SAFETY AND THE NEXT GENERATION SCIENCE STANDARDS

Approved by NSTA Safety Advisory Board – 31 March 2016

Safety and the Next Generation Science Standards

NSTA Safety Advisory Board White Paper

In 2013, Achieve, Inc. released the final draft of the Next Generation Science Standards (NGSS) as an effective research-based approach with the purpose of providing all students access to a high-quality science education. This approach would help to prepare them to enter college, to embark on a career of their choosing, or to make informed decisions about issues relating to the global environment, health care, or space exploration (NGSS Lead States, 2013). The National Science Teachers Association (NSTA) has recommended that state education agencies (SEA) and local education agencies (LEA) adopt and implement the NGSS (NSTA 2013). As these agencies begin implementation of the NGSS, all aspects of the NGSS-based science program (curriculum, instructional practice, assessment, and professional development) must provide deliberate evaluation and communication of safer practices (NSTA, 2015).

Throughout this document, references are made to students and teachers performing a *hazard analysis* and a *risk assessment* of any scientific investigations. A *hazard analysis* is a protocol for workers to focus on job tasks to identify potential sources of harm (hazards) **before** the tasks are performed. An effective hazard analysis focuses on the relationship between the worker (student), the tasks, the materials used, and the work environment. The Occupational Safety and Health Administration (OSHA) provides many resources to assist teachers and students with developing a standard form template for a hazard analysis of laboratory investigations (OSHA, Publication 3071) , (2002).

Risk Assessment takes the results of the hazard analysis to determine the possible dangers to human health, safety, or the environment. A risk assessment will generally focus on 1) the *probability* of harm, 2) *duration of exposure* to harm and 3) the *severity* of harm (National Research Council, 2007). Through the hazard analysis and risk assessment, it can be determined which engineering controls, administrative controls, or personal protective equipment (PPE) may be needed. Alternatively, a hazard analysis and risk assessment may determine that a scientific procedure must not be performed at all (Stroud and Roy, 2015).

Following all hazard analyses and risk assessments, students and teachers need to report the *Safety Actions* that will be implemented. Safety actions should be documented (in lesson plans for teachers and laboratory reports for students) and implemented at the level of engineering controls, administrative controls, and Personal Protective equipment (Stroud and Roy, 2015).

The NSTA provides an extensive list of resources for safety in elementary schools as well as safety in middle/secondary schools (http://www.nsta.org/safety/).

Safety and the Science and Engineering Practices

The NGSS are unique in that student achievement couples practice with content (NGSS Executive Summary, 2013). All of the Performance Expectations of the NGSS begin with a Science and Engineering Practice. Indeed, the three-dimensional representation of the NGSS requires students to use the Science and Engineering Practices to make sense of the Disciplinary Core Ideas of science (National Research Council, 2012). As students apply each Science and Engineering Practice to exploring and understanding science phenomena, the following safety provisions should be observed:

- Asking questions and defining problems: This practice capitalizes on the finding that children of all ages gain understanding of the natural world by building on prior knowledge through actively working with the tools of science (Duschl, et al., 2007). This process of defining problems must include a hazard analysis and risks assessment. Hazard analyses and risks assessments are a crucial part of any scientific protocol. Therefore, students need to be instructed to consider the hazardous implications with any scientific investigation.

- Developing and Using Models: The NGSS states that models are used in science to represent ideas and explanations. Throughout the learning progressions, students are expected to cite the limitations of various models (NGSS, Appendix F, 2013). On one hand, models can be used to represent phenomena that are too dangerous to explore directly (for example, ionizing radiation). On the other hand, students should be sure that any model they create must include its own hazards analysis and risks assessment.

- Planning and Carrying out Investigations: As students are required to design their own solutions to make sense of scientific phenomena, schools must ensure that students receive continuing safety instruction prior to investigation design as well as throughout. Furthermore, students must be shown that hazards analysis and risks assessment is a crucial part of planning and carrying out investigations. Safety precautions must be a deliberate and conspicuous component of any investigation.

- Constructing Explanations and Designing Solutions: This practice includes having students analyze solutions for feasibility, safety, and compliance with legal requirements (NGSS Appendix F, 2013). As students identify various tools, materials, and procedures for designing their solutions, safety training followed by a hazards analysis and risks assessment must precede any work. Safety protocols, including engineering controls and PPE used, should be documented by students.

