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Larry Cuban

The Integration of Sciences into the American Secondary School Curriculum, 1890s–1990s

> On a cold winter's day, a group of porcupines squeezed very closely to each other, using their mutual warmth to avoid dying of cold. Soon, however, they felt each other's quills which once again made them draw apart from one another. But the need for warmth brought them together again, only for the problem to repeat itself, so that they found themselves driven to and fro between the two sufferings until they found finally an intermediate distance affording them the most comfort possible.
>
> Arthur Schopenhauer

Abstract
School reforms in the late 19th century, mirroring larger social, economic, and political changes in American society, account for the permanent lodging of science into the high school curriculum. Major changes in science courses, texts, and instruction occurred in these years. These changes then and since, however, were marked by ideological struggles among groups of reformers representing university academics, policy makers, and educators over why science should be taught and how best to teach the subject. Those struggles over the purposes of science knowledge (should science be taught for its knowledge or its utility in society?) and pedagogy (traditional or progressive methods) reflected deeply embedded value conflicts in American democracy and over the purposes of the high school in such a society.

Chilled porcupines "driven to and fro" between lethal chill and skin-pricking spines is a vivid image. It is also a metaphor for both the dilemmas American educators have faced and the compromises that they have constructed for these dilemmas since the turn of the twentieth century when modern sciences were integrated into the official secondary school curriculum.

I will argue in this paper that larger social, economic, and political changes in late-19th century United States in concert with the emergence of universities led to school reform movements that created fundamental changes in the position of science in the American high school curriculum. A student entering high school in 1890 – and very few at that time ever continued their education beyond the eighth grade – might choose to take a science course from an eclectic mix of courses in botany, zoology, astronomy, geology, and physiology taught from textbooks that saw God's plan in the design of a leaf and the flight of a butterfly. Students would listen to teachers lecture, recite memorized answers on command to teacher questions, and repeat what had been learned on test after test.

Over four decades later, when many more youth attended high school, a grand-daughter of that 1890s student would be required to take at least one year of general science, and, if they considered going to college, additional years of laboratory sciences such as biology, chemistry, and physics. In these courses, the grand-daughter would be surprised to ever find a reference to divine intervention in the natural world from what teachers said or textbooks contained. She would still listen to lectures and take tests but seldom recite since whole-group discussions had replaced scheduled recitations. Moreover, she would attend weekly science laboratories to conduct experiments.

Yet this major change in integrating modern sciences into the secondary school curriculum, albeit one that accumulated over decades, was neither free of ideological conflict then nor tranquil since. Reformers of every stripe, beginning in the late-19th century, pressed their beliefs upon public schools. Ideological struggles among varied groups of university experts, policy makers, and educators over the social purposes of the high school also became encounters over why there should be sciences in the official curriculum and how these subjects should be taught. I will argue that persistent ideological conflict, then and now, over whether sciences should be taught for their intrinsically important and useful knowledge or for helping students to live well regardless whether they went to college or directly into the job market reflected the larger debate over the high school becoming a selective or mass institution for America's youth.

This struggle over purposes derived from a common American ideology grounded in democratic and market principles. Social beliefs in individual freedom and civic responsibility, in excellence and equality, for example, were deeply embedded in the American experience. This ideology contained within itself dilemmas from which compromises in curriculum and practice were forged that satisfied educators and policy makers for a time before they were again refashioned.

To describe and explain the successful penetration of the sciences into the secondary school curriculum and the continuing ideological struggle over its purposes and practices, I will first turn to the sciences that were offered to students prior to the 1890s. Then I will describe the changes that occurred since the turn of the century, and, finally, I will present an explanation for these recurring dilemmas that have accompanied the installing of modern sciences into the American high school official curriculum.

Before moving to these tasks, however, I need to make clear what I mean by curriculum since it is an ambiguous concept that has been defined frequently yet still acts as an inkblot from which researchers and policy makers project their values about what knowledge, skills, and values should be transmitted to the young. The reason for so much ambiguity over the concept is that, as applied to schools, there is not one school curriculum; there are at least five. Because most researchers or policy makers seldom make clear exactly to which version of curriculum they refer, confusion over how much change actually occurs in schools and what actually is being taught and tested often mark discussions of curriculum.

First, there is the *recommended* curriculum. In the U.S., for example, for over a century, national commissions of educators or groups of academic experts have come together and debated their views of what knowledge is most worthy of being included as high school subjects. In 1893, to cite one instance, the National Education Association appointed the Committee of Ten, chaired by Harvard University President, CHARLES W. ELIOT to recommend a standard high school curriculum. This Committee, drawn from a prestigious group of university presidents and scholars, recommended the same curriculum for all high school students, at that time for only about 7 percent of the youth eligible to attend, regardless of whether they continued their education or went to work. Once their report was published, school districts decided how much, if at all, they should heed these recommendations. The decentralized system of schooling in the 1890s and since, meant that policy decisions were made by the local district board of education, not state or federal officials. Some school boards ignored the proposals. Other school districts embraced some or even all of the Committee of Ten's recommendations and proceeded to convert the proposals they accepted into the *official* curriculum (SIZER 1964; KRUG 1964).[1]

The actual courses available to students and published guides for teachers teaching the courses make up the *official* curriculum. Course descriptions cover the array of required subjects or electives with the units or points that count toward graduation, the content that is supposed to be taught, and how much time will be devoted to the subject each day. Many state and local curriculum guides specify the topics and skills that teachers are expected to teach at every grade and for each subject. Thus, the *official* curriculum refers not only to its content and structural organization, as displayed in publications for teachers, students, and parents, but also to the social value that public authorities place on particular bodies of knowledge that the young must learn.

The official curricular content differs from the *taught* curriculum, that is, the content, skills, and values that teachers actually convey in classrooms and laboratories. For example, in high schools, most teachers rely upon textbooks. These texts seldom are identical with the official curriculum. Often the official curriculum for a science course overlaps with the text the teacher is using, but there are inescapable differences in the teacher's grasp of the subject and affection for some topics and activities over others. Thus, many teachers, for different reasons, may be able to finish two-thirds or three-quarters of a text in the time allotted for the course omitting parts of the official curriculum. In biology, to cite one example, a teacher might spend two weeks on the topic of evolution when the text devotes a single page on CHARLES DARWIN and his ideas. Hence, the *taught* curriculum can diverge considerably from the *official* curriculum and even more so from the intent of the one *recommended* by experts.

Then there is the *tested* curriculum. This one includes examinations designed by the teacher, the school, district, state, and national government, all of which have strikingly different purposes. For a teacher who needs to evaluate how much her chemistry students know about acids by having them perform lab experiments, the tasks that she lays out for her students vary greatly from an expert-designed state test with multiple-choice items that will determine which high school students will attend a university. Most tests that have high stakes for students are paper-and-pencil, timed, and selective in what knowledge and skills they assess. The tested curriculum inevitably samples a narrow band of what is taught, what is published in the official guides for teachers, and what experts have recommended.

