DOMAIN I. SCIENTIFIC INQUIRY AND PROCESSES

Competency 0001 **The teacher understands how to collect and manage learning activities to ensure the safety of all students and the correct use and care of organisms, natural resources, materials, equipment, and technologies.**

Skill 1.1 **The beginning teacher uses current sources of information about laboratory safety, including safety regulations and guidelines for the use of science facilities.**

All science labs should contain the following items of safety equipment. The following are requirements by law.

- Fire blanket which is visible and accessible
- Ground Fault Circuit Interrupters (GFCI) within two feet of water supplies
- Emergency shower capable of providing a continuous flow of water
- Signs designating room exits
- Emergency eye wash station which can be activated by the foot or forearm
- Eye protection for every student and a means of sanitizing equipment
- Emergency exhaust fans providing ventilation to the outside of the building
- Master cut-off switches for gas, electric, and compressed air. Switches must have permanently attached handles. Cut-off switches must be clearly labeled.
- An ABC fire extinguisher
- Storage cabinets for flammable materials

Also recommended, but not required by law:

- Chemical spill control kit
- Fume hood with a motor which is spark proof
- Protective laboratory aprons made of flame retardant material
- Signs which will alert people to potential hazardous conditions
- Containers for broken glassware, flammables, corrosives, and waste.
- Containers should be labeled.

It is the responsibility of teachers to provide a safe environment for their students. Proper supervision greatly reduces the risk of injury and a teacher should never leave a class for any reason without providing alternate supervision. After an accident, two factors are considered; foreseeability and negligence.

Foreseeability is the anticipation that an event may occur under certain circumstances. **Negligence** is the failure to exercise ordinary or reasonable care. It is best for a teacher to meet all special requirements for disabled students, and to be good at supervising large groups. However, if a teacher can prove that s/he has done a reasonable job to ensure a safe and effective learning environment, then it is unlikely that she/he would be found negligent. Safety procedures should be a part of the science curriculum and a well managed classroom is important to avoid potential lawsuits

The **"Right to Know Law" statutes** cover science teachers who work with potentially hazardous chemicals. Briefly, the law states that employees must be informed of potentially toxic chemicals. An inventory must be made available if requested. The inventory must contain information about the hazards and properties of the chemicals. Training must be provided in the safe handling and interpretation of the Material Safety Data Sheet.

Skill 1.2 The beginning teacher recognizes potential safety hazards in the laboratory and in the field and knows how to apply procedures, including basic first aid, for responding to accidents.

Safety in the science classroom and laboratory is of paramount importance to the science educator. The following is a general summary of the types of safety equipment that should be made available within a given school system as well as general locations where the protective equipment or devices should be maintained and used. Please note that this is only a partial list and that your school system should be reviewed for unique hazards and site-specific hazards at each facility.

The key to maintaining a safe learning environment is through proactive training and regular in-service updates for all staff and students who utilize the science laboratory. Proactive training should include how to **identify potential hazards**, **evaluate potential hazards**, and **how to prevent or respond to hazards**.

The following types of training should be considered:

a) Right to Know, OSHA, properly recognizing and safely working with hazardous materials, chemical hygiene, and MSDS trainings
b) Instruction in how to use a fire extinguisher
c) Instruction in how to use a chemical fume hood
d) General guidance in when and how to use personal protective equipment (e.g. safety glasses or gloves)
e) Instruction in how to monitor activities for potential impacts on indoor air quality.

It is also important for the instructor to utilize **Material Data Safety Sheets**. Maintain a copy of the material safety data sheet for every item in your chemical inventory. This information will assist you in determining how to store and handle your materials by outlining the health and safety hazards posed by the substance. In most cases the manufacturer will provide recommendations with regard to protective equipment, ventilation and storage practices. This information should be your first guide when considering the use of a new material.

Frequent monitoring and in-service training on all equipment, materials, and procedures will help to ensure a safe and orderly laboratory environment. It will also provide everyone who uses the laboratory the safety fundamentals necessary to discern a safety hazard and to respond appropriately.

Skill 1.3 The beginning teacher employs safe practices in planning and implementing all instructional activities and designs, and implements rules and procedures to maintain a safe learning environment.

With appropriate planning and training, the maintenance of safe practices and procedures in areas of science instruction becomes integrated with the procedures for instruction and laboratory investigation. Safety procedures should be taught early and emphasized often to maintain a high level of safety awareness.

Safety Equipment

- Keep appropriate safety equipment on hand, including an emergency shower, eye-wash station, fume hood, fire blankets, and fire extinguisher. All students and teacher(s) should have and wear safety goggles and protective aprons when working in the lab.
- Ensure proper eye protection devices are worn by everyone engaged in supervising, observing, or conducting science activities involving potential hazards to the eye.
- Provide protective rubber or latex gloves for students when they dissect laboratory specimens.
- Use heat-safety items such as safety tongs, mittens, and aprons when handling either cold or hot materials.
- Use safety shields or screens whenever there is potential danger that an explosion or implosion might occur. Keep a bucket of 90 percent sand and 10 percent vermicullite or kitty litter (dried bentonite particles) in all rooms in which chemicals are handled or stored. The bucket must be properly labeled and have a lid that prevents other debris from contaminating the contents.