- Engaging in Argument from Evidence/Obtaining, Evaluating, and Communicating Information: Scientists and engineers engage in argumentation when testing a design solution, resolving questions about measurements, and using evidence to evaluate claims (NGSS Appendix F, 2013). Students should be shown that their hazards analysis and risks assessment, and resulting safety considerations are important evidence in supporting their claims of a feasible design solution. In some cases, safety concerns may place cost or time constraints on a proposed solution. Regardless, students must be directed to incorporate these safety concerns as evidence to be used in scientific or engineering arguments.

1. **Curriculum and lesson development:** As SEAs and LEAs implement the NGSS, curricular units that are developed must include a thorough hazards analysis and risks assessment. Specific details about these risks assessments may vary according to state and local occupational safety requirements (https://www.osha.gov/SLTC/laboratories/safetyculture.html). However, because curriculum development decisions will reach a wide variety of teachers, students, and families, any curriculum materials or lessons developed using the NGSS should include the following components:

- General statement of safety precautions relevant to the age and learning readiness of the students. The state or local educational agencies need to determine the standards of safety to be observed based on 1) developmental age and readiness of students, 2) educational facilities (laboratories, classrooms, and field environments) and 3) local/national laws, regulations, and guidelines.

- A hazards analysis and risks assessment of the student activities and of the teacher support materials that is a step in the vetting process for adoption of curricular materials. This hazards analysis and risks assessment will evaluate the curriculum or lesson for guidance regarding the following hazards:

  - chemical hazards (chemical management guidelines regarding safer storage, use, personal protective equipment, and disposal of any chemicals used).

  - physical hazards (guidelines regarding safer management and use of electricity, sources of heat, open flame, or refrigeration, and sound). Physical hazards also include mechanical hazards (guidelines regarding safer management and use of sharp edges, moving parts/projectiles, and moving heavy objects). Trip/fall hazards are also included under physical hazards.

  - biological hazards (guidelines regarding safer management and use of live micro-organisms, plants, and animals, as well as safer management and use of preserved animals and plants).

  - radiation hazards. These may include ionizing radiation hazards (sources of short wave ultraviolet waves, radioactive isotopes) or non-ionizing radiation (lasers, bright visible light).

- A list of specific

  - engineering controls (e.g., ventilation requirements, eyewash, fire safety equipment)

  - administrative controls (e.g. laboratory safety protocols, hazard information of materials, storage and disposal protocols for chemicals, plant/animal care schedules for biology investigations) and

  - personal protective equipment (PPE: e.g. ANSI Z87.1 chemical splash goggles, chemically impervious/fire resistant lab coats, gloves appropriate to the investigation)

  are needed for all student and teacher activities. Safety equipment must comply with all federal, state, and local requirements. The SEA or LEA will provide training of teachers responsible for delivering instruction or assessment of NGSS based curriculum. This teacher training is a necessary part of teachers' professional development of science pedagogical content knowledge (Duschl, et al., 2007).

2. **Science Safety for All Students:** The NGSS presents three dimensional science and engineering standards for all students at all grade levels. Students with a variety of learning differences and educational settings are expected to meet the new standards (NGSS, Appendix D, 2013). Each student group presents a unique set of challenges and opportunities to science educators. For this reason, safety instruction and hazards analysis/risks assessment should be incorporated to any instruction and assessment of the NGSS delivered to each group. Appendix D (All Standards All Students) of the NGSS (2013) expresses the role of informal educators, of community resources, and of parents in the delivery of science education. Each of these groups require professional development in science safety protocols as well as hazards analysis and risks assessment.

In addition, Appendix D recommends use of Universal Design for Learning (http://www.udlcenter.org/) as a starting point for providing accommodations or modifications to students with various learning differences. Universal Design for Learning may also be a starting point for assessing and providing for safer procedures and provisions for these students. An important part of the hazards analysis and risks assessment of curricula and lessons will include meeting the needs of students with disabilities or students with limited language proficiency. Any instruction related to safer practice or safety equipment must be accessible by all students and teachers with physical or learning differences.

3. **Engineering and Tools:** The NGSS raises engineering design to the same level as scientific inquiry at all levels of preK-12 science education (NGSS Appendix I, 2013). The core idea of engineering design incorporates three components: Defining and delimiting engineering problems, Designing solutions to engineering problems, and Optimizing the design solution. In many cases constructing models and engaging in engineering design will involve the use of hand and power tools more common to the technology education lab rather than the science laboratory. Teachers have a responsibility to conduct all activities in the safest possible manner.

