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The Hidden Variable: How Organizations Influence Teacher Responses to Secondary Science Curriculum Reform

FOR OVER A CENTURY, there have been continuous efforts to alter both the content of science education and how it is presented to secondary school pupils. In the closing decade of the 19th century, for example, the prestigious National Educational Association's Committee of Ten, endorsing a science subcommittee's report largely produced by university science faculty, recommended that the secondary science curriculum be formally arranged into separate subjects such as biology, physics, and chemistry. That occurred in the following decades (National Educational Association, 1893).[1]

Shortly afterward, another generation of curricular reformers, driven by new ideas about the integration of subjects, linkages with the community, teaching to build pupils' understanding and reasoning, and the role of school in improving society, tried to overhaul secondary school science content and teaching. By the 1930s, the ideas of these progressive educators had become mainstream thinking, particularly in urban schools (Hurd, 1949; *Thirty Schools,* 1942).

In the early 1950s, another renovation of the science curriculum, midwifed into existence by the National Science Foundation and sped along by the Cold War, lasted into the early 1970s. As with the earlier reforms driven by the Committee of Ten, academics interested in modernizing science content authored new courses and textbooks. Its success in altering both the subject matter and practice of teachers continues to be debated by scholars today (Aikin & House, 1981; Dow, 1991; Welch, 1979).[2]

Finally, in the early 1980s, prompted by a series of national reports on the perceived deterioration of public schools, a number of projects have sought to alter science curriculum and instruction across the nation. Again, university academics have dominated the commissions but far more practitioners and informed citizens have participated in the curricular deliberations than in earlier reform movements (AAAS, 1989; West, 1992).

In this swift trip through the last century of reform in science curriculum, two distinct purposes have vied for attention: to have students know bodies of organized scientific knowledge, and to create a science for living. Of the two aims, the former has dominated curricula since the late 19th century, although the latter purpose has been evident in periodic bursts of reform, especially during the early decades of this century. The dominance of content divided into scientific disciplines is (and has been) obvious in most secondary schools where science subjects are separately taught in 45- to 50-minute periods, and teacher-centered instruction is geared to dispensing scientific information to large groups of students.

The quest to link scientific knowledge to daily life—the second purpose—emerged strongly in the curriculum during the progressive education impulse earlier in this century and occasionally penetrated

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THEORY INTO PRACTICE, Volume 34, Number 1, Winter 1995

0040-5841/95$1.25

classrooms. Places that experimented with reorganizing their school, revising schedules, and inventing curriculum linkages between classrooms and daily life differed substantially from most secondary schools. And in the 1990s, there is another, almost neoprogressive, impulse in the science curriculum toward linking scientific content to daily life (AAAS, 1989; Aikin, 1942; Newman, 1990).

This brief description raises at least one puzzling question: Why did reformers in the past committed to the purpose of creating a science for living find it so difficult to alter the prevailing patterns? This question has many possible answers ranging from the accumulated weight of traditional views of knowledge and teaching to the adequacy of resources, who the students were, the presence or absence of leadership, or to schools merely doing what their patrons wanted done. These are plausible answers and, for some, even convincing ones. However, in preparing this analysis of science curriculum reform, I note one other plausible explanation missing from the literature on improving science curricula in the last century: the influence of district, school, and classroom organization upon what knowledge is taught and how it is presented. Examining this factor may suggest to a current generation of reformers reasons why so many curricular reforms in the past ebb and dissolve over time.

The answer I have constructed to make sense of these repeated efforts to improve secondary school science curriculum and classroom instruction is straightforward:

1. Past and current curricular policies require district, school, and classroom organization to transform information and ideas into teaching practices.

2. The constraints of district, school, and classroom organizations (including cultures) shape to a large degree, but do not wholly determine, how teachers teach science.

3. Coping with these organizational constraints, teachers have invented a practical pedagogy that is tailored to fit their beliefs and classroom practices.

4. Hence, to substantially change current science curriculum and instruction will require shifts in district, school, and classroom organization, culture, and teacher beliefs.

This answer assumes that there is not one but four science curricula in secondary schools that need inspection. The *official* curriculum is what state and district officials set forth in curricular frameworks and courses of study. They expect teachers to teach it; they assume students will learn it. These official curricula increasingly are aligned with state-approved textbooks that teachers are directed to use and state-mandated tests that teachers must administer.

