Guest Editorial: Limiting Risk in the K-12 Science Lab Through Increased Supervision

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Abstract

The recent fire on January 2, 2014 in a chemistry lab at Beacon High School in New York City, although horrific, must motivate us to restore science instructional support and oversight; using it to justify further reductions in the frequency and quality of active science instruction will only serve to undermine science education at a time when fewer and fewer of our talented students are choosing to pursue careers in science and engineering.

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The administration and faculty of Beacon High School in New York City are dedicated to an active project-based science learning environment and Beacon HS has been lauded for its success in creating a supportive high performance environment. Active science laboratory instruction has always been an essential means of introducing students to important scientific concepts and the skills required to practice science and engineering. Project based inquiry learning, in which Beacon and many high school research programs specialize, has been associated with students selecting a college major in the sciences at an increased rate (Subotnik, R.F., Tai, R.H., and Almarode, J. 2011). The frequency of lab time and its benefits for content based instruction may depend on the age of the students and their relative proficiency in science and math. Middle school students benefit from more hands-on/lab instruction on content based exams as do honors students in high school (Nations Report Card, 2011; Tai and Sandler, 2009; America's Lab Report, 2005). However, for all students, an active learning environment is the only means to teach the process of inquiry and design; it is the only way to communicate the flavor of a scientific career. Such problem solving is thought to have relevance for all students regardless of their eventual college major or career. For this reason a wide variation in exposure to types of labs and lab skills should be advocated in the hope that cross-over is facilitated.

Accidents like the recent one at Beacon during a chemistry demonstration and the subsequent litigation over the last few decades has limited the variety of hands-on instruction in science and technology within the K-12 environment. Middle school chemistry programs in particular have been decimated; sometimes reduced to a barebones introduction to the periodic table. Similarly chemistry lab specialists in high schools, in the few places where they still are employed, are on high alert because of the liability posed by labs, demonstrations, and the storage of chemical supplies. The liability solution for many school districts has been unacceptable; minimizing authentic lab experiences. For instance, many urban schools have resorted to paper and pen labs or virtual labs – a trend we hope to reverse. While these activities can complement hands-on experiences, alone, they are not enough to teach concepts, let alone to motivate young scientists.

Limiting the use of large amounts of flammable substances particularly solvents has been a focus of lab safety experts for some time and in this respect seeing the rainbow experiment (http://www.youtube.com/watch?v=3LruNzqA8Xw); taking place in a classroom and appearing multiple times on YouTube was a little disappointing. However, the K-12 science lab has always been a place where teachers try to ignite student enthusiasm with drama. Many of us can remember the dramatic displays of heat generated by solid sodium placed in water, for example. Yet today it is not common to see this type of display in the open classroom because although we embrace the excitement of demonstrations - some drama is best kept for video. Teachers should be encouraged to place their carefully crafted demonstrations where all can use them to spark discussion because it is this provoked discussion which is really important for learning.

Video has safety advantages over in-class demonstrations. For example, the teacher can limit set-up time and class time used to provide a visual confirmation of a concept through a demonstration while still providing a exciting motivation for discussion or inquiry. There is no requirement for science learning that in teaching the process of inquiry a student needs to create the experience themselves; they can simply look at an event and try to understand it by asking questions through the teacher. However, the difference between virtual/video experience and demonstration is not just the loss in excitement and relationship building that results from having an event occur live. It is rather that in a great demonstration; the students can observe and then direct the teacher to conduct investigations just like they can do with experiments in their own group. Admittedly some fine motor, design and construction skills are not really developed in demonstrations; but they do not equal teacher centered instruction necessarily – the nature and importance of an activity is all in the details of the classroom pre - and post- demo discussion. Although the value of demonstrations in teaching science is sometimes contested- because it does not involve student-centered instruction and clearly is different from lab instruction in inquiry or design - both types of experiences are required for effective science teaching.

Older lab demonstrations did carry excess risk and some of these risks were reduced by moving from large scale analysis to microanalysis; other dramatic demonstrations were eliminated. This substantially reduced the potential for fire, explosions, and inhalation of dangerous solvents or irritating powders. In this way, the rainbow demonstration involved in the Beacon fire was a movement backwards towards macro-demonstrations which always made an impact on the visual learner, but really are no longer necessary. This does not mean all science demonstrations are unnecessary, but rather, because of advances in technology, we can now select the risks for activities we need and avoid others. Micro-scale experiments can be used, for instance, as demonstrations from the front of the room through the addition of technology; for example, we have used overhead projectors or document readers to project small tube experiments onto a screen, wall, or board.

