Engineering Design in the Classroom: Is it Good Science Education or Is it Revolting?

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Abstract

The changing emphasis of science education today includes a shift from a narrowly disciplinary view of science to a more socially and technologically situated perspective. This article reports on the implementation of engineering design projects in about two dozen U.S. secondary science classrooms, following an inservice professional development course conducted at a university engineering college. Using data from an evaluation of the project and three sociological themes—secrecy and ownership, social persuasion and the status of facts, and the relationship between money and science—I argue that technological design projects provide a sociologically fruitful approach for teaching new themes in science education. However, teachers must rethink the nature of their subject matter, something that may be difficult if their training was disciplinary in emphasis.

The title of this paper is loosely based on Edwin Layton’s (1986) book, The Revolt of the Engineers: Social Responsibility and the American Engineering Profession. Layton’s revolution concerns a historical tension between two views of engineering: A view emphasising the important scientific and managerial roles that engineers played in businesses, versus a view emphasising the professional compact between engineers and the public. In the former view, engineers’ loyalties were to their companies and their companies’ interests. In the latter view, engineers were asked to recognise their obligation to practice with a view to the common, public good, and to concern themselves particularly with the social impacts of technology; their loyalties were supposed to transcend company interests. The “revolt” in Layton’s history was a painful shift within the profession from one view of engineering to another.

Parallels to this tension exist in the history of the science curriculum. Should the chemistry curriculum, for example, concern itself primarily with chemistry as a structured body of scientific knowledge (the “company loyalty” model, where the “company” is the academic discipline of chemistry) or with the social consequences of the application of chemistry, chemical technologies, or technologies that have chemical impacts on society? Although these two views of science education—disciplinary science versus science applied toward (non-academic) public needs—have had periods of both ascendency and decline (Bybee & DeBoer, 1994; DeBoer, 1991), for most of the past three decades, notwithstanding efforts like Science for All (UNESCO, 1983) and the Science-Technology-Society movement (Solomon & Aikenhead, 1994), the disciplinary view of science education has largely held sway.

Today, the narrow disciplinary view of the science curriculum is undergoing radical revision; ironically, much of this revision appears to have been stimulated by mainstream scientific groups like the American Association for the Advancement of Science, whose Project 2061 publications provided a content blueprint for the new National Science Education Standards (National Research Council, (NRC), 1996). In both 2061’s Benchmarks (American Association for the Advancement of Science (AAAS), 1993) and the Standards, among the central themes are technology, technological design, and the social impacts of technology. In contrast, the National Science Teachers Association’s flagship curriculum reform initiative has appeared reluctant to expand its
content focus beyond traditional disciplinary structures. Its first detailed curriculum guide made practically no reference to technology, for example; a more recent publication imaginatively repackaged the NRC's *Standards* so that standards concerning technology and the nature and application of technology are separated from "science subject matter" and practically relegated to footnote status.2

In all fairness, progressive efforts by professional science teachers' associations like NSTA have often evinced little action by teachers; as Fensham (1992) has noted:

Many of their members are more ... comfortable with the traditional types of elite curricula for which their own socialization in science has equipped them. There is considerable evidence of this conservativism among science teachers, and it is a definite brake on the prospects for curriculum reforms. Teachers trained well in one discipline of science are usually loath to teach across the disciplines. (p. 798)

In studying and evaluating our own efforts to promote interdisciplinary teaching among science teachers (in the context of aquatic environmental science), we have come to view this hesitation as a problem of teacher subject-matter knowledge. Teachers often view science in narrow, disciplinary terms: biology is different from chemistry, and biochemistry, if addressed at all, is treated as a subset of one or the other, rather than a discrete area of intellectual activity. Asking teachers to build bridges between the sciences and between the sciences and society is to directly challenge their conceptions of their subject matter, and teachers' status as subject-matter experts is integral to their authority as teachers. We have found that teachers who innovate are likely to be teachers who clearly understand that science includes sociological and technological dimensions (Carlsen & Cunningham, 1993; Cunningham, 1995). From this perspective, the challenge of implementing the new science reform initiatives is in large measure a matter of changing science teachers' beliefs about what science is. History suggests that this change will be resisted. One likely form of resistance is to reassert a demarcation between science and technology, maintaining a disciplinary focus on traditional science content and dismissing design, technology, and engineering to the "extrascientific"—content better left to the industrial arts classroom.

Science education today faces a problem similar to the one with which engineers struggled mid-century; to what should it be loyal: its historical disciplinary patrons—the scientific disciplines—or a public increasingly concerned with the relationship between science and technology, and the social impacts of science and technology? To choose the latter, many teachers believe that they must revolt from a view of science that is familiar, straightforward, and true, to one that is messy and tainted with economic, political, and psychological complexity. In this article, I argue that this is a false choice, not because the new societally and technologically embedded science conforms to teachers' views of science, but because the old science is more socially contingent than as typically portrayed. If that is recognised by teachers, there is good reason to believe that they can and will incorporate into their teaching substantive attention to issues like technology, design, and the social consequences of technology. Evidence for this claim is provided from a longitudinal evaluation of a science inservice program that teaches engineering design.

**Conceptual Framework**

The general conceptual framework for this work is a perspective of science education based on contemporary sociology of science, which rejects views "of" science that rely exclusively on philosophical criteria or on sociological criteria that are fundamentally ideological. A contemporary sociological view of science, outlined elsewhere (Kelly, Carlsen, & Cunningham,