But teachers, working alone in their rooms, choose what to teach and how to present it. Their choices derive from their knowledge of the subject they teach, their experiences in teaching the content, their affection or dislike for topics, and their attitudes toward the students they face daily. In fact, researchers continually find that teachers in the same building will teach different versions of the same course. Thus, the official curriculum and what teachers teach may overlap in the title of the course, certain key topics, and the same text, but can differ substantially in actual subject matter and teaching methods. The *taught* curriculum, then, differs from the official curriculum (Hawthorne, 1992; Oakes, 1985; Page, 1991).

The taught curriculum overlaps with but differs significantly from the *learned* curriculum, or what students learn. Results from paper-and-pencil tests certainly capture a portion of what students learn in a class. Beyond what test scores reveal about learning, students learn to recite, review material, locate sources, seek help, avoid teachers' intrusiveness, and how to act attentive. Collateral learnings, in Dewey's phrase, occur when children pick up ideas from classmates, copy their teachers' habits and tics, imitate their humor or sarcasm, or strive to be as autocratic or democratic as the adults. Thus the learned curriculum differs from the official and taught curricula (Dreeben, 1973; Fenstermacher, 1986).

And what students learn does not exactly mirror what is in the *tested* curriculum. Classroom, school, district, state, and national tests, often using multiple-choice and other short-answer items, do, indeed, capture some of the official and taught curricula. To the degree that teachers attend to such tests, portions of the official and taught curricula merge. But what is tested is a limited part of what is intended by policymakers, taught by teachers, and learned by students. Since so many of these tests seek to sort high achieving students from their lower-achieving peers, the information, ideas, and skills sought on these tests represent an even narrower band of knowledge (Madaus, 1987).

Thus, there are four curricula, not one. Many policymakers and administrators engaged in science

curriculum reform since the turn of the century assumed that the official, taught, learned, and tested curricula were one and the same. By the 1970s, researchers had established clearly that the official and taught differed. In the 1980s and 1990s there is far more attention paid to the taught, learned and tested curricula. I use these distinctions among curricula in elaborating the above argument (Cuban, 1990; Erickson & Shultz, 1990; Jackson, 1990).

Here, then, is an organizational and curricular framework for answering the question: Why did reformers committed to the purpose of creating a science for living find it so difficult to alter the prevailing patterns?

Organizational Influences

But why even explore organizational influences on secondary science curricula? From life experiences, each of us can easily observe that organizations matter. Anyone who has transferred from private industry to the university can talk about how different it is to work for one than the other. Army officers know how battalions in the same brigade and brigades in the same division are very different places in which to work. Similarly, for schools, how activities are organized and members of the organization are governed shapes what occurs daily.

But school organizations are different from business and the military, which have clearly defined products and outcomes: a car manufactured or a hill taken. With schools, defining what they ought to "produce" in their graduates is continually contested. How "good" teaching and "effective" learning occur is ardently debated. Moreover, school board members and their appointed administrators cannot observe directly what teachers do in their classrooms (except when principals occasionally visit) or what students learn (except by monitoring standardized tests). Thus, the technology of schooling (i.e., teaching) is divorced from common managerial controls used to monitor production elsewhere.

Here, then, are organizations that lack consensus on describing the desired product, cannot directly observe the production process, and have trouble explaining how they create products. Such organizations that cannot specify what their key staff must do or what the desired outcomes should be can be called coping organizations or institutions ruled by procedures and beliefs that conform to the expectations of those constituencies that supply political and financial support. The next section analyzes how districts, schools, and classrooms are organized institutionally and their connections to secondary science curricula (Wilson, 1989).[3]

District, School And Classroom Organization

Exactly what formal and informal organizational features affect what and how teachers teach science? In discussing organization, I include how authority is used to govern, the formal building blocks that give structure to the organization, and the informal features that influence how people behave within them, often referred to as organizational cultures. Hence, organizations, as I use the term, include governance, formal structures, cultural processes, and teaching. I begin with the district because each state, the constitutional authority that governs schooling in the United States, uses the district as its political arm to conduct schooling on a daily basis (except Hawaii where the state operates all schools).

In each district, a school board, the policymaking body responsible to the state, hires professional staff, authorizes expenditures, builds schools, sets the curriculum within broad or narrow state mandates, and determines whether its goals are being met. Historically, such decentralized governance of schooling (as compared to centralized control of schooling in European, African, and Asian nations) means about 15,000 school districts in the United States, down from a high of 130,000 in 1931 (Tyack, 1990).

The school board sets the conditions for classroom teaching. Boards determine how schools and classrooms are organized, the funding level committed to the enterprise (influenced increasingly by the availability of state funds), the official curriculum, and staff to implement that curriculum. Governance is the formal side of school boards' influence on classrooms; informally, the district's culture also shapes the degree to which a spirit of tradition or instructional improvement mark schools and classrooms.