Finally, there is the *learned* curriculum, that which students take away from required and elective courses, from teachers, from textbooks and other media, from tests, from peers, and from the silent but powerful informal norms that

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1 The percentage of students attending high school comes from the National Center for Education Statistics, *Digest of Education Statistics* (Washington, D.C.: Government Printing Office, 1981), p. 49.

mark each school. Few researchers have studied the *learned* curriculum because of the obvious intense and sustained labor of capturing what individual students have learned. Moreover, disentangling the numerous influences upon what is learned to trace a path from the recommended curriculum through the official, taught, and tested curricula to see what, if any, congruence exists overwhelms most researchers (GLATTHORN 1987; GOODLAD 1979; EISNER 1985).[2]

Examining all of these curricula is beyond the scope of this paper. I will analyze the recommended, official, and taught science curricula to highlight three points. First, the recommended and official curricula often dominate researchers' accounts of changes in schools rather than what and how teachers taught. Such accounts, often exaggerate the extent of innovations in classroom use since researchers often infer from national reports and published curricula that what is in these documents occurred within schools and classrooms.

Second, the recommended and official curricula contained the ideological dilemmas (individual freedom vs. civic responsibility, academic excellence vs. equity, socializing the young vs. creating independent thinkers) that inspired national and local debates. These debates over conflicting values became *policy talk*, a common form of discourse in which public officials and educators diagnosed problems and advocated solutions. On occasion, *policy talk* led to *policy action* or the conversion of some proposals into new courses and programs. *Policy action* or decisions to introduce changes in the official curriculum, however, differs dramatically from teacher *implementation.* What content teachers chose to teach and how they organized their classroom to convey that content becomes the taught curriculum. The ideological dilemmas that appeared in the recommended and official curricula now become the lived or classroom dilemmas that teachers struggled with daily in their exchanges with students.[3]

2 For a critique of the different views of curricula, see JACKSON (1992), pp. 3–40. For a synthesis of historical studies of different curricula and the advantages of such studies, see KLIEBARD 1992, pp. 157–184.

3 The concepts of policy talk, policy action, and policy implementation are drawn from TYACK/CUBAN (1995). The concepts of *ideological* dilemmas and *lived* dilemmas comes from BILLIG et al. (1988). See pp. 25–42 for the distinctions that they draw between the ideological and lived dilemmas. In brief, they say that ideologies are intellectual systems of ideas (e.g., liberalism, Marxism) that are seldom internally consistent but contain conflicting beliefs that produce dilemmas. Both the autonomy of the individual and the importance of civil authority are cherished ideas within the ideology of liberalism dating back to the Enlightenment. The tension between these values create the seedbed for dilemmas and subsequent compromises to reduce the conflict between highly prized values within this ideology (e.g., individual freedom to speak and act as the person sees fit and federal laws that prohibit discrimination or judicial decisions over freedom of speech). This is an example of an ideological dilemma.
A lived dilemma is what occurs when ideological dilemmas travel beyond books, journal articles, intellectual debates, and conferences and inhabit the living rooms, newspapers, bars, offices, and classrooms with which most Americans experience. The value of individual autonomy so crucial to the ideology of liberalism, for example, conflicts with daily expressions of prejudice and social practices that discriminate against individuals from different races, ethnicities, gender, and social class (e.g., language that people use to express their ambivalence toward newly-arrived immigrants or racial groups: a teenager says: "I'm not being color prejudiced, you know. I've got friends who I would like to stay in this country. But if it was either get 'em all out, ... or keep 'em all in, I'd rather get 'em all out." (BILLIG et al., p. 113).
This, ideological and lived dilemmas bring the intellectual trade in ideas that contain internal conflicts together with everyone else who has converted these ideas into "common sense" to

Confusion, then, often arose because highly publicized discourse (*policy talk*) over which policies to adopt (*policy action*) encouraged researchers and policy makers to assume that teachers had put into practice (*policy implementation*) new courses and programs. When evidence eventually emerged that some teachers were faithfully implementing the adopted policy while most of their colleagues continued with traditional practices, policy makers and researchers expressed disappointment with teachers and curricular reform. That disappointment, however, was anchored in confusing what appeared in the recommended and official curricula with what teachers did everyday.

A final reason to focus upon the recommended, official, and taught science curricula is to underscore the powerful influence of non-school factors. The social problems arising from industrialization and the frantic growth of cities led to diverse proposals for school-based solutions, including the introduction of modern sciences. Competing ideas of which sciences were important to teach were measured against a country undergoing profound social and cultural changes at the turn of the century and increasing numbers of youth attending high school. These conflicting ideological beliefs became embedded in the recommended and official curricula causing frequent value-conflicts and subsequent compromises over how and why science should be offered to students. With this introduction to different kinds of curricula, I now turn to the 19th century high school.

High School Science Prior to the 1890s

The steady industrialization of 19th century America generated both excitement and doubt among the middle and upper-classes who were grounded in an agrarian economy. The ideological purposes of schooling to build citizens and moral character began to shift as schooling became slowly linked to a manufacturing economy and students getting better jobs. From the first Boston high school in 1821 that offered Latin, Greek, English, history, moral philosophy, math, and sciences to families who could afford to have their sons and daughters attend, the conflict between the classical course of study (Latin and Greek) and practi-

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cope with the daily experience of similar conflicts. I apply ideological dilemmas to the recommended and official curricula as arenas for debating and reconciling competing social beliefs (individual excellence vs. equity) within the ideology of American democratic and market principles. I apply lived dilemmas to the taught curriculum. In classrooms, teachers experience practical conflicts in deciding what to teach and how to organize classroom activities to convey that content, skills, and values. For example, a first-grade teacher has to decide whether to take time to find out why Juan is crying and reorganize the next 15 minutes of the math lesson or ignore the boy's tears and continue with the whole-group lesson on number-lines. A biology teacher may ask herself: if I let my less able students in my fourth period work in our classroom garden and in the lab with the aquarium and terrarium, will they do as well on the required district biology test as my more able students in the first period who I have been lecturing to and who read the supplementary texts that I give them? These are instances of common lived dilemmas. I will make one minor change in applying these concepts. I will substitute the phrase "classroom dilemmas" for "lived dilemmas. A few other researchers have inquired into these classroom dilemmas". See SARASON (1982); ELBOW (1983); LAMPERT (1985); LYONS (1990); DELPIT (1986), pp. 379–385.

cal subjects (geometry and astronomy) was so deeply embedded in the official curriculum that it persisted throughout the next half-century. Frequent adding and dropping courses was a sign of shifting socioeconomic conditions and the public changing attitudes toward schooling (REESE 1995, p. 107).

This tension between classical and modern subjects, between the academic and the practical as the warring sides became known in the mid-to-late 19th century, had roots in the multiple but opposing purposes of tax-supported public high schools and the social classes that supported it. For some, the mid-19th tax-supported public high school – often called the "people's college" – represented a chance to secure a classical education that would prepare them to be suitably employed, God-fearing, and a person of refined tastes.

