



## Position Statement

### The Integral Role of Laboratory Investigations in Science Instruction

#### Introduction

A hallmark of science is that it generates theories and laws that must be consistent with observations. Much of the evidence from these observations is collected during laboratory investigations. A school laboratory investigation (also referred to as a lab) is defined as an experience in the laboratory, classroom, or the field that provides students with opportunities to interact directly with natural phenomena or with data collected by others using tools, materials, data collection techniques, and models (NRC 2006, p. 3). Throughout the process, students should have opportunities to design investigations, engage in scientific reasoning, manipulate equipment, record data, analyze results, and discuss their findings. These skills and knowledge, fostered by laboratory investigations, are an important part of inquiry—the process of asking questions and conducting experiments as a way to understand the natural world (NSTA 2004). While reading about science, using computer simulations, and observing teacher demonstrations may be valuable, they are not a substitute for laboratory investigations by students (NRC 2006, pg. 3).

For science to be taught properly and effectively, labs must be an integral part of the science curriculum. The National Science Teachers Association (NSTA) recommends that all preK–16 teachers of science provide instruction with a priority on making observations and gathering evidence, much of which students experience in the lab or the field, to help students develop a deep understanding of the science content, as well as an understanding of the nature of science, the attitudes of science, and the skills of scientific reasoning (NRC 2006, p. 127). Furthermore, NSTA is committed to ensuring that all students—including students with academic, remedial, or physical needs; gifted and talented students; and English language learners—have the opportunity to participate in laboratory investigations in a safe environment.

#### Declarations

NSTA strongly believes that developmentally appropriate laboratory investigations are essential for students of all ages and ability levels. They should not be a rote exercise in which students are merely following directions, as though they were reading a cookbook, nor should they be a superfluous afterthought that is only tangentially related to the instructional sequence of content. Properly designed laboratory investigations should:

- have a definite purpose that is communicated clearly to students;
- focus on the processes of science as a way to convey content;
- incorporate ongoing student reflection and discussion; and

- enable students to develop safe and conscientious lab habits and procedures (NRC 2006, p. 101-102).

### **Integration of Labs into the Science Program**

Inquiry-based laboratory investigations at every level should be at the core of the science program and should be woven into every lesson and concept strand. As students move through the grades, the level of complexity of laboratory investigations should increase. In addition, NSTA recommends that teachers and administrators follow these guidelines for each grade level:

#### ***Preschool and Elementary Level***

- With the expectation of science instruction every day, all students at the preschool and elementary level should receive multiple opportunities every week to explore science labs that fit the definition described in the Introduction.
- Laboratory investigations should provide all students with continuous opportunities to explore familiar phenomena and materials. At developmentally appropriate levels, they should investigate appropriate questions, analyze the results of laboratory investigations, debate what the evidence means, construct an understanding of science concepts, and apply these concepts to the world around them.

#### ***Middle and High School Levels***

- With the expectation of science instruction every day, all middle level students should have multiple opportunities every week to explore science labs as defined in the Introduction. At the high school level, all students should be in the science lab or field, collecting data every week while exploring science labs.
- Laboratory investigations in the middle and high school classroom should help all students develop a growing understanding of the complexity and ambiguity of empirical work, as well as the skills to calibrate and troubleshoot equipment used to make observations. Learners should understand measurement error; and have the skills to aggregate, interpret, and present the resulting data (NRC 2006, p. 77).
- As students progress through middle and high school, they should improve their ability to collaborate effectively with others in carrying out complex tasks, share the work of the task, assume different roles at different times, and contribute and respond to ideas.

#### ***College Level***

At the college level, all students should have opportunities to experience inquiry-based science laboratory investigations as defined in the Introduction. All introductory courses should include labs as an integral part of the science curriculum. Laboratory experiences should help students learn to work independently and collaboratively, incorporate and critique the published work of others in their communications, use scientific reasoning and appropriate laboratory techniques to

define and solve problems, and draw and evaluate conclusions based on quantitative evidence. Labs should correlate closely with lectures and not be separate activities. Exposure to rigorous, inquiry-based labs at the college level also is important because most teachers develop their laboratory teaching techniques based on their own college coursework laboratory experiences.

### **Support for Teachers of Science**

To give teachers at all levels the support they need to guide laboratory investigations as an integral part of the total curriculum, NSTA recommends:

- Ongoing professional development opportunities to ensure that teachers of science have practical experiences that familiarize them with the pedagogical techniques needed to facilitate inquiry-based labs matched to appropriate science content (NSTA 2006, NRC 2006, p. 150-151).
- Yearly evaluation of the laboratory investigations to determine if they continue to be an integral and effective part of the whole program and the delivery of all content.
- Periodic training in lab logistics, including setup, safety, management of materials and equipment, and assessment of student practices. Safety equipment and annual safety training should be provided so that science educators are well informed about yearly changes in safety procedures to ensure that students and educators are protected (NSTA 2000).
- Training to work with students with academic or remedial needs, physical needs, and gifted and talented students so that teachers can differentiate instruction appropriately. Assistive equipment, additional personnel, and facilities, modified as needed, also should be provided to ensure appropriate instruction of all students.
- Effective preservice programs that prepare teachers to carry out science labs as a central part of every science curriculum.

### **Support for Science Labs**

To ensure that laboratory investigations are implemented in schools, administrative support is crucial. NSTA recommends that the school administration recognize the instructional importance, overarching goals, and essential activities of laboratory investigations and provide the following:

- An adequate facility where labs can be conducted. At the preschool and elementary levels, this means a classroom with sufficient work space, including flat moveable desks or tables and chairs, equipment, and access to water and electricity. At the middle and high school levels, a safe, well-equipped lab space should be available, with necessary equipment and access to water and electricity. In addition, appropriate facilities to work with students with special needs should be provided. (Beihle 1999)

- Adequate storage space for all materials, including devices and materials in common use that are considered hazardous. (Beihle 1999)
- Funding for yearly educator training on how to manage materials and guide inquiry-based learning during labs.
- A budget for regular maintenance of facilities and equipment, as well as annual costs for new or replacement equipment, supplies, and proper waste management.
- A budget that recognizes additional costs required for field experiences.
- Laboratory occupancy load limits (number of occupants allowed in the laboratory) set at a safe level based on building and fire safety codes, size and design of the laboratory teaching facility, chemical/physical/biological hazards, and the needs of the students (Roy 2006; NSTA 2000). Science classes should have no more than 24 students even if the occupancy load limit might accommodate more. (NSTA 2004) Research data shows that accidents rise dramatically as class enrollments exceed this level. (West 2001) Teachers should not be faced with a Hobson's choice—teach in an unsafe environment or sacrifice the quality of teaching by not doing labs.

### **Assessment**

Assessment, a powerful tool in science education, serves both formative and summative purposes. Not only does it help show what students have learned and the nature of their reasoning, it also indicates what gaps remain in learning and what concepts must be reviewed (NSTA 2001). NSTA recommends the following steps to ensure that laboratory investigations are part of the assessment process:

- Teachers of science, supported by the administration, be given the time and training to develop assessments that reveal and measure inquiry skills—the ability to design, conduct, analyze, and complete an investigation, reason scientifically, and communicate through science notebooks and lab reports.
- Instruction and assessment be aligned so that formative and summative assessments are meaningful and can be used to improve the science curriculum as well as determine what students have learned.

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### **References**

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### **Additional Resources**

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