Virginia Association of Science Teachers Position Statement

The Role of the Laboratory in K-12 Science

> Science is not just a body of knowledge that reflects current understanding of the world; it is also a set of practices used to establish, extend, and refine that knowledge.
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> —*A Framework for K-12 Science Education*, National Research Council, 2012

Background and Introduction:

The laboratory provides the environment in which all science is studied. Science in this setting is not a check list of items to be covered or content to be mastered. We want students to learn science by doing it rather than by simply reading about it. The usefulness to learning through experiences lies at the heart of what it means to be human; we are wired to learn through the manipulation of objects. The laboratory is the means for the process of inquiry and provides an essential way to show comprehension, understanding, and application of knowledge. In the sense that sound science requires the active participation of the practitioner in discovering and verifying the principles upon which it depends, it could be said that science begins and ends in the laboratory. It involves multiple senses and approaches.

As an organization of, by, and for science teachers, the Virginia Association of Science Teachers (VAST) maintains that the role of developmentally appropriate laboratory explorations is crucial for students to clarify the experiential nature of science. Much of current work in revising science standards and approaches [NRC, 2006; NGSS, 2013; AP Science Revisions, 2012] stresses the importance of engaging students in the process of inquiry including experimental design, data collection strategies, analysis and evaluation of data, and interpretation of scientific explanations and theories. For example, four of the seven overarching practices in Advanced Placement (AP) science revisions involve inquiry-based laboratory (lab) experiences.

VAST also maintains that rigorous inquiry-based experiences provide students the means to develop the essential hands-on practices of science during their K-12 development of critical thinking and problem-solving skills, habits much in demand in today’s and tomorrow’s world. Moreover, students show improved ability to cooperate and communicate with others, share responsibilities, assume different roles, and contribute and respond to ideas. [NSTA, 2007] Some lab experiences are exploratory in nature while some are confirmatory; however, lab experiences should be neither rote nor tangential to students’ understanding of science. Well-designed rigorous laboratory experiences will give students actual exposure to both the empirical and the theoretical facets of science. In addition, students are exposed to the complexity and ambiguity of scientific research as they gain experience in manipulation, appropriate arrangement, and troubleshooting of apparatus. Research has shown that students at all levels learn science best by doing it rather than by being told about it [Donovan, 2005], an appropriate extension of David Kolb’s well-known work on learning styles and the learning cycle.

Although demonstrations, computer simulations or analyses of data provided by others have their value, they must not replace the actual process of manipulating appropriate equipment and apparatus, collecting valid data, analyzing results, and communicating findings to others either verbally or in writing. [NRC, 2006] VAST is committed to the importance of making such lab experiences available to **all** K–12 students regardless of background, ability, or physical or academic need.

Declarations:

Integration of laboratory experiences into the science program:

Students need to understand science is a discipline whose theories and laws are subject to continual experiential examination and verification. Therefore, lab experiences should take a prominent position in any curriculum, serving as the core of every major topic or strand. Consistent with the increased emphasis on laboratory time in the revisions in AP science [College Board, 2012], multiple opportunities must exist for all K-12 students to collect and analyze data in the lab or field on a weekly basis. This is especially true of students enrolled in distance-learning science courses where local school- or laboratory-based opportunities need to be available for frequent hands-on lab experiences. Emphasis should be upon student-structured explorations over teacher-led activities.

Data Interpretation and Analysis [NRC 2012]:

Meaningful organization and interpretation of data are crucial to the expansion of laboratory experiences into everyday life. This includes:

- Asking questions and defining problems
- Developing mental and conceptual models
- Presenting data to show patterns and relationships
- Communicating these relationships with clarity
- Using mathematical and computational reasoning
- Constructing explanations and designing solutions
- Engaging in arguments from evidence
- Reflecting on significance of data and error analysis.

Structure:

Not only does there need to be sufficient time in the weekly schedule to permit genuine laboratory experience, but class size must be appropriate for the physical arrangement and safety in a class or laboratory. The Virginia Department of Education guidelines as published in *Safety in Science Teaching* recommend a minimum of 4.2 square meters (45 square feet) per student in a laboratory setting. Furthermore, studies have shown a dramatic rise in accident rates where student-teacher ratios exceed 24:1 regardless of physical space [NSELA 2013]. Higher ratios also have a detrimental effect on student-teacher and student-student interactions, both vital components of successful laboratory experiences.

Administrative support:

Administrative support is vital to the effectiveness of K-12 laboratory experience. Supportive measures must take a variety of forms:

- Scheduling (class size and location) must permit adequate time and space for safe and supportive laboratory work. Load limits need to adhere to all fire and occupancy codes.
- Budgetary allowances must exist for provision of sufficient equipment (apparatus, computer hardware, software, and probe-ware) for each student to have a reasonable chance for personal data-gathering.
- Adequate storage space and location of equipment should provide convenient access to all teachers in a team.
- Strong professional development programs should be provided for both pre-service and in-service training. Teachers need both the time and financial support to attend and conduct hands-on experiences either during or after school hours, including the availability of summer workshops.
- Safety training must be provided for teachers and students, including chemical storage and handling, equipment maintenance, and periodic safety checks.
- Liability protection is needed for the teacher as well as the school. [NSTA 2000]

Assessment:

Teachers need the time and training to construct appropriate and challenging authentic assessment vehicles to measure student understanding and interpretation of laboratory experiences. They should emphasize students' ability to communicate results and analyze data and conclusions for peer review in a classroom setting. Students' ability to demonstrate creative solutions and critical thinking is particularly important, the depth depending on their level of proficiency and advancement through the K-12 spectrum. In addition, teachers should review annually the set of laboratory investigations which they have used in order to strengthen, add, or discard exercises based on student success rates in understanding and analyzing data. Success should be measured not only by formative and summative assessment, but also in the setting of lab practica; in all cases both assessment of learning and assessment for learning should occur.

Further Reading:

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