Appendix VII
Science and Technology/Engineering Laboratories

The integration of science and engineering practices with disciplinary core ideas has direct implications for the design of active learning experiences for students. This means students in STE learning environments at all grade levels should regularly be mentally and physically engaged (Clough, 2002). Current Massachusetts policy provides for districts to make local determinations of what constitutes an inquiry- or design-based STE curriculum, and what constitutes the definition of a "laboratory science" course (in high school). What should matter in defining quality STE learning experiences is what students are doing, not where they are doing it.

STE experiences, at every level, need to account for appropriate physical space (e.g., MSBA, 2010), reasonable equipment and materials, and safety (see Appendix XI).

Elementary Labs

There are many possibilities for pre-K–5 STE learning experiences, in the classroom or in and around the school. Elementary grades should introduce students to practices and procedures that generally start with teachers facilitating and leading students to observe and investigate natural phenomena, interact with real objects and/or models, and collect and manipulate different types of data. As students gain new knowledge, ask questions, and analyze and discuss evidence related to their work, they can design and develop their own STE experiences. They learn to work together or individually to carry out their own investigations, generate and design solutions, and use evidence to communicate and demonstrate understanding.

The physical space allocated for pre-K–5 STE experiences can vary widely. Spaces that are more open and have mobile tables can be configured to accommodate a variety of materials, equipment, and experiences. However, STE experiences take place in a wide variety of settings, including dedicated science classrooms, regular classrooms, athletic fields, school or community gardens, or nearby parks.

STE equipment can include hand lenses, a variety of measuring tools, microscopes, hand tools, interactive equipment, or computers that provide access to scientific databases, models, simulations, and visualizations that are age appropriate for pre-K–5 students. (See Appendix XI for information on safety in STE classrooms.)

Middle and High School Labs

Middle and high school lab experiences should offer a wide range of learning opportunities for STE concepts and practices. Striking a balance between teacher-led lab experiences and student-driven investigations is optimal for middle and high school students. Opportunities for students to interact directly with natural phenomena, design problems to understand empirical data that they or others may have collected, and grapple with scientific error, as they analyze, interpret, and debate their lab findings, are essential for understanding science content and practices. Middle and high school students can design and develop authentic lab experiences based on questions that emerge from instruction and increase their ability to collaborate effectively.

The physical space allocated for STE labs varies depending on the types of experiences planned, equipment needed, and the availability of resources. Generally, middle and high school lab spaces are larger than a typical classroom to account for safety and equipment and have the flexibility to be rearranged for difference types of experiences.

Lab equipment may include access to a water source and sinks, visible and accessible equipment, measuring devices, safety equipment, refrigerators, dishwashers, heating equipment, and standing-height and/or moveable tables. Other equipment found in labs can include hand tools, interactive models and devices, and computers. (See Appendix XI for information on safety in STE classrooms.)

Defining "Laboratory Science" Courses in High School

The inclusion of science and engineering practices in the standards suggests that the key factor in defining a "laboratory science" course is the nature and prevalence of the active learning experience. A definition of such courses should include two critical elements:

1. A balance between open and procedural investigations in which students learn and apply science and engineering practices.
2. The percent of course time engaged in inquiry- or design-based experiences.

Any course aligned to the STE standards, including technology/engineering courses, can be designated as a laboratory course. STE curricula should give students regular opportunities to develop distinct science and engineering practices and occasional opportunities to apply those together as a collective set of practices. A defined number of minutes, or an extra course period, can be used for—but is not the critical feature of—a lab definition. "Laboratory science" does not have to be in a laboratory; effective STE learning also occurs through field work, in a sufficiently supplied traditional classroom, through project-based experiences, in well-designed virtual courses, and in other learning environments (e.g., out of school time, see Appendix X). *America's Lab Report* (NRC, 2006), which reviewed research and best practices across the country, supports these perspectives.

References

Massachusetts School Building Authority (MSBA). (2010). *Science lab guidelines*. Retrieved from www.massschoolbuildings.org/programs/science_lab/guidelines

National Research Council (NRC). (2006). *America's lab report: Investigations in high school science*. Washington, DC: The National Academies Press.

Clough, M.P. (2002). Using the laboratory to enhance student learning. In R.W. Bybee (Ed.), *Learning science and the science of learning* (85-96). Arlington, VA: NSTA Press.