By culture, I mean the unexamined, deeply-embedded norms and expectations that district staffs share about performing their central tasks of schooling children. These feelings, values, and patterns of behaving are often unarticulated and passed on to newcomers unobtrusively. For example, many district organizations, especially in big cities, tilt toward centralized,

hierarchical control of school operations. In such districts, major curricular, budgetary, and staffing decisions to implement school board policies often are made at headquarters and each school is expected to comply. The district culture of top-down decision making values efficiency and compliance; such values often seep into schools (McNeil, 1986; Wise, 1979). Informally, many teachers and administrators resist these values and exert discretion when they can (Weatherly & Lipsky, 1977).

Some district boards and superintendents govern schools by more decentralized procedures such as allocating resources to schools and leaving certain curricular and staffing decisions to each school's principal, faculty, or school-site council. Shared decision making at the school site is the norm in such districts. In these instances, the district prizes the values of school autonomy, professional discretion, independence, and experimentation; practitioners realize quickly that their ideas in and out of class are respected (Lightfoot, 1983; Sizer, 1992).

School Organization

A school organization can be analyzed also by its formal and informal structures. The term *structures* refers to the essential building blocks of a school that are often taken for granted; they are seen as the lakes, mountains, wind, and sun of a natural terrain. At the risk of being too obvious, I list these familiar, formal structures to point out that these are not like the wind and sun because they were quite different a century and a half ago and have been adapted to meet changing political, social, and economic needs. In short, they are made and unmade by human hands.

The age-graded school

Imported from Prussia by mid-19th century American school reformers, the age-graded school revolutionized the governance, structures, cultures, and practice of schooling and teaching. These reformers sought to restructure the then current one-room schools and the role of the teacher to fit a new vision for how an industrializing social order and political democracy could provide mass schooling.

The new age-graded, multi-room elementary school in late 19th century cities and towns upended the one-room district school. Now the school had a principal and a separate classroom for each teacher. Children were grouped by age and attended for 8-9 months a year. The subject matter of the curriculum was divided into grade-level chunks, and each year, the teacher decided who should be promoted to the next grade or be kept back for another year. These were fundamental changes in the organization and delivery of schooling (Angus, Mirel, & Vinovskis, 1988; Fuller, 1982; Tyack, 1974).

The implicit theory underlying the age-graded school is that educational quality, efficiency, and equity come from uniformity. If a teacher teaches a group of students for a certain amount of time, according to the theory, almost all of these students will learn the required amount of knowledge at roughly the same rate and will move on to the next teacher. Those who do not keep pace will take longer to learn the standard course of study.

By the early 1900s most urban school districts had reorganized their schools into age-graded schools. The new organizational form was *the* only way to design schooling and, except for sporadic (and largely failed) attempts to introduce nongraded schooling, has since remained the prevailing form of district-wide elementary and secondary school organization across the nation. How do age-graded school structures influence the actions of both adults and children in schools (Goodlad & Anderson, 1987; Kaestle, 1983; Tyack, 1974)?

Differentiated curricula, schedules, tests

The structure of age-graded schools (e.g., self-contained classrooms, a curriculum divided up into chunks for each level, 50-minute periods in secondary schools, and tests constructed by the district, school, or teacher) derived from the basic imperatives of public schooling: to manage in an orderly manner masses of students from varied backgrounds and motivations who were compelled to attend school and absorb certain knowledge.

Teacher norms and expectations also flowed from these imperatives. Because the building itself isolated teachers from one another, this further complicated monitoring and hindered collaboration; teachers came to expect little supervision. The age-graded school created norms of teacher self-reliance and solo practice. The differentiated curriculum increased the isolation.

A differentiated curriculum also refers to the varied official courses of study in comprehensive secondary schools containing three or more sets of

courses (e.g., college preparatory, commercial, vocational, and general or regular courses of study) that were packaged to appeal to students and their parents who sought varied job and career futures after graduation. Within the differentiated courses of study, separate disciplines dominated what was offered. In the college preparatory curriculum, for example, 10th graders would take biology, 11th graders chemistry, and 12th graders, physics (Bidwell & Dreeben, 1990; Krug, 1964; Oakes, 1985; Powell, Farrar, & Cohen, 1985).

To manage differentiated curricula, administrative procedures had to be put into place. The adoption of the Carnegie Unit in the early 20th century led to school administrators dividing the school day into equal chunks of time (45- to 50-minute periods). The resulting multi-period day in secondary schools made it possible for students to collect many different subjects and credits for graduation, but it played havoc with laboratory courses requiring double periods so that science labs could meet college standards (Tompkins & Gaumitz, 1954).