Teaching Procedures

- Set a good example when demonstrating experiments by modeling safety techniques such as wearing aprons and goggles.
- Help students develop a positive attitude toward safety. Students should not fear doing experiments or using reagents or equipment, but they should respect them for potential hazards.
- Always demonstrate procedures before allowing students to begin the activity. Look for possible hazards and alert students to potential dangers.
- Explain and post safety instructions each time you do an experiment.
- Maintain constant supervision of student activities. Never allow students to perform unauthorized experiments or conduct experiments in the laboratory alone.
- Protect all laboratory animals and ensure that they are treated humanely.
- Remind students that many plants have poisonous parts and should be handled with care.
- For safety, consider the National Science Teachers Association's recommendation to limit science classes to 24 or fewer students.

Student Safety Tips

- Read lab materials in advance. Note all cautions (written and oral).
- Never assume an experiment is safe just because it is in print.
- Do not eat or drink in the laboratory.
- Keep personal items off the lab tables.

- Restrain long hair and loose clothing. Wear laboratory aprons when appropriate.
- Avoid all rough play and mischief in science classrooms or labs.
- Wear closed-toed shoes when conducting experiments with liquids or with heated or heavy items.
- Never use mouth suction when filling pipettes with chemical reagents.
- Never force glass tubing into rubber stoppers.
- Avoid transferring chemicals to your face, hands, or other areas of exposed skin.
- Thoroughly clean all work surfaces and equipment after each use.
- Make certain all hot plates and burners are turned off before leaving the laboratory.

Lab Environment

- Place smoke, carbon monoxide, and heat detectors in laboratories and storerooms.
- Ensure that all new laboratories have two unobstructed exits. Consider adding additional exits to rooms with only one door.
- Frequently inspect a laboratory's electrical, gas, and water systems.
- Install ground fault circuit interrupters at all electrical outlets in science laboratories.
- Install a single central shut-off for gas, electricity, and water for all the laboratories in the school, especially if your school is in an earthquake zone.
- Maintain Material Safety Data Sheets (MSDS) on all school chemicals and an inventory of all science equipment.
- Conduct frequent laboratory inspections and an annual, verified safety check of each laboratory.

Skill 1.4 The beginning teacher understands procedures for selecting, maintaining, and safely using chemicals, tools, technologies, materials, specimens, and equipment, including procedures for the recycling, reuse, and conservation of laboratory resources and for the safe handling and ethical treatment of organisms.

Safety goggles are the single most important piece of safety equipment in the laboratory, and should be used any time a scientist is using glassware, heat, or chemicals. Other equipment (e.g. tongs, gloves, or even a buret stand) has its place for various applications. However, the most important is safety goggles.

All laboratory solutions should be prepared as directed in the lab manual. Care should be taken to avoid contamination. All glassware should be rinsed

thoroughly with distilled water before using, and cleaned well after use. Safety goggles should be worn while working with glassware in case of an accident. All solutions should be made with distilled water as tap water contains dissolved particles which may affect the results of an experiment. Chemical storage should be located in a secured, dry area. Chemicals should be stored in accordance with reactability. Acids are to be locked in a separate area. Used solutions should be disposed of according to local disposal procedures. Any questions regarding safe disposal or chemical safety may be directed to the local fire department.

The following chemicals are potential carcinogens and are not allowed in school facilities:

> Acrylonitriel, Arsenic compounds, Asbestos, Bensidine, Benzene, Cadmium compounds, Chloroform, Chromium compounds, Ethylene oxide, Ortho-toluidine, Nickel powder, Mercury.

Dissections - Animals which are not obtained from recognized sources should not be used. Decaying animals or those of unknown origin may harbor pathogens and/or parasites. Specimens should be rinsed before handling. Latex gloves are desirable. If gloves are not available, students with sores or scratches should be excused from the activity. Formaldehyde is a carcinogen and should be avoided or disposed of according to district regulations. Students objecting to dissections for moral reasons should be given an alternative assignment.

Live specimens - No dissections may be performed on living mammalian vertebrates or birds. Lower order life and invertebrates may be used. Biological experiments may be done with all animals except mammalian vertebrates or birds. No physiological harm may result to the animal. All animals housed and cared for in the school must be handled in a safe and humane manner. Animals are not to remain on school premises during extended vacations unless adequate care is provided. Many state laws stipulate that any instructor who intentionally refuses to comply with the laws may be suspended or dismissed.

