lab/classroom. If this is not possible, the prep room should be no more than 760 feet from the science lab/classroom and chemistry teachers should never be assigned a room that does not have a prep room adjoining it.*

The prep room should have a window through which to supervise the classroom/laboratory. NSTA recommends approximately 9–10 square feet of prep/equipment storage area per student in the class.

The prep room should have:

- Utilities including electricity and gas outlets, and hot and cold running water in an acid-resistant sink.
- Appliances including a phone, a refrigerator, and a dishwasher.
- Cabinets for prep room material storage. (The prep room should not be used for general equipment storage.)

[2] The Science Teacher, *Science Facilities by Design*, Sandra S. West, Lamoine L. Motz, and James T. Biehle

[3] National Science Teachers Association (NSTA). 2007. NSTA Position Statement: Liability of Science Educators for Laboratory Safety.

- Fume hood, which can be shared between the prep room and lab if necessary. (Refer to the Fume Hood segment of this section for specific information.)
- Accommodations for fixtures such as an autoclave, demineralizer, etc.

The space should be designed for safe, effective use. If a storage area is integral to the prep area, the room should be designed to limit chemical movement, and should have immediate access to emergency response items including fire extinguishers and neutralizing agents.

The prep room should have designated signage and should not be a teacher's office. The prep room requires separation due to the hazards involved in chemical handling and storage. Science teachers should have their own workspace, apart from the preparation space.

The Prep Storage Room

The preparation area should also include a storage room/area used solely for the storage of chemicals and materials. The room should be approximately 50 to 200 square feet depending on the number of classrooms and students it is serving. The rule of thumb is approximately 1 square foot of storage space per student served. The room should only be accessible from the preparation room (see **Figure 1)** or a room between two classrooms/laboratories **(See Figure 2**).

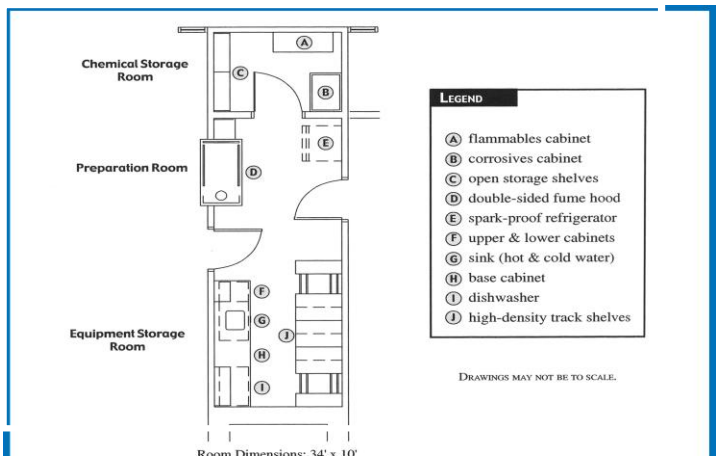

Figure 1 – Prep / Storage Room Layout for Single Laboratory[4]

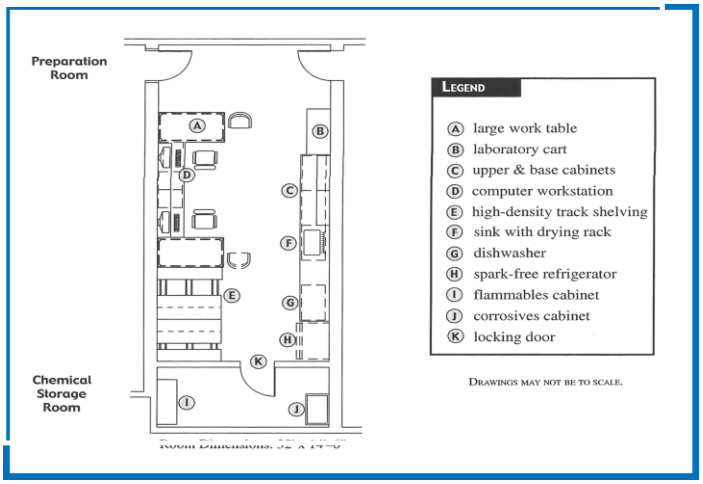

Figure 2 – Prep / Storage Room Layout for Dual Classrooms[3]

[4] *Figures 1 and 2 are reprinted from "Science Facilities Standards" by the University of Texas Dana Center.*

(Refer to *Section VI - Chemical* Storage for additional information).