Moreover, there was the instrumental value of Latin and Greek, philosophy, and rhetoric found in the "mental discipline" it offered students. The metaphor of the mind as a muscle that required appropriate exercise was the dominant psychological principle that justified study of classical subjects. In short, it was practical to study the classics because what was learned could be transferred easily to worldly uses.[4]

For the families of an expanding middle class, high school subjects had to be geared to a steadily industrializing economy where knowing how to measure, count, and apply knowledge of physics, chemistry and geology to everyday life was more important than how to parse Greek verbs. Conflicting ideas of what a "good" high school education was mirrored in the gradual decline in supporters for classical subjects – the traditionalists of the day – and the increase in those who sought more math and science courses – the reformers of the day.[5]

The justification for sciences in the mid-19th century official curriculum as being practical had two meanings that often were entangled in these and subsequent decades. Reformers saw a personal usefulness in science courses when students strengthened their logical reasoning and powers of observation. They argued that these skills enhanced one's chances of getting a job after leaving school. The individual utility of the sciences was precisely what HERBERT SPENCER and other mid-19th century reformers had championed and was a central plank in the liberal democratic platform of the day.

Furthermore, with growing public concern over unregulated industrialization, unflagging immigration, corrupt city governments, increased labor strife, deepening poverty, and spreading crime American reformers – progressives as they were called at the turn of the century – came to see public schools as institutions that had to take on larger social tasks beyond inculcating basic literacy. Schools had to Americanize newcomers, train the young to behave as good citizens, and find a niche for young men and women in an ever-changing labor market. Thus,

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4 The "mental discipline" justification for a classical education is elaborated in KLIEBARD (1986), pp. 106–109.

5 For studies of particular high schools where these tensions between the English and Classical Departments occurred, see BURNS (1988); LABAREE (1988). LABAREE points out that the first high school in 1821 was called the Boston English Classical High School and, three years later, was renamed Boston English High School, p. 10.
For the argument that the origin and expansion of the high school was anchored in the social needs of a growing middle class rather than the working class, see KATZ (1968) and MARIS A. VINOVSKIS (1985).

the sciences were not only individually practical there was a larger social utility for academic subjects. Schools had to be "efficient" in adapting the young to the imperatives of an urban, industrialized society. Liberal reformers merged these two senses of individual and social usefulness – both values anchored deeply within a democratic and market ideology – to justify increasing the grip of sciences upon the official curriculum (DeBoer 1991).[6]

When one examines the sciences in the high school's official curriculum in the closing decades of the 19th century, the range of subjects offered was impressive. High school teachers taught a medley of courses that included physiology, botany, zoology, physics, chemistry, astronomy, physical geography, and geology. Reformers of the day promoted these science courses to both youth and taxpayers for their individual and social utility and consistency with religious beliefs.

Textbook writers for these courses, many of whom were college professors, also stressed practical applications while making clear that God's presence was obvious in the natural world. The author of a popular chemistry book that sold nearly 150,000 by mid-century wrote that science teaches "the processes of human industry, connects its operations with our daily experiences, involves ... life and death, and throws light upon the sublime plan by which the Creator manages the world". As late as the 1870s, most zoology and geology texts ignored or barely mentioned Charles Darwin. As the author of one geology text in 1882 wrote: "no gorilla ever took out a patent" (Reese, pp. 109–110).

High school teachers, for the most part, having limited preparation in their subjects, relied heavily upon expert-written textbooks for the authoritative content of the different sciences. These texts were filled with facts and scientific principles that students were expected to memorize and recite to the teacher on command. Teaching routines not only reflected this reliance upon texts but also common college practices of lecturing, frequent recitations, and constant quizzes.

Even though the ideas of Pestalozzi and Herbart, stressing individual children's experiences and teachers guiding rather than dictating to students, had been embraced by American reformers in their speeches, books and journal articles – policy talk of the day – the taught curriculum largely mirrored practices aimed at socializing students to accept the intellectual and moral authority of text and teacher. Accounts of classroom instruction in late-19th century high schools reported students sitting in rows of bolted-down desks listening to teachers lecture and awaiting the teacher's instruction to name the constellations in the winter sky, repeat chemistry equations, or list the bones in the hand (Cuban 1993, Reese 1995).

Student recitations demanded memorization of the text and lectures. The practice of recitation also required much from the teacher.

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6 The concept of "social efficiency" is elaborated fully in Krug (1964). For the impact of industrialization, immigration, and mushrooming cities upon schools, see Tyack (1974). I draw my ideas about democratic ideology from the following works: Guttmann (1987); Sandel (1996); Westbrook (1991); Bell (1978); Carnoy/Levin (1985); Lindblom (1977).

> [A] teacher is obliged to carry on simultaneously a number of distinct trains of thought. Having put a question, he must attend to the answer, assign to it a mathematical value out of ten or twenty possible marks, correct errors, frame the next question, select the next scholar, all at once, keeping meaningful a general grasp of the subject, and a general hold of the class, and a general eye to the lapse of time...(REESE 1995, p. 140).[7]

Recitations, by their very nature, were competitive. Awards went to those that shined when they stood to recite while those who went blank received stares, heard giggles, and endured humiliation. For those few teachers who innovated by using models, specimens, and laboratories, they experienced the classroom dilemmas of having to decide how far they should depart from familiar teaching practices that parents and supervisers expected (STEVENS 1913).

Common teaching practices also included tests. The purpose of tests was to publicly demonstrate that learning had occurred. Students repeated the information teachers thought important in the assigned text chapter and previous lectures. Tests selectively reinforced what science knowledge was deemed socially important. Prior to the 1890s, facts and concepts drawn from the various disciplines came largely from lectures and texts. Only occasionally were lectures supplemented by models and specimens. In 1870, physiology teachers in the two Cincinnati high schools pleaded for a replacement of the one skeleton they had because of its shabby condition due to its being carried back and forth between the two schools. The laboratory method, initiated in German universities in the last quarter of the 19th century, had yet to penetrate American colleges, much less the high school. Not until 1886 did Harvard University, for example, allow a high school course conducted through laboratory experiments to count for admission (REESE 1995, p. 140; DEBOER 1991, p. 59).

Major changes in the Recommended, Official, and Taught Curricula (1890s–1930s)

At the turn of the century, reform-minded administrators began trimming the prolific offerings in science (as many as a dozen different subjects) to a cluster of basic science courses. For example, biology, a new subject that incorporated physiology, botany, and zoology, grew from an offering in 10 percent of the high schools in 1890 to 84 percent in 1923. In that latter year, only 30 percent of the high school still offered botany and 2 percent had zoology in its official curriculum. What had occurred to account for these dramatic changes? (ROSENTHAL/BYBEE 1987).

The factors that account for these striking changes can be seen in the larger contexts in which the high school was embedded. Influencing what academic subjects got emphasized in high schools were the socioeconomic changes that had been slowly accelerating in the closing decades of the 19th century. Industrialization of manufacturing generated hundreds of thousands of jobs for farmers and immigrants. Cities mushroomed in population. Non-English speaking immigrants sent their children to school. The ills that accompanied

7 . The description is dated 1862.

such sudden growth emerged as well: slums, disease, poverty, and crime. Historically, families that had learned to be economically self-sufficient and responsible for rearing their children found themselves dependent upon others – employers, neighbors, city officials, and schools to carry out what their fathers and mothers had ordinarily done. Weekly paychecks softened somewhat the heartbreak and pain of bleak lives in slums. Boom and bust business cycles, however, occurred often in the last quarter of the 19th century plunging middle-class families into poverty and working-class families into pauperism. Within this socioeconomic setting, progressive reformers prodded public schools to take on more social responsibility that once families had themselves discharged (WIEBE 1967; CREMIN 1961).

