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Using Microscopy for Authentic Science Teaching: A Learning Sciences Perspective

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We are currently experiencing a new national effort to improve science education in K-12, one that is building on a somewhat failed effort from the mid-1990s to introduce "inquiry" into the science classroom. This new movement is build around the adoption and implementation of the Next Generation Science Standards [1], which themselves represent a faithful translation of a National Research Council report that provided the basic guidebook for these new standards, entitled *A Framework for K-12 Science Education* [2]. In contrast to previous science education standards from the 1990, the new ones are formulated as so-called "performance expectations"; performance expectations specify what a student should be able to do or demonstrate in terms of scientific or engineering competency that can be observed or tested. The NGSS are therefore not curriculum guidelines, but the endpoint of a learning or teaching effort that is oriented towards a student outcome. How this is achieved is left to curriculum developers or teachers.

There is much controversy over the adoption and implementation of standards in general, so-called common core standards in particular, and the NGSS as well [3]. Since the NGSS are performance standards, some of the potential controversy is tight to how one would know whether students perform to expectations [4]. However much these questions might currently dominate some of the public discourse around science education reform, the fact remains that a new vision for science education and science learning has been formulated by the *Framework*, and been channeled into the political process via the NGSS. These standards now provide an exciting opportunity for authentic engagement with science in K-12 [5].

This talk will elaborate ways in which *microscopy* as an easily accessible scientific instrument/method can be used to further the vision for science education reform. The new opportunities for enriching K-12 science education through microscopy arises through the eight science and engineering practices that now form the central avenue through which students are to engage with a limited set of core disciplinary ideas and so-called cross-cutting concepts in science – those that are common in all disciplines.

The practices are:

1. Asking questions (for science) and defining problems (for engineering)
2. Developing and using models
3. Planning and carrying out investigations
4. Analyzing and interpreting data
5. Using mathematics and computational thinking
6. Constructing explanations (for science) and designing solutions (for engineering)
7. Engaging in argument from evidence
8. Obtaining, evaluating, and communicating information.

Microscopy allows us to explore the unseen, to use technology to extend our ability to explore natural phenomena. Moreover, it invites the learner to pay attention to details; to distinguish between that which can be seen and which is imputed; to consider the limitation of a scientific instrument; and just as much, explore the intersection between instrumentation and scientific insight. Using microscopy, therefore, not only touches on many of the 8 practices in some form or another, it also creates an opportunity to link engineering, the resulting technology, mathematics and science, and therefore creates an integrated approach towards STEM [6].

Microscopy is not limited to school-based investigations. Informal or out-of-school learning is sometimes more powerful than schooling, and increasingly a new perspective on student-centered, lifelong and 24/7 learning across settings and time emerges as a new paradigm in our knowledge society [7] [8]. Microscopy is not only being used widely in museum settings, it also opens the door to many hobby scientists, and many children explore at home the world with microscopes in their spare time. This is not trivial statement: using scientific instruments as part of spare time activities is a powerful means for creating an identity as a science learner, and maybe even as a future scientists. Research on learning suggests that active engagement and practice are essential in developing scientific understanding [9]. Microscopy, when used as an authentic tool for exploration into the unknown and unseen, can and should therefore be an essential tool in formal and out-of-school science learning.

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