- Chemicals should be stored in a lockable room that is inaccessible to students, sealed and inaccessible from the ceiling or ductwork, and has a self-closing, outward opening door (that is never propped open).
- Walls and door of the storage room should be fire rated in compliance with federal and local building codes. Due to flammable hazards there should be no electrical outlets used for personal use in this room. Linked fire and smoke detectors should be installed in the chemical storage area and in a nearby main hallway, and both should alarm when either is tripped.
- The storage room should have storage space (wall-mounted adjustable shelving and base cabinets) sufficient for the expected number of chemicals, vented NFPA/OSHA compliant cabinets for acid and flammable chemicals, and storage below eye level for all hazardous materials.
- Per the OSHA Laboratory Standard 1910 - 4 to 12 room air changes (bring in fresh air) per hour is adequate general ventilation, depending on the chemicals used. Fresh air must be brought into the storage area from outside and exhausted to the outside, away from building fresh air intakes. Check your local building codes for specific venting requirements.
- An ABC rated fire extinguisher must be located within the room, along with a bucket of dry, organics-free sand (for alkali fires). If teachers are expected to respond to a fire, they should be properly trained.
- Use the following *Ward's Science Prep Room Equipment Checklist* as the minimum requirements when setting up your Prep Room.

Ward's Science

Prep Room Equipment Checklist

Furniture

- ☐ Epoxy Countertops
- ☐ Large Sink with Overflow
- ☐ Tote Tray Cabinet
- ☐ Rolling Carts
- ☐ Benches for Kit Assembly

Chemical Storage / Solution Preparation

- ☐ Fume Hood
- ☐ Acid Cabinet
- ☐ Flammables Cabinet
- ☐ Poison Cabinet (Optional)
- ☐ Open Chemical Shelving with Shelf Lip

Appliances

- ☐ Water Deionizer/Distiller
- ☐ Flammable Storage Refrigerator
- ☐ Incubator

Safety

- ☐ Safety Shower
- ☐ Eye Wash
- ☐ (2) ABC Type Fire Extinguishers
- ☐ Buckets of Sand and Vermiculite for Spill Control
- ☐ Chemical Transport Containers
- ☐ Acid and Base Neutralizers
- ☐ Spill Control Products
- ☐ Broken Glassware Box
- ☐ Hazard Signs (NFPA Diamond)

Personal Protective Equipment

- ☐ Full Coverage Indirect-vent Chemical Splash Goggles
- ☐ Face Shield
- ☐ Gloves (various kinds applicable to chemicals used)
- ☐ Rubber Apron

The Classroom and Laboratory

To best serve students, design a chemistry classroom/laboratory that is as flexible as possible. The NSTA recommended configuration has movable tables, and can serve as a classroom (for instruction) as well as a laboratory space (with utilities, sinks, and benches around the perimeter of the room). See **Figure 3**, on the following page. When arranging the space available to you, consider the pluses and minuses of each layout scheme. Some points of concern are overcrowding, tight spaces, and dead ends.

Remember that the classroom/laboratory should not be overcrowded. NSTA recommends 55 to 60 square feet of working space per student, depending upon the type of activities to be performed. The lab should be designed for no more than 24 students per teacher. Therefore, a classroom/laboratory combination should be a minimum of 1,320 square feet to provide adequate space for laboratory work.

The following should be used as reference in planning and laying out your chemistry classroom/laboratory:

- The room should have two exits, both opening outward and at least 5 feet wide (1.5 meters) to accommodate handicapped students and serving as emergency exits. Doors should have reinforced glass windows.
- The student workstations should be located so they can all be observed from the teacher workstation. Emergency/master shut-off controls for water, gas, and electricity should be located at or near the teacher's station.
- Typically a student lab workstation or working area should provide nine square feet of horizontal surface, a 15-inch by 15-inch sink with running water, and a duplex electrical outlet (at a minimum). If a permanent eyewash and shower hose is not in place in the laboratory, sinks should have goose-necked faucets to allow the attachment of portable ones. Chemistry laboratories should be provided with natural gas, and each workstation should have safety gas connections.
- A separate HVAC system should be dedicated to the science classroom/laboratory. Per the OSHA Laboratory Standard, four to 12 room air changes (bringing in fresh air) per hour is adequate general ventilation. The system should be adjustable for up to 12 air changes per hour depending on the chemicals used. This is needed in case of a chemical spill or if particular experiments or demonstrations generate hazardous vapor or strong odor. When increasing ventilation and the amount of air changes, open doors and windows to allow for a maximum flow of fresh air. The polluted air should be exhausted outside of the building away from any fresh air intakes.
- In order to meet Americans with Disabilities Act (ADA) requirements for handicapped and disabled students, there should be at least 20 square feet (1.9 square meters) of additional working space per student to the space allowance defined above. One student workstation must be accessible to disabled students. In order to provide accessibility, the workstation should have a lower counter and sink height, gooseneck controls that do not require twisting, and enough space around the workstation to maneuver a wheelchair.
- ADA requirements also require aisle space between tables and space at the perimeter of the room to accommodate wheelchair passage (a minimum of 32 inches of clearance). Add additional space if equipment and material will be transported through the aisles. The floor should be tiled and covered with non-skid wax.
- Lab table and counter surfaces should be made of material that are resistant to acid, alkali, solvent, and temperate heat.
- There should be electrical outlets located at six to eight foot intervals (1.8–2.4 meters), which should be covered when not in use. Electrical outlets within 5 feet (1.5 meters) of water/sinks should be equipped with ground-fault interrupters (GFIs).
- The laboratory/classroom should have a variety of cabinets and drawers above and below lab workstations for student material and equipment storage.
- The room should have adequate natural lighting for experiments. The general lighting level should be between 538.2–1076.4 lumens per square meter.