Within this socioeconomic context, the sciences as a highly-valued and socially useful body of knowledge had initially gained primacy among the highly educated in Europe and the U.S. by the 1890s, scientific knowledge, especially as applied to new technologies, had virtually trumped its rival, religious revelation, as a source of knowledge about the human condition. The spread of Darwinist ideas, for example, proved contagious in small, urban intellectual communities and emerging universities on both continents as ways of justifying business entrepreneurs who reaped enormous profits from their work. The growing reliance in the American business community upon engineers and scientists for improvements in industry, transportation, mining, and other profit-taking activities further strengthened the position of scientists in society and turned corporate heads toward universities and public schools (OLESON/VOSS 1979, DEGLER 1991, NOBLE 1977).

Newly-founded American universities (e.g., Johns Hopkins, Clark, Stanford, University of Chicago) moved swiftly at the turn of the century to not only legitimate the natural and physical sciences as proper subjects of systematic inquiry but to seek linkages with business, industry, and government. University presidents hired science faculty and equipped laboratories for research. Faculty experimented and published results. They consulted with industrial chiefs, mayors, and public health officials. If manufacturing and other industrial activities benefited from the application of scientific knowledge, so did urban water supplies and city dwellers' health.

The reach of science into everyday life increased demands for more skilled workers, managers, and scientists. Such demands for a trained work-force spilled over universities and colleges initially and then public high schools. With the growth of cities and an expanding economy, school enrollments climbed each decade of the new century. Crowded grammar schools contributed small but steadily growing numbers of graduates who sought a high school diploma.

Between 1890 and 1918, on the average, more than one new high school was opened each day of the year (TYACK 1974, p. 183).

Enrollments 1890–1930[8]		
Year	High School	College
1890	202,963	157,000
1900	519,251	238,000
1910	739,143	355,000
1922	2,155,460	681,000
1934	4,496,514	1,055,000

Thus, it is reasonable to claim that socioeconomic changes in the United States that began in the early 19th century and accelerated tremendously by century's end stirred the ideological struggle over the social purposes of public schooling and, more specifically, what they should teach. The arena in which the value-laden policy talk took place was the official curriculum of the high school.

Within twenty-five years, two national reports recommending what the official high school curriculum ought to be captured the continuing ideological struggle over what purposes high school should serve in a democratic, market-driven society and the role of the sciences in meeting those purposes. The Committee of Ten report in 1893 and the Cardinal Principles of Secondary Education in 1918 bracketed a quarter-century of contentious debate over what subjects students attending college and those entering the job market should take.

Other writers have analyzed each of these reports in detail. What I propose to do is sketch out the general outline of these major reports to capture the ideological dilemmas over contending goals for American high schools (and the sciences) as enrollments climbed and how the policy debate was temporarily resolved only to become undone in later decades (SIZER 1964; KRUG 1964; CREMIN 1961).

Altered socioeconomic conditions, then, not chance or rational planning, propelled the reform-minded leadership of the National Education Association (NEA) in 1892 to appoint six university presidents, the U.S. Commissioner of Education, and three high school principals to a Committee of Ten. The charge to the Committee was to decide what subjects must be taught, how they should be taught, how much time should be devoted to each subject, and how best to evaluate students' achievement.

After extensive reports from subject-matter committees, the Committee recommended that all students, regardless of whether they went to work or college, had to take the same academic subjects, including sciences. This was clearly a victory for those reformers who believed that the best preparation for life, be the student a future lawyer or clerk, was to study academic subjects.

There was further consensus among the Committee that the sciences developed high school students' intellectual ability and that the best way of teaching the sciences was through direct experience with what was being studied accompanied by teachers' demonstrations and explanations. Hence, the Committee

8 *The Statistical History of the United States: From Colonial Times to the Present* (Stamford, CT: Fairfield Publishers, 1965), pp. 210–211.

embraced wholeheartedly the science committee's recommendation that the laboratory be a standard part of every science course and that the laboratory portion of the course be extended to a double period with Saturday morning exercises and one afternoon a week to be spent in outdoor instruction. The thrust of these science recommendations, then, was that the basic principles in the subjects should be taught and learned as sciences and, when done appropriately, would strengthen every student's intellectual capabilities and thus bridge both worlds of college and work (DeBoer 1991, pp. 40–63.).

Between this report's recommendations in 1893 and the 1899 recommendations in the NEA Committee on College-Entrance Requirements, biology, chemistry, and physics became fixtures in the official high school curriculum and acceptable for college admission. The latter report reconciled competing social beliefs of individual freedom and community demands: all students must take at least one year of a science to graduate high school and, for those students choosing to attend college, they could elect other science courses. By 1900, many school districts had converted the policy talk of the recommendations into policy action thereby establishing the sciences as academic subjects in the official high school curriculum and welding those very same subjects to college admission requirements (ibid).

Thus, the mid-19th century generation of reformers who called for practical subjects being substituted for much of the classical curriculum had succeeded in introducing modern languages and sciences by the latter part of the century. But the unceasing, steady transformation of an agrarian economy into an industrial one led a later generation of education reformers – now called "progressives" – to focus upon the majority of high school students who chose the workplace over attending college. By 1910, this generation of reformers had begun seriously questioning the Committee of Ten's recommendations and the belief that all high schools students should take the same academic subjects. The high school, progressives critics claimed, was geared only for those preparing for college. Too many were leaving school for the workplace; they needed to be retained until graduation. What had been an earlier struggle between classical and modern or practical subjects was about to be reformulated as a struggle between preparation for college or preparation for life (Cremin 1961; Tyack 1974; Krug 1964; Cohen 1968).

By World War I, the vocational education movement that had begun decades earlier, had matured into a national lobby for job-preparation within schools by World War I. The capstone to the movement's success was the passage of the Smith-Hughes Act (1917) that provided, for the first time, federal funds to subsidize vocational preparation in public high schools. These efforts, of course, were linked to what curricula should be included in high schools and, particularly, what sciences should be taught and for what ends (Kantor 1982; Cohen 1968; Fisher 1967).

Contested beliefs over exactly what fit there had to be between the high school and society, between the purposes of the curriculum and the social destinations of students who attended, led to another NEA-appointed national commission. Where the Committee of Ten was composed of university presidents and academic specialists, a former New York City math teacher, Clarence Kingsley, and dozens of other progressive educators in colleges and schools gave intellectual leadership to the NEA's Commission for Reorganizing Secondary Education (CRSE) (DeBoer 1991, pp. 67–72.).

In 1918, the CRSE issued its final report, *Cardinal Principles of Secondary Education*, and called for seven goals for high schools: health, command of fundamental processes, worthy home membership, vocation, citizenship, worthy use of leisure, and ethical character. All school subjects, academic or vocational, had to justify themselves in relation to these seven goals. The best way to organize the official curriculum, the report said, was to have different curricula for students whose occupational futures would diverge in the same high school. Here was the rationale for the progressives' invention of the *comprehensive high school* that came to dominate the organization of secondary schools since the 1920s. Rather than pursue separate schools for vocational education and for college preparation, the Commission endorsed a high school where all students could choose courses of study that would prepare them for both work and life.

