Laboratory Science
Frequently Asked Questions

Q #1: Should laboratory investigations be part of the science curriculum at all grade levels, from preschool to 12th grade?

A: Hands-on investigations in science, whether they are called laboratories or not are a vital part of the learning experience for students. However, to be most effective, laboratory work needs to be integrated into the science instruction that is taking place in the curriculum. It should not consist of isolated activities that are conducted merely because they are interesting or dramatic. Carefully crafted, hands-on lab experiences with clear goals allow students to see cause and effect, the role of variables in experimental design, the importance of observations, use of data and the significance of evidence in coming to conclusions.

Additionally, laboratory investigations meet the needs of students with different learning styles or those students who have difficulty with reading. For example, a second grade student who has not yet learned to decode text can still be successful in conducting an experiment and explaining the results either verbally or pictorially.

Q #2: What kinds of equipment and facility should be available in a traditional school laboratory?

A: A generic laboratory that is used for Biology, Chemistry, Earth Systems Science and Physics should include sinks, tables or waist-high counters, gas, acid trap for wastewater, and a secure chemical storage facility. An alternative to gas as a source of heat is the use of hot plates that can boil water. Equipment includes safety goggles and sanitizing cabinet, safety shower and eyewash, fume hood, fire blanket, aprons, microscopes, glassware (beakers, graduated cylinders, test tubes, etc.), balances, thermometers (alcohol), computers, sufficient electrical outlets and more specialized equipment for specific laboratory exercises.

A combined laboratory-classroom is often an effective solution to laboratory space. These rooms are particularly helpful in limiting the movement of teachers and students and they also can minimize scheduling difficulties. For example, if there is one “laboratory room” shared by three or four teachers, labs can only be done when the teacher is scheduled into that room. In a combined room, laboratory exercises can be done at any time. This is particularly important for long-term projects which require students to make daily observations or measurements.

Regardless of the specific facility utilized, the room should be free of clutter so that students and staff can move freely about the room and general safety rules should be clearly posted in the room.

Q #3: Must all schools have traditional laboratories available for their programs? High Schools? Middle Schools? Elementary Schools?

A: The need for a "laboratory" varies with the subject, the level of complexity of the experiment, the safety issues involved, and the sophistication and ability of the students. Certainly high school Chemistry requires a higher level of laboratory support than a third grade science program.

It is probably best to look at this issue on a continuum from little in the way of traditional laboratory needs at the elementary level to a more robust set of equipment at the high school level. In most elementary schools, classroom teachers are responsible for instruction in all academic subject areas (Language Arts, Mathematics, Science and Social Studies). At the very least, every elementary classroom should have a sink with running water. Middle school students should certainly be involved in experiential activities in science that involve data collection and analysis. However, they may not need complex equipment or chemicals to accomplish this. Sinks and running water would be important for a quality science program at the middle level. Portable laboratory stations complete with running water and gas are a viable option when introducing laboratory investigations into aging facilities for which the addition of new plumbing is cost prohibitive.

Q #4: Must all high school science courses be taught in a traditional laboratory?

A: The courses do not have to be taught in a laboratory, but labs should be accessible when needed to conduct experiments related to the subject content. Many schools have laboratories that are shared by multiple classes and teachers on a "lab day" that is part of the course schedule. A combined laboratory-classroom might be a better solution (see Question # 2 above).

Q #5: What if my school does not have traditional laboratories? Can my school be required to construct such laboratories?

A: Construction of any school facility is a local decision made by individual boards of education and the voters of a district. A school should make every effort to provide students with the tools they need to be successful in science. It should also be noted that it is often difficult for schools without laboratory facilities to attract science teachers. The combined lack of laboratories and experienced teachers can result in less than ideal science instruction for students.

As with many other issues related to educational quality, the availability of adequate laboratory facilities often becomes an issue of equity. In a survey of school principals in New Jersey that was conducted by Mark Schneider of the Education Law Center in 2003, it was found that students who attended schools in poor districts were three times as likely to have inadequate laboratory facilities when compared to schools that were in districts with average to above-average family incomes. State funding for school construction with an emphasis on the "Abbott Districts" is an attempt to remedy this situation.

Q #6: Can schools use university or private laboratories to satisfy the State requirements regarding laboratory science courses?

A: This certainly is possible but the logistics might prove daunting. It would require transporting students, which involves both time and money. The use would probably be, at best, episodic and the liability issues would preclude most facilities from allowing high school students in their laboratories.

Q #7: May some laboratory courses be taught without access to a traditional laboratory?

A: This would be difficult unless the equipment and supplies could be provided in a regular classroom. If the classroom were outfitted with desks, conducting laboratory exercises would be problematic and unsafe. If the classroom had tables, there would be a better chance of success.

Q #8: Beyond traditional laboratories, what are some other settings where laboratory investigations may occur? How can schools get access to these settings?

A: The number one issue in conducting laboratory exercises is safety. Any rooms in a school that have large tables could be used for lab work. This includes home economics or shop classrooms. These alternatives are certainly not optimum and would require transporting science and safety equipment through hallways, which imposes added burdens to teachers. Science investigations can also be done outdoors in a schoolyard or park for such topics as ecology, daytime astronomy, and physical science.