- There should be a telephone or an intercom available for notifying building staff and/or authorities of an emergency.
- The classroom/laboratory should have a hands-free emergency safety shower/eyewash station with a flow rate of 1.5 gallons per minute (5.7 liters per minute) at a pressure below 25 psi, with a drain to accommodate the water flow. The unit should be located near the door, accessible from both sides, and unobstructed at all times. The station should be handicapped accessible. The emergency safety shower/eyewash station should be maintained in accordance with ANSI standard, Z-358.1-1998. Test eyewash weekly for 3-5 min. Typically, if an individual is splashed in the eyes with a chemical, they should flush the eyes with water for at least 15 minutes.
- If audiovisual equipment or computers are to be used in the lab, add the following additional space to the total classroom/laboratory area:
  - Computer Station: Add approximately 15 square feet (1.4 square meters).
  - Television w/ VCR or Laser Disc Player: Add approximately 10 square feet (.9 square meters).
  - Projector: Add approximately 12 square feet (1.1 square meters).
- A fire blanket, an ABC rated fire extinguisher, and a bucket of dry, organics-free sand should be located within 50 feet of any point in the room. If teachers are expected to respond to a fire, they should be properly trained. A first-aid kit should be immediately available, stocked appropriately to contend with the potential injuries associated with a science lab.

