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Science Education and the New Sciences

Education, and science education in particular, is notoriously subject to “reforms”, most of which are reflective of larger political demands and environments. It is naive to claim that science education serves as a vehicle to teach the canon of science disciplines with periodic updates reflecting new discoveries and technologies. At its more benign, one can say that science education mirrors our conceptions of what science is, does, involves doing. This has changed over the years and arguably, what constitutes the “new science” and “new science education” is just a reflection of the latest version in this ideological connection. We can also argue that the forms and content of science education reflect what we think as a society the purposes of education are, including processes of enculturation and “sorting”; development of literacy (functional, critical, and otherwise); and general (r)evolution and change (or keeping everything the way it is). Science and science education are tools in this process and the question of what is “new” and what isn’t is complex.

What isn’t new is that things change just to remain the same—or so it would seem if we look at the history of science education at least in the United States. Currently, despite international calls for increased scientific literacies among all students, outcomes-based educational standards for all, and even mandated enrollments in upper level science classes for everyone who wants to graduate from secondary schools, women and girls, low SES students and children from minority backgrounds continue to score lower on high stakes science exams, continue to feel alienated from science, and remain underrepresented in the science workforce. Although much attention has been paid to these underrepresented groups and they have made a great deal of progress towards equity, their level of participation has leveled off both in enrollment in college and in the work force in science, engineering, and math fields. For example, women still have not obtained demographic parity or occupational parity with men in the United States. In fact, women represent less than 10% of the engineering workforce, and only about 25% in the working science population in the United States. If underrepresented groups are to achieve higher levels of representation amongst scientists, efforts must be mobilized to reverse trends such as lower scoring on exams and under-representation. This is widely acknowledged.

We are now almost 25 years into our most recent reform efforts in science education (“science for all”) in the United States, designed to address such disparities,
and similar reforms have been going on for similar lengths of time in many other countries. As we just stated however, the more a reform calls for change in one direction, the more its déjà vu all over again—educational reform never seems to build on the lessons of the past nor does it seem to last long enough to come to fruition. Indeed, in many countries calls for equity and access seem to be fading to silence and instead we are hearing increased calls for science education to produce global leaders in science—innovators and inventors—a market-driven, elitist argument which mirrors the post-Sputnik arguments in the United States to upgrade science education.

Looking at the history of trends and changes in science education and asking ourselves, “What’s new here?”, we can see the spiraling nature of changes in the field. Using the United States as one example and tracing things back a little further, early 20th-century education, the pre-progressive period, found itself in the midst of arguments concerning what should constitute secondary education. Standards became established that regulated secondary schools so that graduates would have accomplished similar (and comparable) courses of study (Duschl, 1990), including science, which became a permanent part of the high school curriculum. It was believed that students should have basic coursework in the life sciences, the physical sciences (physics and chemistry), and geology (DeBoer, 1991).

The pre-progressive era conceived a threefold purpose for science education. First, science was a tool for disciplining the mind. At the turn of the century it was widely believed that science could strengthen the mind through vigorous mental exercises. Second, because science was based on observation and inductive reasoning, it was viewed as a valuable way of thinking and of organizing the modern world. Third, science was considered a useful body of knowledge essential for survival in the new industrial era.

The goals of science education in the pre-progressive period were intellectual as well as utilitarian in nature (Kliebard, 1992). Schools taught science to develop the general intellect of those students who wished to seek college placement, as well as to provide functioning members of society. Many leaders in the educational community who favored an elitist education preached the former goal, whereas others who favored a more populist approach pushed for the more practical science education based on social utility. Both forces were equally influential after the turn of the century, with the populists gaining momentum as the period drew to a close. The result of such different orientations to science education led to a two-tiered system. Those students from wealthy and educated families who were expected to attend college were often placed in classes intended to prepare them for college. Those who were not expected to go to college often received no science and, when they did, it had a vocational orientation (Duschl, 1990).

The next period in US education, the progressive period, was at its strongest during the Great Depression/pre-World War II years. In many ways, the progressive period was a reaction to the elitist science education of the pre-progressive period. The main thrust of progressive education was to provide a means with which the US could transform its young into responsible, social human beings. Underlying this
vision was the belief that the teaching of science was important for all learners, not just for the intellectual elite. Like the pre-progressive period, part of making socially responsible human beings was developing the intellect. However, unlike the previous reform period, progressive educators viewed intellectual development within the larger arena of social and moral growth. Consequently, science education shifted from a focus on science as a discipline to science as a tool for solving problems. Classroom practices shifted the acquisition of skills and techniques through drill and laboratory demonstrations, to learning science concepts and skills within meaningful and community-based problem-solving. Thus, progressive science educators aimed to develop science curriculum and pedagogical strategies around applications of less concepts explored in depth, and on the social rather than disciplinary importance of knowledge. Scientific concepts were taught experientially and classrooms were student-centered and places of exploration.

The mid-1950s were shaped by the Cold War and educational policy followed. Many critics of the progressive reforms believed that the nation lacked the scientific and technological expertise to maintain its global position. Such critics also wanted an educational system that would create a country of international superiority. As a result, they advocated dismissal of progressive ideals for a renewed emphasis on the “pursuit for excellence.” It was believed that only massive upgrading of the scholastic standards of the public schools would guarantee the future prosperity and freedom of the United States. Schools shifted emphasis from socially relevant and application-oriented classes to conceptual understanding of fundamental scientific principles. The resulting science education reforms of the 1960s differed from previous reform periods, for the initial call to “a pursuit for excellence” was followed by a more pluralistic effort to focus on scientific practices. Scientists joined together with psychologists and practicing teachers to generate curricular materials that combined rigorous examinations of the disciplines with teacher guided inquiry into the process and content of science. Additionally, as these reforms developed during the 1960s, they became increasingly influenced by the political movement of the time towards equity across race and gender.