With these recommendations, the earlier compromise between competing beliefs constructed by the Committee of Ten was abandoned. The CRSE fashioned another compromise among conflicting values that was still committed to individual freedom (each student choosing the best course of study) with far more emphasis on the social usefulness of developing individual students' personal and work life (courses on families, vocational preparation, getting along with other people, community relations, etc.); the tradeoff was less emphasis on individual academic achievement.

What is striking about this report compared to the Committee of Ten's 1893 report is the shift in views of a "good" high school. A "good" high school education, according the Committee, could be found in four years of rigorous academic work for all students. The word "vocational" never appeared in the report. By 1920, the view of a "good" high school education was one that was both differentiated and intensely vocational in seeking to develop the individual to appropriately live and work in society.

The shift in purposes for a high school education were no less pronounced in why the sciences should be taught. In the Committee of Ten's formulation, sciences were taught for their intrinsically worthwhile intellectual content and skills of inquiry. The laboratory was a place where scientific principles could be seen in action. Applications of science to daily life were viewed as means for stimulating student interest in the subject, not as an end in of itself.

But in the CRSE's view, as expressed in a subsequent report from the science committee (1920), the purposes of having students take science in high school was to contribute to the community's public health, to use new technologies in the home and on the job, and appreciate the natural world and the role of science in making a better life. The science laboratory filled with microscopes and beakers was only one place to do experiments and work on projects; other "laboratories" were the home, the factory, the nearby river, the community itself. No longer were sciences justified on either intellectual or vocational grounds; science helped individuals live a worthy life. The progressive-minded science committee of the CRSE called for a reorganization of the official curriculum and teaching that would be consistent with the center of gravity shifting from studying the *sciences* of life – what the Committee of Ten recommended – to studying sciences for *living* (ibid, pp. 89–97).

Moving from the recommended to official science curriculum (1890s–1940s). It is one thing for progressive educators on national commissions to call for major revisions in what high schools should offer – policy talk; it is quite another thing for public officials to tell hundreds of thousands of school districts to change the words in published curricula – policy action – and then to modify the time schedule of the school, buy different textbooks, and get teachers to alter routine teaching practices – policy implementation.

Based on the few inquiries that historians have made, the stated goals for official curricula did change after the *Cardinal Principles* report and new courses were introduced. Whether these changes occurred because of the CRSE report, the general acceptance among educators of progressive policy talk, or the increasing numbers of youths attending high school or some combination of these is difficult to disentangle.

Historian DIANE RAVITCH reviewed general studies of curricula in the 1920s and 1930s and found a "pronounced shift ... away from concern with intellectual development and mastery of subject matter to concern for social and emotional development". She found new courses called "Basic Living", and "Common Learnings". Progressives also urged that subjects be combined, such as English and history or math and science, into a core curriculum so that students could see the connections between different disciplines and their lives more easily. Traditional subjects such as history were folded into a new high school subject called "social studies," a combination of history, economics, sociology, political science, and other social sciences. Moreover, HERBERT KLIEBARD found in the rapid growth of vocational courses in the official curriculum a victory for progressive reformers. In the sciences, a new course called "General Science" was introduced that began a sequence available to all high school students: general science followed by specialized courses in biology, chemistry, and physics (RAVITCH 1983; HERTZBERG 1981; KLIEBARD, pp. 128–151; DEBOER, pp. 86–92).

The spread of new courses, goals, and official curricula can be easily documented. What needs to be acknowledged also was a strong undertow of resistance to the progressive policy talk and action stemming from the CRSE report and changes in the official curricula. That such resistance existed should come as no surprise since the CRSE compromise diminished greatly the highly valued social belief in individual academic excellence. Moreover, much of the official science curriculum was shaped by textbooks written by college professors, college and university admission requirements, and tests. In 1913, for example, many colleges began to accept biology as meeting their entry standards and, the next year, the College Entrance Examination Board began testing in biology (ROSENTHAL/BYBEE 1991, p. 136).

Thus, the familiar conflict among educators for decades of whether or not to stress the needs of the individual learner over the constraint of covering academic content to meet larger societal needs persisted even though the policy talk and official curriculum were clearly tilted toward connecting the student's life to the world beyond the classroom door. What about the taught science curriculum? Had teaching practices shifted with changes in the recommended and official curricula?

The taught curriculum in classrooms (1890s–1940s). Determining to what degree the shift in purposes for teaching and learning science had translated into teaching practice is difficult because of so little systematic study of classrooms in these years and the problem of generalizing from fragmented evidence. What those few researchers interested in what teachers taught have done is examine changes in textbooks, tests, and actual teaching practices.

High school physics can serve as an example. In 1937, after examining physics curricula and textbooks, ALEXANDER EFRON, a university science educator, lamented that the single goal of these courses was to prepare students for college. Unsurprisingly, the professor found that most high school and college freshman physics classes used the same text. One best-selling text in the 1930s had chapters on heat, sound, light, magnetism, electricity, and mechanics – a physics closer to NEWTON than EINSTEIN. At the end of the text, there was a chapter describing practical applications of the principles of physics studied in earlier chapters such as the airplane and automobile. The text authors, aware that many teachers would hardly ever reach this last chapter, noted that they tried to make the treatment of these topics (heat, light, sound, electricity) so simple and so interesting that pupils will want to study them for their own information, even when the pressure of time for fundamentals ... may not permit the assignment of all of these topics for class study (DONAHUE 1993; DEBOER 1991, pp. 87–107).

Recall that educational progressives at the turn of the century continually complained about traditional science teaching practices of lectures, recitation from textbooks, and infrequent demonstrations or use of a laboratory. ALEXANDER EFRON of Teachers College, Columbia University, had also surveyed high school physics teachers. He found that most of them lectured and used demonstrations rather than students experimenting in the labs. One high school biology teacher wrote in 1930 about how the course was being taught:

Many of our present day methods in biology have been directly handed down from the university. The university has emphasized morphology with its ... drawings. High school teachers have, in many cases, bodily transplanted this method to secondary school biology. The time has passed when a high school course in biology consists of a somewhat simplified edition of a similar course in the university (DONOHUE 1993, p. 325; DEBOER 1991, p.119).

Another Detroit high school teacher, writing in 1945, reflected on the past two decades of science curricular reform.

A fair criticism of our present courses is that they are too nearly limited to a ‚giving back' by students of information which we, or our textbook writers, deem essential. Many times we fail to distinguish between learning and memorizing (DEBOER 1991, p. 107).

In other high school subjects, the pattern of lectures and recitations punctuated by occasional student reports and whole-class discussions, dominated teaching practice, according to surveys and occasional researchers venturing into classrooms. Yet, it would seem, with the focus in the 1920s through the 1940s on practical applications of science and active student involvement with scientific principles, the laboratory would become a place where both could occur (CUBAN 1993, chapters 2–5).

Not so, according to GEORGE DEBOER's study of science education over the last century. With the introduction of the science laboratory at the turn of the century, the high hopes that students would learn the inductive method and solve scientific problems through experimentation dissolved. The rhetoric of progressive reformers promoted students using the community as a science laboratory, not just a stuffy room filled with preserved specimens, bunsen burners, and beakers. But, over the years logistical problems of scheduling double periods of laboratories one day a week to accommodate students and meeting college requirements led one friendly observer of science classrooms in 1920 to criticize many teachers who still had students reciting from text and using the laboratory to confirm principles presented in lectures, a method contrary to the progressive policy talk of learning through doing (DeBoer 1991, p. 110, citing G.M. Ruch).