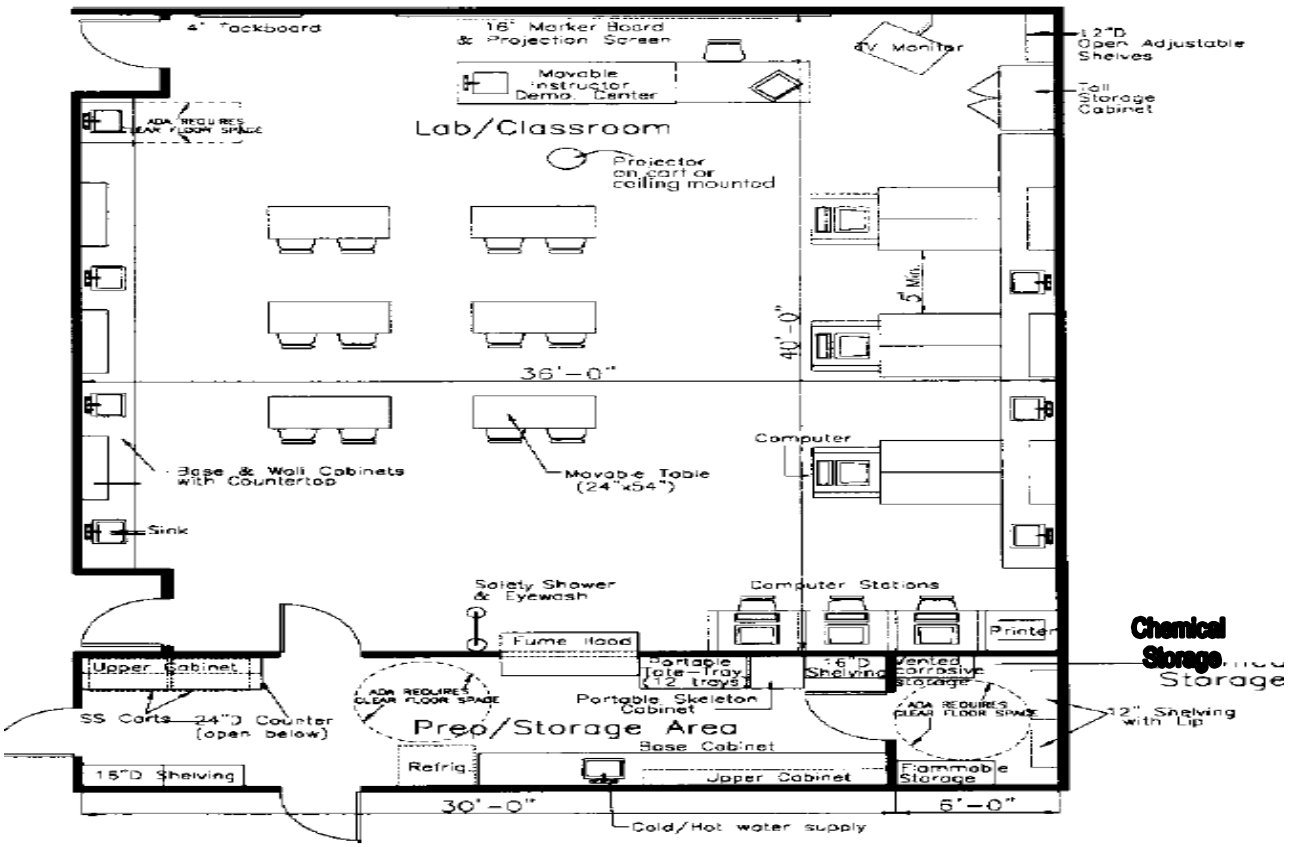

Figure 3 – Science Classroom / Laboratory / Prep Room Layout
Reprinted *from The Science Teacher, Science Facilities by Design,*

by Sandra S. West, Lamoine I. Motz and James T. Biehle.

The Fume Hood

A laboratory fume hood protects against inhalation exposure and keeps hazardous atmospheres, resulting from chemical preparations and demonstrations, from spreading to other areas.

There are several types of fume hoods including laboratory fume hoods, exhausted laminar flow hoods, and biological safety cabinets. The laboratory fume hood is the most common local exhaust ventilation system and is the one typically used in a school chemistry classroom/laboratory/prep room, and will be the only type of hood discussed in this section. When operated correctly, a laboratory fume hood can control gases, dusts, mists, and vapors released by hazardous chemicals.

For high school laboratories, where chemicals of low to moderate toxicity are used, at least one functioning portable or permanent exhaust hood that meets American Society of Heating, Refrigerating, and Air Conditioning Engineers (ASHRAE) 110 testing standards, should be used.

- The fume hood must provide a face velocity of approximately 80–120 linear feet per minute (24.4–36.6 meters/minute).
- A fume hood is not considered part of the room's ventilation. The exhaust from a chemical fume hood is separate, and comes under separate requirements than the room ventilation system. It should meet the American National Standards Institute (ANSI) Z9.5 Standard.
- Exhaust should be vented to the outside through the roof or outside wall. A common through-the-wall hood may serve the laboratory and preparation room.
- Exhaust hood(s) should be located at least 10 feet (3.1 meters) away from entrances and exits, windows, intake ducts, and high traffic areas.
- Do not store equipment under the hood unless it was designed for such use. Items in the hood will prevent proper airflow while it is in use, decreasing the efficiency of hood and creating a potential safety risk.

Check the fume hood and ductwork regularly to make sure it is operational. An annual test with a small smoke generator, or velometer, can ensure that the hood is venting properly.

You Have a Legal Responsibility to Provide a Safe Science Classroom and Laboratory

As a teacher you and your school have a responsibility to provide a safe learning environment. This task starts with the design and layout of your classroom, lab, and prep room. This design responsibility is not optional or based on convenience, but is a legal responsibility to your students. The following are excerpts from *The Science Teacher, Science Facilities by Design*, by Sandra S. West, Lamoine I. Motz, and James T. Biehle.

The Potential for Litigation

"The link between science facilities and the legal arena has a long and unfortunate history. In one Texas science classroom, students were working quietly when one student bumped the elbow of an adjacent student who was holding a compass, and the point penetrated the student's eyelid. The accident happened because students simply did not have sufficient "elbow room" to work safely. Because the science class was held in an existing science room, the only viable safety accommodation was to decrease the maximum class size for any one class assigned to that room. Although no litigation resulted from the accident, the potential for a court finding of negligence by the school was significant."