The failure of a teacher to recognize that a better/safer demonstration technique was available was really due to a lack of science oversight; but getting rid of large scale displays or removing incendiary conditions does not eliminate risk, it just reduces it. Science teachers have used variations on the rainbow demonstration for many decades- even in middle school -to demonstrate the flame emission spectrum; but in most schools we use small wooden splints or metal inoculating loops with the metals which limit exposure to metal fumes, solvents, and large flames. Even in the micro-labs demonstrating this concept, for instance, I have seen hot splints soaked in metals ignite the paper or plastic they were accidently placed on starting small fires. There are choices we make to accomplish our goals; but for the most part active learning is not without some risk.

Despite the instructional concerns about substitutes for a hands-on curriculum, much of the safety concern regarding lab activities is justified – accident rates in high school labs far exceed those in regulated industries (Beryl Lieff Benderly, 2010). Specific factors have been identified that contribute to school based accidents. For instance, accidents were more likely to occur in the classroom of a teacher with less than five years of experience (J A. Gerlovich et al., 1986). Yet, in urban environments increasingly science teachers have two or fewer years of experience; rotating through for brief stays in teaching. All of us who have evaluated lab instruction probably agree that the most important person in the protection of the student is the skilled and trained teacher; but with less experienced teachers more supervision is required. Unfortunately, a safe learning-lab environment really requires envisioning the future actions of students before they happen; only many years of experience or the help of an experienced team allows teachers to see the possible failures clearly. In the current lean environment and with novice teachers, failure to provide adequate safety resources and oversight by school administrators may be an important component of accidents and implicate school administrators and district staff. However, the courts have made it clear that it is up to the teacher to define the limits of activity within the available resources and facilities. In a litigatory environment this perspective may be unfair to the novice teacher. The emerging Next Generation Science Standards and revised College Board Courses are asking for even more lab time and more freedom for students to inquire, which although essential, will burden the young teacher elevating the risk of lab injury even further.

Therefore, the current trend to increase lab requirements, hire more teachers with less science teaching experience, and decrease science oversight will without a doubt combine to increase the accident rate. Teacher experience and resources are not the only obstacle to reducing risk in the lab. In NYC area schools in particular, but also across the country as well, science specialists have been eliminated. Lab specialists in NYC historically controlled supplies and oversaw to a certain extent the safety of the lab curriculum, but for the most part these jobs have been eliminated. Similarly, science specialists who were responsible for insuring compliance with regulations and providing expertise to assigned schools have been eliminated. Finally, although in Beacon the science program still had some administrative oversight provided by a science teacher, the classical authoritative control of science practice by more experienced faculty has been eliminated in most schools. Science oversight has been minimized, not just to save money but also because few people in school administration understand how clearly different secondary lab instruction is from all other types of classrooms. They are simply unaware how much additional risk there might be in having unsupervised teachers running their own active learning program. In small schools in particular, science teachers are often now inexperienced and isolated without enough resources or oversight to carry the burden of lab risks.

Most of school safety is not about proper safety equipment, but rather on-site, on the spot oversight which safeguard the health and safety of students moment to moment. For safety to really to be ensured, labs and demos must be reviewed by multiple eyes and all eyes trained to look for possible safety concerns. There is a reason why science departments often used to have a demonstration and laboratory practice manual – one agreed upon by the entire teaching team. This team approach increased oversight and limited risk. Isolated teachers or people in general can miss risks in their excitement to teach something new; risks that a reviewing team would often see. The Beacon High School case is an example of this isolation, where a momentary lapse of judgement by essentially a lone science teacher allowed the solvent vapor to be accumulate too close to the flame. Isolation of science teachers is increasing, as the small school movement has taken over instruction for more and more urban school districts, reducing the possibility of this oversight, thereby also increasing these unsupervised lab activities with their corresponding momentary lapses of judgment. In the place of a large faculty oversight, other approaches to forming science team oversight must be found. One idea would be to provide teams and cooperation through virtual science teacher networks using virtual meeting software. These networks would not be just list-serves or annual conferences, but a virtual meeting where teachers would go to weekly or monthly within which they can actually show-off and receive suggestions on their active teaching tools, demos, and labs – just like we do with science departments in larger schools.

Many schools are attempting to reduce liability by minimizing authentic lab experiences. For instance, many urban schools have resorted to paper and pen labs or virtual labs which can complement the hands-on experiences, but which are not enough alone to teach concepts or to motivate young scientists. At a time when fewer and fewer of our talented students are taking an interest in majoring in a science or engineering discipline after graduating from high school, we need to embrace the risk of the science laboratory as an economic necessity. We can limit the impact of accidents not by eliminating experiential learning, but by restoring oversight and expertise for science instruction in districts throughout the country – a system which will now take a decade to rebuild and develop. Only in this way can we protect our health and preserve our pipeline for an innovative economy.

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