Teacher-made, district-designed, and state-required tests became increasingly critical milestones in a student's school career. To move from one grade to another and from one subject to another required some evidence that content and skills designated for that grade or subject had been absorbed by pupils. Test results met that need. Thus, the procedural regularities of school bells, 45-minute periods, and frequent tests grew out of the structural demands of differentiated curricula in the age-graded school. Similar regularities arose in the classroom from these formal structures.

Classroom Organization

The central feature of secondary school buildings is that they contain separate classrooms for one teacher and 25-35 students of approximately the same age who must spend about one hour daily in a room. Within this one classroom, the teacher, like colleagues in other rooms within the school, is expected to maintain control, teach certain subject matter, motivate students to learn, vary levels of instruction according to student differences, and display evidence that students have performed satisfactorily.

Considering these many demands generated by the structure of a self-contained classroom, teachers who survive beyond the initial years have learned to ration their energy and allocate their time carefully. More importantly, they have invented and polished a repertoire of teacher-centered instructional practices that have emerged as resilient, imaginative, and efficient solutions to dealing with a crowd of students in a small space for extended periods of time. They have created a practical pedagogy that reconciles the dilemma of two conflicting values: maintaining order within a classroom and getting students to learn subject matter and skills they would not ordinarily learn elsewhere. From this practical compromise, teaching regularities have arisen (Cuban, 1984; Doyle, 1986; Goodlad, 1984; Sarason, 1971).

Arranging desks into rows and using seating charts, for example, permit the teacher easy surveillance of pupils to maintain order. Teacher-established routines for students raising their hands to answer questions and to speak only when recognized by the teacher establishes a framework for whole-group instruction. Students asking permission of the teacher to leave the room silently underscores a teacher's authority and satisfies the imperative of maintaining classroom order.

Moreover, teaching the entire class at one time is simply an efficient and convenient use of the teacher's time—a valuable and scarce resource—to cover mandated content and to maintain control. Lecturing, recitation, seatwork, homework drawn from texts, and weekly tests made up of multiple choice items are other efficient, routine ways of transmitting subject matter to groups and determining whether students have learned the material. These practical regularities grow out of the larger expectations that teachers strive to meet and the demands of the classroom as a workplace. Teachers, then, learned to manage the situational dilemmas imposed by this structure, over which they had little control, by inventing creative compromises in the shape of teacher-centered instructional practices

Other pedagogical approaches, where students work alone or in small groups, move freely around the room, and leave the room and school to learn in other settings, in the minds of most teachers, disrupts classroom routines geared to efficiently handling batches of students. Of greater importance to teachers is that such student-centered activities violate many—but not all—teachers' deeply-held beliefs and values about how teaching should occur, the importance of students absorbing subject matter, and how pupils should learn.

Shifting the center of gravity from a teacher-centered classroom to one in which teachers and students share responsibility for learning is substituting one set of beliefs for another. Student-centered approaches disturb the regularities of a practical pedagogy tailored to the contours of self-contained classrooms. Such practices are incompatible with existing norms, expectations, and beliefs held by most teachers about their authority to govern and the organizational structures within which they work. Such a shift in classroom cultural values would require a complete overhaul of the teacher's roles (e.g., from captain of the ship to coach; from information-giver to question-asker) and basic modes of classroom operation (Cuban, 1993; Sizer, 1984).

School and Classroom Cultures

Of course, school and classroom practices vary. Not all schools are alike nor do all teachers teach alike. But the dominant tendencies in school and classroom regularities as I have described them are well documented. What helps account for the variation is organizational cultures and individual differences among teachers (Cuban, 1991; Goodlad, 1984; Sarason, 1971).

Culture—those deeply-ingrained, patterned responses to familiar and new situations mirroring common basic values held by group members—matters. Teaching kindergarten or high school chemistry matters. The ways high school teachers are trained in the disciplines and how they are organized into departments also matter. In elementary schools teachers are, by and large, far more willing to work together and share ideas than in high schools. There is more sensitivity to the emotional and social development of children than, again in general terms, in high schools.

For example, within high schools one dominant value among teachers is prizing the freedom to act as a solo practitioner who closes the classroom door and teaches a class unimpeded by supervisors, other teachers, or community members. When that value gets wedded to the common belief among teachers trained in subject-matter disciplines that students must learn content first before they can analyze and solve problems, instructional practices get shaped quietly and powerfully. Such values and beliefs stitched together with others make a school culture that influences both school-wide and classroom behaviors in such important matters as, for example, responding to innovations imported from outside the school (Cohen, 1989; Feiman-Nemser & Floden, 1986; Lortie, 1975).