Summary

The period between the early 1890s and the 1930s marked the years that modern sciences moved from the recommended to the official curriculum. Much of this was policy talk that engaged academic specialists, policy makers, administrators, and occasional teachers in books, journal articles, and conferences. The talk was important in generating national debates and moving particular ideas from pages of commission reports to actual policy changes in the official curriculum.

That rhetorical victory for reformers, however, also featured a continuing conflict in social beliefs over the purposes for teaching science that reflected the larger, on-going ideological struggle over the purposes for the high school as student enrollments climbed. Were high schools to serve primarily those who prepared for college or for all students including those who went into the workplace? Were the sciences to have students learn essential principles of biology, chemistry, and physics and think like scientists? Or were the sciences to prepare students to understand the personal and social aspects of living in an increasingly technologically-driven world?

Progressive reformers generally came down on the side of high schools being comprehensive, that is, serving all students with a differentiated curriculum that was personally connected to their lives in school, at home, and in the community. For those not attending college or leaving before graduation, they would at least take a course in "general science" or enroll in commercial and vocational courses where practical applications of science would prepare them for the workplace. Opponents to progressive reformers saw these changes in the official curriculum as losses. Individual freedom to excel academically had become subordinate to the value of equity where every student in a comprehensive high school could find a personally appropriate niche for themselves in an industrialized, increasingly technological world. Each of the compromises worked out in 1893 and 1918 tried to reconcile ideological dilemmas that were embedded within the generally accepted American lexicon of values that prized both individualism and civic responsibility, excellence and equity, the classical and the modern, the theoretical and the practical.

When the taught curriculum is examined, however, the victories that progressives could claim in policy talk and policy action fade. Yes, many of the national commissions recommendations from 1893 and 1918 had been adopted. Yes, a sequence of four years of high school science courses had been established. Yes, there had been sporadic efforts by a minority of science teachers to have units on "kitchen chemistry" and send students into the community to do public health surveys. And, yes, textbook had been revised with up-to-date sections on new scientific information.

But the central mission of transmitting to students scientific knowledge remained. Unlike university presidents or public officials who make recommendations and have no responsibility once the report is published, teachers faced the ideological dilemmas and had to make choices over how much time to spend on individual social and personal development and how much time to spend on content that was tested or that the teachers thought was important. Teachers still had to decide how much of the text and laboratory manuals to cover in the limited amount of time they had each week and each year. So teachers decided among conflicting values and constructed compromises in their classes.

Teachers still lectured and asked students to memorize the names for parts of the frog. Laboratory experiments took students step-by-step through lab manuals that neatly confirmed scientific principles the teacher had lectured about and were in the textbook. College entrance examinations tested students' grasp of scientific concepts. As one passionate advocate of the progressive view, CHARLES PROSSER, pointed out: "Like Mark Twain's weather, there has been a great deal of talk about the curriculum of the secondary school, but nothing much has been done about it." To the degree that the available evidence of teaching practices represents what was typical, what appeared in most texts and classrooms was an older version of teaching science – once a reform in of itself – of conveying the essential concepts of science as a way of learning the basic principles of the disciplines, and, of equal importance, learning the methods of thinking that scientists used (PROSSER et al. 1985, p. 274).

From this summary, two final questions arise: Did these ideological and classroom dilemmas over the purposes for science and teaching practices appear again after the 1930s? If so, why have these ideological conflicts persisted so long after the clear integration of modern sciences into the official curricula? I now turn to these questions.

Did these Ideological and Classroom Dilemmas over the Purposes for Science and Teaching Practice appear again after the 1930s?

The answer is yes. Between the mid-1950s and early 1970s and, again, between the early 1980s to the mid-1990s, the ideological and classroom dilemmas over purposes and teaching persisted.

The Cold War's impact upon science education. By the early years of the Cold War, the progressives' grip on policy talk and the official curriculum had loosened considerably. A new generation of federally-funded reformers, mostly university-based scientists, derided the kinds of science taught in post-World War II high schools. These reformers sought academic excellence in high school science courses. They wanted their disciplines to be taught for their basic principles in ways that would engage students by having them duplicate how scientists think and work.

Fear of Soviet Russia overtaking the U.S.'s commanding leadership in science – especially after the launch of Sputnik in 1957 – overcame Congressional objections to using federal dollars for education. Within a decade appropriations to the National Science Foundation (NSF) soared. NSF funded university scientists to overhaul the teaching of science in America's high schools. Fellowships went to high school science teachers to learn how to teach new curricula. All of this money sought to create a new generation of students who would eagerly enroll in high school science courses, continue their quest in college, and eventually become engineers and scientists who would protect the nation against the Soviet threat (DeBoer 1991, pp. 147–172).

Yet even at the peak of federally-funded curricular reforms, progressive reformers from an earlier generation and a few contemporaries raised earlier ideological dilemmas by asking questions that had been previously posed about the purposes of science education. Wasn't the aim of learning the sciences for all students, not just those going on to college? For learning to occur, they asked, didn't students have to be engaged in studying content relevant to their lives? The sciences, they said, again and again, served all students best by preparing them to live well whether they attended college or went into the workplace. While their voices often went unheard, and their proposals unfunded, the social beliefs they shared about science education came out in their questions of Cold War university-based reformers.

This is not the place to review the origins and occasionally-contested spread of new math and science curriculum reforms that began in the mid-1950s and extended through the 1960s. Others have captured the intensity and impact of a decade-long movement led by federally- and privately-funded scientists. A brief review will be sufficient (Jackson 1983, pp. 143–166).

Cold War reforms in the official curriculum turned away from the earlier emphasis of science educators on personal and social relevance of science for all students. Instead, reformers prodded students, especially those preparing for college, to learn the concepts and structure of the scientific discipline. Academic scientists wanted college-bound students to understand biology from the inside, as biologists knew biology, as physicists knew physics. They wanted to motivate students to go to college to become engineers, mathematicians, and scientists – then believed to be in short supply. Moreover, these university-based reformers wanted teachers to help students experience the joy of discovery. Guided by teachers who acted more as coaches than lecturers, new materials, equipment, and cleverly-designed activities would lead students to duplicate how scientists practiced their disciplines. Not only was the recommended curricula to become the official one, but both were to be implemented in every high school teacher's classroom. The reformers staked out an ambitious agenda.

Within a decade, these amply funded, university-based reformers had produced many science courses with accompanying texts (e.g., New Biology, New Chemistry) that combined the fundamental ideas of each discipline with detailed instructions for teachers to help students discover basic concepts. When researchers surveyed districts in the mid-1970s to determine the impact of the massively funded effort to change both the official and taught science curricula, they found that overall enrollments in the sciences had risen from 54 percent in 1949 (before the surge of science curricular reform) to 60 percent in 1961 (in the midst of increased federal funding) only to fall to 47 percent in 1972 (when federal funding sharply declined). If the overall goal was to encourage more students to take high school science, the results were underwhelming (WELCH 1979, p. 297).[9]

What about the use of innovative materials? Surveys turned up that over 50 percent of all school districts were using the newly-developed biology courses. In physics and chemistry, less than one-quarter of the districts responded that they were using the new materials. These figures were the high-water mark, however. Of course, district officials answering surveys that schools were using the innovative texts said little about what occurred in classrooms (DEBOER 1991, pp. 166–167).