Q #9: What are virtual laboratory experiences? What are some examples? How can they be included in laboratory science courses? Where can schools get access to these virtual experiences?

A: Virtual laboratories are usually computer-based simulations that allow students to manipulate variables in an experiment, which then generates a set of data to analyze. They can be found on the Web. Some virtual labs include:

- **www.explorelearning.com**
- **www.virtuallaboratory.net**
- **www.ciese.org**

Some of these involve subscribing to a service which may become a funding issue; others are free. They do have a role in science instruction, particularly in dealing with topics that are not easy to replicate or investigate in a laboratory (e.g., earthquakes, astronomy, atomic particle interactions). They should not be a total substitution for real laboratory experiences.

Q #10: What resources (e.g., lesson plans, content, etc.) are available to teachers who want to increase and enrich the laboratory investigations in their instruction?

A: The Teacher's Guides of most good science textbooks have suggestions for laboratory investigations. Many of these are embedded in the student text. Other resources include online sites such as Access Excellence, and the National Science Teachers Association's list serv in specific subject areas.

Q #11: Where can a teacher access professional development opportunities regarding laboratory investigations?

A: Professional associations in New Jersey offer training to teachers through their meetings and conferences. These include the New Jersey Science Convention (sponsored by the NJ Science Teachers Association and the NJ Science Education Leadership Association), the NJ Earth Science Teachers Association, Chem TAG, NJ Chapter of the American Association of Physics Teachers, and the Biology Teachers Association of NJ. As and example, Liberty Science Center offers a full array of professional development programs which show teachers how to conduct safe inexpensive laboratory investigations,

Q #12: How do laboratory investigations relate to the State's assessments in science, especially the new performance assessments in high school Biology?

A: Quality assessment in science tries to balance content and process knowledge. Students can certainly gain a great deal of content knowledge by reading books and watching videos. To really understand the process of science, students need to be engaged in collecting data from experiments and then analyzing these data in a thoughtful way. This includes the recognition that there is error involved in measurement, the data are rarely perfect and that science is more about questions than answers. This is the "messiness" of real science that does not come through to a student from reading a textbook.

The New Jersey Performance Assessment in Biology, field-tested in the spring of 2008, assumes that students have the necessary tools to interpret the results of an experiment using mathematics, graphing skills and verbal explanations. Carefully chosen laboratory investigations prepare students with these skills.

Q #13: Are "inquiry-based science education" and laboratory investigations the same thing? If no, how are they related?

A: Inquiry-based science tends to be more open-ended than traditional laboratory investigations. In the former, students pose their own problems, develop a strategy for investigating the problems, and then analyze the results, which may or may not be predictable. In traditional laboratories, teachers present the problems, give students the directions for investigating the problems and the outcome is usually predictable, at least from the teacher's perspective.

Inquiry-based science mirrors what actual scientists do in the real world of research, but it is time consuming and may require equipment that is not available. In addition, every student could conceivably be doing something different. Traditional laboratory investigations tend to repeat and confirm what scientists have already done. They make efficient use of time and equipment, but do not give students a sense of ownership of results. A balance of inquiry and traditional investigations would probably be the best that teachers could hope for given the constraints of time and money. This approach requires that teachers know their content and curriculum in depth so that they can determine in advance which key concepts are best developed through an inquiry approach; appropriate activities can then be designed for completion with a realistic time frame which allows for coverage of other concepts by traditional approaches. The key component in both of these approaches is giving students adequate time to reflect on what they have done and to discuss their work with their peers.

Q #14: How do the State's regulations regarding laboratory safety relate to laboratory investigations, at all grade levels?

A: The safety of students is a teacher's most important responsibility, regardless of the subject or the setting. Laboratory investigations must be closely supervised and teachers need to stress the safety precautions to the students prior to beginning any exercise. These precautions should be in writing as part of the laboratory directions and explained verbally to the students. Safety goggles need to be used when necessary and teachers should know the difference between goggles that protect eyes from impacts and goggles that protect eyes from chemical splashes.

New teachers need to be trained in P-OSHA regulations and veteran teachers need to have updated training periodically. All teachers need to recognize the importance of active supervision of laboratory activities, especially those involving potentially hazardous materials. Chemicals need to be stored properly and all doors need to be locked when teachers are not present.

Q #15: How can high schools schedule laboratory time into the instructional day?

A: There are several issues involved in this question. If a school is on a block schedule, there is usually sufficient time in the block to conduct a laboratory investigation. If the school is on a regular schedule of 40 – 45 minute classes, it is often difficult to conduct a laboratory in a single period, particularly a chemistry lab in which the students need to boil water or in a biology lab where a major dissection is involved. In this case, many schools have one double laboratory period during the week. This period often dovetails with either a study hall or physical education class. The state of New Jersey requires 150 minutes of Health and Physical Education per week. There is no requirement that it be offered every day and schedules can be built taking this into consideration.

Revised 5/7/09