Looking at this brief recount of the history of science education in the United States we can see that ideas of what constitutes science and how these ideas should be reflected in classrooms have both changed and remained the same over time. The threads started in the pre-progressive and progressive eras are still present today. Arguably, since the early 1960s, there have been three major turns in both how we envision science and how we think about its teaching. Our beliefs about the nature of science have changed, with science now commonly accepted as, at least, tentative and under construction, and by more radical thinkers, as shaped and validated by political and community-constructed discourse. The equity issues of the 1960s gave rise to increased attention to new concepts in science pedagogy—teaching science through inquiry practices and developing science literacy. Articulating what these mean and how to enable children to engage in these has been ongoing. The changes in ideas about science education and science curriculum include shifts in our concepts about the nature of science, the now entrenched belief that all children
should have access to and be successful in science education and what form that should take, and the resulting shift in pedagogical practices.

Since the early 20th century, teachers, curriculum writers, and policy makers have hoped that science teaching and learning would have an impact on how people live their lives as well as on the development of the next generation of Nobel Prize winners. To this end, children in our schools have been asked to “do” science as well as learn about it. Since the shift in the 1970s to teaching science through inquiry studies and then embedding this in evolving ideas about science literacy, this has been compounded by equity issues and shifting beliefs about the nature of science and scientific knowledge. Placed in this context, talking about a “new science” and a “new science education” becomes both problematic and controversial.

The authors in this issue have taken a number of different cuts on this. One thread, however, runs through them all—the nature of science teaching is complex, multi-dimensional, and a work-in-progress. All the authors write about what science teachers need to know to be able to do their work in a manner that responds to this complexity.

In his article “Towards a Better Understanding of Science Teaching”, John Loughran argues that using a “New Science” approach in teacher preparation might help to change the way that science teachers view the development of theory from practice. He offers an invitation to reconsider the importance of the interplay between science teaching and learning and the teaching of science teaching. He claims that conceptualizing a “New Science” of teaching involves making the tacit knowledge of science teaching explicit so that such knowledge might genuinely be viewed within the profession as having a real and meaningful influence on practice.

Michael Reiss, in “Teacher Education and the New Biology”, focuses on the complexity of biology in the modern age—that to know biology is to know more than just the discipline; it also involves being conversant in bioethics and the societal implications of biology. He also argues that what teachers need to know to be able to teach a science that transcends science is highly complex. With his statement, “Biology teaching sometimes needs to result in more than understanding—it should develop the potential for action”, Reiss contends that while the scientific literacy movement has much to commend it, it still offers too narrow a vision of what science education might achieve. He goes on to argue that teachers need to explore what a science curriculum might be like that took as its premise the notion that science education should aim for social justice.

Similarly Judy Moreland, Alister Jones, and Bronwen Cowie write about this in their article “Developing Pedagogical Content Knowledge for the New Sciences: The example of biotechnology”. In this case, the science is complicated in other dimensions by its interdisciplinarity. The authors describe the components of pedagogical content knowledge that teachers require to teach such a subject and highlight planning strategies to enhance teachers’ understandings and abilities and subsequent classroom interactions.

Three articles focus on how to go about helping teachers acquire the kind of sophisticated knowledge of science and practice necessary to teach now: Din-yan Yip, “Using History to Promote Understanding of Nature of Science in Science Teachers”;
Jay Fogleman, Barry Fishman, and Joe Krajcik, “Sustaining Innovations Through Lead Teacher Learning: A learning sciences perspective on supporting professional development”; and Ken Tobin, “Learning to Teach Through Coteaching and Cenerative Dialogue.” Yip describes a method of teaching pre-service teachers about the nature of science in order to enable enquiry teaching while Tobin and Fogleman et al. describe ways of working with practicing and pre-service teachers that enable the complexities of practice to enable opportunities to learn about practice.

In particular, Tobin describes using the technique of co-generative dialogues between teachers and teachers and students. He calls them “fertile seedbeds” for the production of new classroom and school culture, and places where “youth and adults listen, speak, and learn successfully across temporal, social, cultural, and economic boundaries.” Fogleman et al. describe similar “workcircles” with district teachers and administrators as they work to plan and conduct professional development around reform-based curriculum materials.

Finally, Barbara Hug and George Reese give us “How Technology Integration in Mathematics and Science Teaching Can Occur: The role of the maverick teacher”. In this article, they describe helping teachers to change practices by adopting new tools and pedagogical approaches. This article tells us about a teacher who is an early adopter of a technological innovation. The authors describe how she then went on to encourage others to use this innovation and develop and articulate new pedagogies, curriculum and teacher knowledge—in essence the “New Science” defined by John Loughran in his article.

In truth, to see anything new in the “new science” and the “new science education” one has to take a more fundamental perspective. Has what is being taught in science classes changed in any more than surface details? A more fundamental change has occurred in how it is being taught. The relationships between people and the relationships between people and knowledge are different in this post-modern era from what they were in the past. The authors and their articles reflect this in their concern with pedagogy, teacher learning, and development, and how things come to happen the way they do in classrooms.

Margery Osborne and Hui Li Christine Chin

References