Few researchers stepped inside classrooms to see exactly what teachers were using of the new courses and precisely how they using the materials. The few that did, funded by NSF, were less than encouraging. They found that many teachers initially used the materials but ended up using the texts and activities not in ways intended by the designers. Furthermore, many teachers modified the courses to fit their students and schools. Researchers described how teachers used traditional ways of teaching the New Biology, the New Chemistry, and the New Physics (STAKE/ EASLEY 1978; HELGESON / STAKE / WEISS 1978).

During the Cold War decades of the 1950s and 1960s, policy talk about the structure of the scientific disciplines and inquiry methods in the classrooms had spread swiftly among university-based reformers, NSF officials, and district superintendents. Speeches, articles and books, and proposals adopted the new vocabulary of the essential ideas of a discipline being taught to students through discovery. Moreover, some policy talk had been converted into policy action. Recommended and official curricula merged in the production of innovative courses and instructional materials. Yet the overall impact of the new courses and spurts of funding were limited enrollment gains within high school science courses over a decade or more and use of the new materials by teachers in the ways unintended by designers. Implementation failed to yield the gains anticipated by the reformers. By the late-1970s, this much was fairly clear to the reformers who, by and large, had already retreated back to their academic and federal offices.

Even at the height of the federally-funded curricular reforms, reformers from an earlier generation and contemporaries who disagreed with the direction taken by university-based scientists still raised the central questions that progressives had asked previously about the purposes of science education. What about the connections between science and daily life, including technology? What about students' interest in the subject and applications to work and the community? Wasn't science aimed at helping all students – not just those preparing for college – to understand society and to use science to live well? Science for all or science to make mini-scientists? These questions surfaced in the late 1970s during rising concern for America's economic competitiveness in world markets.

9 Enrollment in high school sciences in the early 1990s is 48 percent. National Center for Education Statistics, *High School Seniors' Instructional Experiences in Science and Mathematics* (Washington,D.C.: U.S. Department of Education, Office of Educational Research and Improvement, 1996) NCES 95–278, p. 14.

Scientific literacy in the 1980s and 1990s. At a National Academy of Sciences conference in 1982, scientists, public officials, corporate leaders, and educators gathered in Washington to declare that the nation's schools were facing a crisis in science and mathematics. In competing globally, America had lost its edge in the technological marketplace, participants claimed. That meeting was followed a year later by a report from the National Science Board of NSF that laid out a plan of action for improving math, science, and technology education to make American students' "achievement ... the best in the world by 1995". Why? "Because the Nation's national security, economic strength, and quality of life depend upon the mathematics, science, and technology literacy of all of its citizens." The same year, the *Nation at Risk* report pointed out the stiff global competitiveness that faced the U.S. and a "rising tide of mediocrity" among high school graduates that could be traced back to poor academic programs.[10]

Thus, a counter-movement, responding to corporate and official complaints over the U.S.'s slipping role in a global economy, sought to bring back into science education academic rigor, individual excellence in academic achievement, and rich connections with daily life and the workplace. Societal needs more than personal growth fueled the reforms of the late-1980s. Compressed into a slogan, "scientific literacy" for all students, another generation of reformers brandished familiar ideological dilemmas.

As before, much of this current counter-movement was federally- and corporate-funded and driven, in part, by a fear that there would be insufficient engineers and scientists for a global, technologically-based economy. Emerging in the early 1980s the movement for teaching the sciences for their applications to all students flowered and has retained its dominance into the late 1990s. Because of national nervousness over losing economic competitiveness in a global economy in the closing years of the twentieth century, what seems to have occurred is that the Committee of Ten report of 1893 and the CRSE recommendations in 1918 had now merged into one over-riding recommended goal for "scientific literacy".

The term "scientific literacy" can be traced back to science educator PAUL HURD who coined it in an 1958 article. He argued that "More than a casual acquaintance with scientific forces and phenomena is essential for effective citizenship today. Science instruction can no longer be regarded as an intellectual luxury for the select few." In 1970, the National Science Teachers Association (NSTA) identified scientific literacy as the most important goal of science education: Soon enough the theme of scientific literacy merged with the idea that the connections between science, technology, and the larger society were just as important as understanding the concepts and processes of science. As a NSTA position paper put it in 1982:

Many of the problems we face today can be solved only by persons educated in the ideas and processes of science and technology. A science literacy is *basic*

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10) U.S. Commission on Excellence in Education, Nation at Risk (Washington, DC: Government Printing Office, 1983. The National Science Board Commission on Precollege Education in Mathematics, Science, and technology, Educating Americans for the 21st Century (Washington, DC: NSF, 1983), Letter of Transmittal.

[original emphasis] for living, working, and decision making in the 1980s and beyond (BYBEE/DEBOER 1994, pp. 376–378).

By the end of the 1980s and into the early 1990s, official national commissions and science organizations published reports recommending overhaul of high school sciences and how teachers were to help students become scientifically liter- ate. The title of the 1989 report issued by the American Association for the Advancement of Science echoed the earlier progressive educators' call for curricular reform: *Science for All Americans.* For the official curricula, the report also joined earlier reformers' recommendations in calling for schools to reduce "the sheer amount of material covered", "eliminate rigid subject-matter boundaries", "present the scientific endeavor as a social enterprise that strongly influences – and is influenced by – human thought and action", and encourage "scientific ways of thinking". The report concluded that "there are no valid reasons – intellectual, social, or economic – why the United States cannot transform its schools to make scientific literacy possible for all students" (AAAS 1989, p. 5 f.).

How were teachers to teach science? The report urged that all science teaching "be consistent with the spirit and character of scientific inquiry and with scientific values". This suggests such approaches as starting with questions about phenomena rather than answers to be learned; engaging students actively in the use of hypotheses; the collection and use of evidence; and the design of investigations and processes; and placing a premium on students' curiosity and creativity (ibid.).

Teachers were expected to design activities that would enable students to apply their knowledge of science concepts. Small-group work and different techniques of asking questions were to be used to promote interactions among students and, therefore, deeper understanding. There was to be more focus on in-depth learning of a smaller number of powerful principles that stressed understanding and reasoning rather than factual recall, definitions of terms, and rules to follow (WEISS 1997, p. 1).

Throughout the 1990s, national associations of math and science teachers created model curricula that were recommended for all public schools, kindergarten through high school. Federal and private funds flowed to states and local districts to renovate their official curricula and to train teachers to implement the recommended ways of overhauling science education (Biological Sciences 1995).

What has happened? The previous ideological and classroom dilemmas that I have noted in earlier movements to reform science education in the 1890s, 1920s and 1930s, and 1960s would predict that conflicts continued to exist between the recommended and official curricula and between what is in the official curriculum and what content teachers teach and how they teach it. The evidence, however partial, supports the prediction.