Finally, each teacher creates a mini-culture in his or her classroom with rules for students, ceremonies, activities, and behavioral and academic expectations quietly and informally expressed. Each classroom, like each individual, becomes a distinctive personality because each teacher's experiences, beliefs, and values vary. A Jaime Escalante, Vivian Paley, Eliot Wigginton, Chris Zajac, and James Herndon create classrooms very different from one another (Herndon, 1968; Kidder, 1989; Mathews, 1988; Paley, 1979; Wigginton, 1985).

Yet even with these individual variations across classrooms within the same school, most teachers share beliefs about what they ought to do in their classrooms and what is best for students. These shared beliefs run like a bright red ribbon throughout a school tying together adults and children. So, cultures, organizational structures, and individual teacher beliefs matter in understanding how classroom practices have come to be as they are.

Now, I briefly turn to the present-day moment of science curricular reform to see where it fits into previous efforts to improve science content and pedagogy and its assumptions (both explicit and implicit) about the influence of district, school, and classroom organizations.

Science Curricular Reform In The 1990s

In *Science for All Americans* (AAAS, 1989), a document that guides Project 2061 and has influenced many contemporary science curricular reforms, the purpose of creating a science for living is vigorously and unapologetically stated. The current phrase for that purpose is "scientifically literate." Without reference to earlier efforts of progressive educators who shared a similar purpose, The American Association for the Advancement of Science (AAAS) endorsed a wholesale overhauling of the official, taught, learned, and tested curricula. The AAAS was less interested in constructing marginal changes in existing structures; they sought fundamental changes in what science content is taught, how it is taught, and what is learned and tested.

Other science efforts to create content and assessment standards are similarly motivated by a neoprogressive purpose of creating a science for living.

What has become obvious in the rhetoric and prescriptions for science education reform is that the official curriculum contains neoprogressive assumptions. However, in the desire to shift from age-graded to nongraded schooling and from teacher-centered activities to cooperative learning activities, what appears to be missing is an awareness of how powerful organizational influences have frustrated such changes in the past. The absence of serious attention in these documents to strategies in countering the powerful influences wielded by district, school, and classroom organizations and teacher beliefs suggests again that amnesia about earlier (and similar) reforms will simply create more rather than less complications in altering the taught and learned science curriculum (Gardner et al., 1990).[4]

Notes

The preparation of this article and the research reported in it were supported in part by the National Center for Science Teaching and Learning under a contract with The American Association for the Advancement of Science. Any opinions, findings, conclusions, or recommendations expressed in this article are those of the author and do not necessarily reflect the views of the sponsoring agencies.

I gained a great deal from comments on an earlier draft from Mike Atkin, Paul Hurd, and Mary Budd Rowe. My thanks also to Robert Donmoyer for his insistence that this be written.

1. I focus on secondary school science because as I read the history of science curricular reforms over the last century, it is the concern over the high schools that dominates definitions of the problems, particularly preparing students for studying science in college. The impact of college admission standards upon secondary school curriculum has been noted fully and frequently. Solutions invariably focused upon subject matter taught in secondary schools. Nature study in elementary schools was aimed at an appreciation of nature and rural life; nature study never found a grip-hold upon secondary school science.

2. Note further that not all the sciences taught in secondary schools followed the pattern I described for the various decades. In physics, for example, the science for life purpose was a post-World War II phenomenon rather than occurring in the pre-World War II period as with other science subjects, according to Donahue (1993). "Unlike other subject areas that were altered by progressive notions of making education relevant to a variety of student interests and needs," Donahue writes, "physics was still most heavily influenced by the single goal of preparing students for college. In fact, most high school and college freshman physics classes used the same text." When "kitchen physics," and "everyday physics" texts were used in the 1950s and teachers' questions such as "What is the coefficient of friction between an automobile tire and the road?" were common, the motive often was to boost sagging enrollments in physics, a decline that had begun before World War II (Donahue, 1993).

3. For the description of institutional organizations where procedures and beliefs conform to social beliefs and are loosely linked to what happens in schools and classrooms, see Meyer & Rowan (1978) and Weick (1976).

4. In a fine collection of papers delivered at a 1988 conference of leading researchers deeply involved in science education reform, one of the 16 papers (12 pages out of a book of 339) deals with the social organization of the school and its consequences. None deal directly with the question of organizational influences on curriculum or instruction. Nor is there a listing for "organization" in the index (Gardner et al., 1990).

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