Laboratory Science in the 21st Century

Recent proposed changes to Administrative Code and the proposed revised NJ Core Curriculum Content Standards emphasize the importance of laboratory-based sciences in New Jersey public schools. There is a great deal of misunderstanding and concern about the new requirements. Let me begin this primer by saying up front that Lab Science is a practice not a place.

One of the arguments that I have commonly heard in opposition to the updated expectations is that “I have taught my way for 20 years and it works just fine for my kids.” Really? Did you know that only about 6% of our graduating seniors enroll in a STEM major when they enter post secondary education? Setting aside that your kids may have had good results on HSPA tests or End of Course Competency Exams, is this acceptable data? Most of us entered science education because we love the content. We need to bring the passion and sense of wonder back into our secondary classrooms. Sitting and taking notes, reading textbooks, and doing a cookbook lab once a week is a not likely to inspire many students to want to learn more. Let me put forward a less idealistic concept. NJ’s economy is largely based on innovations in STEM disciplines, in order to revitalize our economy we need to provide innovative intelligent graduates. A little closer to your classroom, I need to remind you that future chemistry and physics teachers largely come from our own classrooms. That being said let me move on to the nuts and bolts of the expectations.

The updated expectations are grounded in a better understanding of how students learn science. A National Research Council report titled America’s Lab Report (2007) is a consensus document that describes in detail much of what has been translated into code and into standards. In short, the research is compelling in its arguments that curriculum should be developed and delivered so that students independently create scientific arguments and explanations for observations made during investigations.

Science education thereby becomes a sense-making enterprise for students in which they are systematically provided with ongoing opportunities to:

- Interact directly with the natural and designed world using tools, data collection techniques, models and theories of science;
- Actively participate in scientific investigations and use cognitive and manipulative skills associated with the formulation of scientific explanations;
- Use evidence, apply logic, and construct arguments for their proposed explanations.

The Science Standards (2009) implicitly and explicitly point to a more student-centered approach in instructional design that engages learners in inquiry a term that is regularly used in science education, but often interpreted differently. Inquiry as defined in the revised standards envisions learners who:

- Are engaged by scientifically oriented questions;
- Give priority to evidence, which allows them to develop and evaluate explanations that address scientifically oriented questions;
- Formulate explanations from evidence to address scientifically oriented questions;
- Evaluate their explanations in light of alternative explanations, particularly those reflecting scientific understanding; and
- Communicate and justify their proposed explanations.

Fundamental principles of instructional design assist students in achieving their intended learning goals through lab experiences that are:

- Designed with clear learning outcomes in mind;
- Sequenced thoughtfully into the flow of classroom science instruction;

- Integrate learning of science content with learning about the processes of science;
- Incorporate ongoing student reflection and discussion (NRC, 2007).

Lab Science includes the following student experiences:

Physical manipulation of authentic substances or systems under investigation

This may include such activities as chemistry experiments, plant and animal observations in biology, and investigation of rock outcrops for uncovering the geologic history of an area in earth science.

Interaction with simulations

In 21st century laboratory science courses, students can work with computerized models, or simulations, representing aspects of natural phenomena that cannot be observed directly, because they are very large, very small, very slow, very fast, or very complex. Students may also model the interaction of molecules in chemistry or manipulate models of cells, animal or plant systems, wave motion, weather patterns, or geological formations using simulations.

Interaction with authentic data

Students may interact with authentic data that are obtained and represented in a variety of forms. For example, they may study photographs to examine characteristics of the moon or other heavenly bodies or analyze emission and absorption spectra in the light from stars. Data may be incorporated in films, DVDs, computer programs, or other formats.

Access to large databases

In many fields of science, researchers have arranged for empirical data to be normalized and aggregated—for example, genome databases, astronomy image collections, databases of climatic events over long time periods, biological field observations. Some students may be able to access authentic and timely scientific data using the Internet and can also manipulate and analyze authentic data in new forms of laboratory experiences (Bell, 2005).

Remote access to scientific instruments and observations

When available, laboratory experiences enabled by Internet link students to remote instruments, such as environmental scanning electron microscope (Thakkar et al., 2000), or allow them to control automated telescopes (Gould, 2004).

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