In a survey of almost 3500 high school science teachers in 1992 about the instruction that they offer seniors, 96 percent said that they consider "increasing students' interest in science" a "major" to "moderate" focus in their teaching while 69 percent said that "memorizing scientific facts, principles, and rules" were emphasized in their classes. Almost 90 percent of the teachers said that "preparing students for further study in science" was a "moderate" to "major" direction in their teaching. And 92 percent said that "developing problem-solving/inquiry skills" was also of the same importance in their classes (National Center for Education Statistics 1996, p. 23).

When teachers were asked how they taught, 58 percent of the teachers said that they lecture daily or "almost daily" and another 33 percent said they do so once to twice a week. Two-thirds of the teachers said that they ask students to answer questions orally on the subject matter daily or "almost daily". Just over half of the teachers said that they have students work together in small groups once or twice a week. Almost one in five teachers said that they have students work in such groups daily or "almost daily". Lab time ranged from a low of 40 minutes a week for low-achievement science classes to 76 minutes a week for the highest achieving students (ibid., p. 28).

In a 1993 survey of 6000 teachers in grades 1–12 who taught math and science, IRIS WEISS reports that in the high school "lecture/textbook methodologies continued to dominate science ... instruction". Over 90 percent of high school science classes "listened and took notes during presentations by the teacher at least once a week, and 60 percent did so on a daily basis" – figures that are close to the1992 survey described above. She points out that 62 percent of the science classes never went on field trips and 43 percent never worked on a week-long science projects. What did turn up as encouraging to WEISS was that the majority of science teachers worked with small groups of students at least once a week and the use of "hands-on" classroom activities occurred at the same frequency – again, similar to the results of the other teacher survey (WEISS 1997, p. 2ff.).

These fragments of evidence reveal the enduring dilemmas that face teachers in their classrooms. A gap remains between the revised official curriculum focusing on scientific literacy for all students and what teachers do to reconcile competing needs of cultivating critical thinking skills among students and transmitting socially-demanded (and often tested) content and skills. Survey responses also suggest that these classroom dilemmas have led more teachers to make choices that are beginning to expand their instructional repertoire to include activities recommended by reformers. It is, however, this durable pattern of ideological dilemmas and conflicted teacher choices over the last century that brings me to my last question.

Why have these Ideological Conflicts Persisted so long after the Clear Integration of Modern Sciences into the Official Curricula?

The argument I have made thus far is that national and local curriculum debates have become arenas for exploring ideological dilemmas over the social purposes of the high school, the priority that science should have in the official curricula, and how science should be taught. These intellectual debates in universities and on editorial pages between traditionalists and progressives of each generation (with teachers largely excluded from the exchanges) were often triggered by economic, social, and political changes in the larger society to which public schools slowly but inexorably responded – industrialization, the Cold War, fears for slipping economic competitiveness. Within the context of an overall ideological system of conflicting social beliefs, rival factions among taxpayers, public officials, university scientists, and top educators each sought to secure their views of what was best for America's children. The official curriculum – or what students are expected to learn – became the forum for those ideological dilemmas to be contested and reconciled.

That has been the pattern since the late-19th century. The Committee of Ten report in 1893, the CRSE report in 1918, and the Cold War-driven reform of the sciences mirror the shifting back and forth in recommended and official curricula between the importance of the sciences as a body of knowledge transmitted to all students and the importance of the sciences as a way of connecting the larger society to students' personal and social development. The sallying back and forth reflects the opposed values of schooling children for their individual growth and for serving larger social ends, of students achieving individual excellence and all students being equitably treated, of seeking self-disciplined youth who are fully socialized into community norms and self-determining youth who can decide for themselves what is best.

What makes these social beliefs into ideological dilemmas is that reformers of each generation, who seek either to preserve or change schools embrace common societal values. They prize both individual freedom and civic responsibility, excellence and equity, socialization and independent thinking. These common beliefs derive from an American political and economic ideology grounded in democratic and market principles that contain the contradictions within which progressives and traditionalists have struggled for generations. Reformers seeking traditional or progressive ends, in other words, belong to the same intellectual and moral family (SANDEL 1996; GUTTMAN 1987).

I am reminded of the epigraph introducing this article of those freezing porcupines drawn together for warmth yet repelled by each other's quills. Again and again they drew apart only to return until they found a comfortable space midway between cold and warmth. They, like perennial traditionalists and progressives, cannot get too close yet both belong to the same species: American school reformer.

Not until the early 1980s, did an apparent reconciliation of these opposing values into the recommended and official curricula, propelled by national anxiety over a changing global economy, occur. In the phrase "scientific literacy", the expressed values of the 1893, 1918, and Cold War curricular reforms seemingly merged. *Science for All Americans*, (1989) National Science Education Standards (1995), and adopted reforms pressed for understanding key scientific concepts, student engagement in the sciences, problem-solving, and independent thinking for all students regardless of whether they were going to college or into the job market.

Note, however, that I am not arguing that the enduring ideological struggle over the official curriculum between traditionalists and progressives fought initially between those who held on to classical subjects and those who championed practical subjects in the mid-19th century and repeatedly throughout the 20th century is finally over. Because competing political and economic beliefs are embedded deeply in the American ideology, future changes will press policy makers and educators to re-do the apparent compromise of the 1990s. Ideological dilemmas will surface again. My confidence in these dilemmas recurring stems not only from the historical patterns I have described but also from their sturdy presence in classrooms for over a century.

The deep and intimate connection between ideological and practical classroom dilemmas reinforces my certainty. What has been argued by public officials, university-based scientists, corporate executives, and top educational administrators in the forums of the recommended and official curricula have been intellectual dilemmas that resonated in teachers' classrooms but were (and are) pursued very differently there because teachers face the practical consequences of their choices while few policy makers, academicians, and public officials ever deal with children after they propose or decide policy.

The taught curriculum resides in the classroom where ordinary teachers, not noted educators or officials, face these dilemmas daily. For it is in the classroom, that microcosm of American values, where conflicts arise. Strong constraints force teachers to make practical choices. No reconciliation of conflicting values has yet occurred in classrooms in the 1990s, as the few surveys of teaching practices have revealed. Of course, teachers are indirectly affected by the ideological dilemmas embedded in policy talk, and revisions in the official curriculum. But what shapes routine classroom practices, far more than policy talk or adopted policies, are the past experiences of teachers as students, their preparation for teaching, their beliefs about teaching, the organizational realities of a high school workplace, and the students that sit in front of them. Because of all of these influences, and because teachers also share in the common democratic ideology of opposing beliefs, they juggle conflicting values and make practical choices that constitute their daily work.

It is these classroom dilemmas that teachers face each time they prepare lessons and meet their students which will continue to create gaps between the other curricula and what teachers teach. It is these classroom dilemmas of the taught curriculum entangled with larger ideological dilemmas that explain why there have been persistent conflicts over the sciences, prior to and since they have been integrated into the official curricula. It is these classroom dilemmas with their internal contradictions that make teachers lay philosophers who share a landscape that we all inhabit. Finally, for all of us who are pushed and pulled in opposing directions in our daily lives, it is these classroom dilemmas that connect us to teachers for we, like them, try so hard to reconcile conflicting values and negotiate, both carefully and clumsily, our dilemmas by making choices and living with the consequences of our compromises.

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