Many of the engineering and STEM (science, technology, engineering and mathematics) or STEAM (A=Art) activities that students and teachers will engage in will involve the use of hand and power tools. Before using these tools with students, teachers should ensure that they are familiar with the safer use of each tool. OSHA has created a booklet on Hand and Power Tools which should be consulted before any tool is used in the laboratory.

Before allowing students to use hand and power tools, teachers should demonstrate the safer use of each tool and the personal protective equipment that must be used when working with that tool. In order to provide this information, teachers who have not learned to use hand and power tools as part of their professional preparation may need training. Employers are required to provide this training according to OSHA (Hand and Power Tools, OSHA, 2002), when they are assigning teachers to teach in areas outside their professional expertise. Providing this training will help teachers to reduce and avoid liability and accidents in the laboratory. Collaboration with the technology education teachers may help science teachers explore better professional practices with regard to tool use.

Districts should have standard operating procedures for the use of hand and power tools. These procedures should be developed with the technology education teachers and should include engineering controls, personal protective equipment, safety protocols and procedures for using hazardous equipment (Roy, 2015). To further enhance safety, districts can use posters and other classroom resources to highlight the safe use of tools.

There are five basic rules that should be followed to prevent the hazards associated with hand and power tools (OSHA, 2002):

- Keep all tools in good condition with regular maintenance.
- Use the right tool for the job.
- Examine each tool for damage before use and do not use damaged tools.
- Operate tools according to the manufacturer’s instructions.
- Provide and use properly the right personal protective equipment.

Before having students use hand and power tools, safety rules should be reviewed and documented in the lesson plan. Teachers should also have students and parents sign a safety agreement that deals specifically with hand and power tools. An example of such an agreement is below.

Safety Acknowledgement Agreement for the Use of Hand and Power Tools

Before working in any laboratory where hand and power tools are being used, students must review the rules below and agree to abide by these rules. Parents are asked to review these rules and emphasize to their child the importance of behaving in an appropriate manner in any laboratory where hand and power tools are in use. Students and parents are asked to sign this document and return it to their classroom teacher.

1. Always understand and follow directions when using any power tool. Pay attention to the name plate on the tool and any warnings that may be listed on the tool itself.
2. Always wear the appropriate protective equipment, including safety goggles or safety glasses with side shields. Dust masks should be worn with tools that will produce dust, and hearing protection should be worn if a tool is to be used for a prolonged period of time.
3. No loose fitting clothing, neckties, jewelry or dangling objects of any kind should be worn.
4. Tie long hair back and out of the way.
5. Closed toed shoes, preferably with non-slip soles should be worn. Sandals and flip flops are not to worn when hand and power tools are in use.
6. Hand and power tools should not be used if you are tired, distracted, ill or under the influence of drugs or alcohol. Even over the counter drugs, such as cold medicine can negatively affect your ability to concentrate when you are using hand and power tools.
7. Work areas should be clean before and after you work with tools to prevent debris being ignited by hot tools or sparks.
8. Work areas should have plenty of light. Students should not crowd around any tool when it is in operation.
9. Switches should be OFF before any power tool is plugged in.
10. All guards should be in place and working before a tool is used.
11. Tools should be turned off and unplugged before adjustments are made.
12. Only accessories designed for a particular tool should be used.
13. Power tools should not be used in wet or damp conditions.
14. If a tool is damaged or not functioning properly it should not be used.
15. Any tool that is broken or damaged should be reported to your teacher so that it can be taken out of service.
16. Only heavy duty extension cords should be used.
17. Only cutters and blades that are clean, sharp and securely in place should be used.
18. Students must behave appropriately in the laboratory. Any student failing to behave in an appropriate manner will be removed from the laboratory setting and disciplinary consequences will occur.
19. Take your time when you work, and pay close attention to what you are doing.
20. Always use the right tool for the job.
21. Unplug, clean and store any tool that you have used in its proper place at the end of the period.

I ______________________________________ have read the rules of Safe Hand and Power Tool use and agree to abide by each and every rule.

____ _______________________

Student's Signature Date

I have reviewed the above set of rules with my child and will encourage him/her to abide by each rule so that they can operate safely in the laboratory.

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Parent's Name

____ ______________________

Parent's Signature Date

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