Microbiology - Pathogenic organisms must never be used for experimentation. Students should adhere to the following rules at all times when working with microorganisms to avoid accidental contamination:

1. Treat all microorganisms as if they were pathogenic.
2. Maintain sterile conditions at all times

Skill 1.5 The beginning teacher knows how to use appropriate equipment and technology (e.g., Internet, spreadsheet, calculator) for gathering, organizing, displaying, and communicating data in a variety of ways (e.g., charts, tables, graphs, diagrams, written reports, oral presentations).

Scientists use a variety of tools and technologies to perform tests, collect and display data, and analyze relationships. Examples of commonly used tools include computer-linked probes, spreadsheets, and graphing calculators.

Scientists use computer-linked probes to measure various environmental factors including temperature, dissolved oxygen, pH, ionic concentration, and pressure. The advantage of computer-linked probes, as compared to more traditional observational tools, is that the probes automatically gather data and present it in an accessible format. This property of computer-linked probes eliminates the need for constant human observation and manipulation.

Scientists use spreadsheets to organize, analyze, and display data. For example, conservation ecologists use spreadsheets to model population growth and development, apply sampling techniques, and create statistical distributions to analyze relationships. Spreadsheet use simplifies data collection and manipulation and allows the presentation of data in a logical and understandable format.

Graphing calculators are another technology with many applications to biology. For example, biologists use algebraic functions to analyze growth, development and other natural processes. Graphing calculators can manipulate algebraic data and create graphs for analysis and observation. In addition, biologists use the matrix function of graphing calculators to model problems in genetics. The use of graphing calculators simplifies the creation of graphical displays including histograms, scatter plots, and line graphs. Biologists can also transfer data and displays to computers for further analysis. Scientists connect computer-linked probes, used to collect data, to graphing calculators to ease the collection, transmission, and analysis of data.

Classifying is grouping items according to their similarities. It is important for students to realize relationships and similarity as well as differences to reach a reasonable conclusion in a lab experience.

Graphing is an important skill to visually display collected data for analysis. The two types of graphs most commonly used are the **line graph** and the **bar graph** (histogram). Line graphs are set up to show two variables represented by one point on the graph. The X axis is the horizontal axis and represents the dependent variable. Dependent variables are those that would be present independently of the experiment. A common example of a dependent variable is time. Time proceeds regardless of anything else occurring. The Y axis is the vertical axis and represents the independent variable. Independent variables are manipulated by the experiment, such as the amount of light, or the height of a plant. Graphs should be calibrated at equal intervals. If one space represents one day, the next space may not represent ten days. A "best fit" line is drawn to join the points and may not include all the points in the data. Axes must always be labeled, for the graph to be meaningful. A good title will describe both the dependent and the independent variable. Bar graphs are set up similarly in regards to axes, but points are not plotted. Instead, the dependent variable is set up as a bar where the X axis intersects with the Y axis. Each bar is a separate item of data and is not joined by a continuous line.

Normally, knowledge is integrated in the form of a **lab report**. A report has many sections. It should include a specific **title** and tell exactly what is being studied. The **abstract** is a summary of the report written at the beginning of the paper. The **purpose** should always be defined and will state the problem. The purpose should include the **hypothesis** (educated guess) of what is expected from the outcome of the experiment. The entire experiment should relate to this problem. It is important to describe exactly what was done to prove or disprove a hypothesis. A **control** is necessary to prove that the results occurred from the changed conditions and would not have happened normally. Only one variable should be manipulated at a time. **Observations** and **results** of the experiment should be recorded including all results from data. Drawings, graphs and illustrations should be included to support information. Observations are objective, whereas analysis and interpretation is subjective. A **conclusion** should explain why the results of the experiment either proved or disproved the hypothesis.

Skill 1.6 The beginning teacher understands how to use a variety of tools, techniques, and technology to gather, organize, and analyze data and how to apply appropriate methods of statistical measures and analysis.

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Graphical models combine probability theory and graph theory to provide a natural tool for dealing with uncertainty and complexity, two major issues in applied mathematics and science. This type of model may provide the user with a visual representation of dependencies and correlations among random variables, or a computer generated and easily manipulated representation of a system to be studied. A computer aided design (CAD) system can be used to generate graphical models of 2- or 3-dimensional objects. These programs are designed to allow variable input dimensions, enabling graphic models to represent moving parts, to portray various scenarios and to provide the option of interaction between operator and model. Quantitative data, such as geometry and dimension observations, are entered into such programs by the operator through standard input means including keyboards, graphic tablets, etc. Following data entry, models and drawings are plotted according to the CAD's particular analysis method and purpose.

Care of microscopes

Light microscopes are commonly used in high school laboratory experiments. Total magnification is determined by multiplying the ocular (usually 10X) and the objective (usually 10X on low, 40X on high) lenses. A few steps should be followed to properly care for this equipment.

- Clean all lenses with lens paper only.
- Carry microscopes with two hands, one on the arm and one on the base.
- Always begin focusing on low power, then switch to high power.
- Store microscopes with the low power objective down.
- Always use a cover slip when viewing wet mount slides.
- Bring the objective down to its lowest position then focus moving up to avoid the slide from breaking or scratching.