You must attain an assurance that you and the school are providing the safest and best classroom environments to the best of your ability. Lawsuits are a regular occurrence and many times are based on ignorance and negligence of the school and/or teacher. The following excerpts from *The Science Teacher, Science Facilities by Design* cite examples of negligence for which lawsuits have been brought:

Malfeasance, *or forcing employees or students to assume unnecessary risk, such as asking students to move chemicals from room to room or requiring teachers to work in unventilated spaces that violate federal, state, or local standards. Litigation focuses on working environments made unsafe by inadequate space, poor ventilation, insufficient supervision of students, a lack of personal protection equipment such as eyewashes and showers, or lack of separate and secure chemical storage.*

Nonfeasance*, or failure on the part of school authorities to do what should be done, such as provide adequate facilities or alter the curriculum when facilities are inadequate. In one case, a 14-year-old girl was badly burned while carrying alcohol to light burners in a classroom that was not equipped for laboratory work. The court found against the teacher for inappropriate supervision and against the principal for scheduling the science class in a room with improper and inappropriate facilities*

(Bush v. Oscoda Area Schools, 1981).

In another case, a Texas chemistry teacher was working alone after school preparing chemicals for the next day's class. She was seriously injured when she dropped a bottle of concentrated sulfuric acid, slipped in the acid, and fell backwards onto a large piece of glass. In addition to the acid burns, she suffered a long and deep cut in her back. She called for help and a colleague carried her to the nearest shower in the girl's gym. The lack of a safety shower in the chemistry laboratory was a clear violation of all safety recommendations. The court found that the school had not made a reasonable effort to provide a safe working environment for the science teacher or students (Lubbuck Avalanche Journal,1989).

School districts need to analyze and update science classrooms and laboratories on a regular basis. You can never design a science classroom and laboratory that is completely accident-proof, but you need to make a recognized concerted effort. The next section is designed to assist you and your school in recognizing deficiencies in your science classroom and laboratory, and tell you how to correct them. School districts, planners, and teachers should use and learn from this manual in concert with recommendations of associated recognized professionals and accepted standards.

Science Room Inventory Checklist

GENERAL LABORATORY LOCATION

- ❑ Room Number _____
- ❑ Phone Number _____
- ❑ Building Interior w/ windows
- ❑ Building Interior w/o windows
- ❑ Floor Location
- ❑ Separate Science Building

TYPE OF LABORATORY

- ❑ Biology
- ❑ Chemistry
- ❑ Physics / Physical Science
- ❑ Prep Room
- ❑ Other _____

SAFETY SUPPLY CHECKLIST

- ❑ Eyewash
- ❑ Safety Shower
- ❑ Safety Glasses / Goggles
- ❑ Lab Aprons
- ❑ Fire Blanket
- ❑ Fire Extinguisher
  Quantity ? _____
- ❑ First Aid Kit
- ❑ Safety Signage
  - ❑ Exits
  - ❑ NFPA
  - ❑ Other _____
- ❑ Safety Goggles Cabinet / Sanitizer
- ❑ Smoke / Heat Sensor
- ❑ Secondary Containment
- ❑ Spill Control Materials
- ❑ Waste Containers
- ❑ Other _____

GENERAL SERVICE HOOD

- ❑ Electric
- ❑ Gas
- ❑ Vacuum
- ❑ Water
- ❑ Other _____

FUME HOOD CHECKLIST

- ❑ Is there a fume hood in the lab?
- ❑ CFM* at Full Sash Raised Position
- ❑ CFM* at ½ Sash Raised Position
- ❑ CFM* at Full Sash Closed Position
- ❑ Airflow Sensor
- ❑ Other _____

  ** cubic feet per minute*

LAB SUPPLY CHECKLIST

- ❑ Autoclave
- ❑ Beakers , flasks, etc.
- ❑ Broken Glass Container
- ❑ Central Air Supply Cutoff
- ❑ Central Gas Cutoff
- ❑ Central Power Cutoff
- ❑ Central Vacuum Cutoff
- ❑ Central Water Cutoff
- ❑ Recycling Bin
  - ❑ Glass
  - ❑ Biohazard

CHEMICAL STORAGE

- ❑ Segregation
- ❑ What Method?
- ❑ Acid Storage Cabinet
- ❑ Chemicals Labeled
- ❑ Chemical Storage Shelf lips
- ❑ Corrosive Storage Cabinet
- ❑ Flammable Storage Cabinet
- ❑ Flammable Waste Container
- ❑ Gas Cylinder Support
- ❑ Storage Ventilation
- ❑ Explosion Safe Refrigerator
- ❑ Other _____

_____

Inventory Taken By

_____

Signature

_____

Date

General Lab Layout Comments _____

_____

_____

General Lab Storage Comments _____

_____

_____

Condition of Lab _____

_____

_____

Casework _____

_____

_____

Countertops / Benchtops _____

_____

_____

Fixtures _____

_____

_____

Sinks and Traps _____

_____

_____

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