Curriculum Change in Science: Power and Processes

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KNOWN as the "revolution in education" and the "curriculum reform movement," rapid curricular change has, in a single decade, become an accustomed style of educational life. Revolutions often pursue new directions in midstream. When this happens, the causes that precipitated the revolution and the identity of those persons providing the original impetus for change may become obscure. Thus, the early call to arms, "science for survival," is rarely heard now that the educational revolution has become an accepted part of the educational scene.

In 1958 the "critical areas" of the curriculum, in terms of national purpose, as set forth in Title III of the National Defense Education Act, were science, mathematics, and modern foreign languages. They were subsequently broadened to include other curriculum areas because: (a) it is impossible to establish "emergency priorities" on an indefinite basis; (b) the scientists had achieved the goal of having their subject matter receive powerful and long-range federal support; (c) those representing curriculum areas excluded from support began agitating for inclusion; and (d) with curriculum reform projects well under way in the original three "critical areas," those who held the mandate for change did not regard similar changes in other fields as a competitive threat.

As the national defense goal for curriculum change faded into the background, this urgency began to appear unrelated to the current character of curriculum change. However, as will be determined in the course of this article, the identity of the dominant forces initiating curriculum change for more than a decade has not changed.

Analyzing Change in Science

Who initiated science curriculum change? What were the sources of their power and the methods of their influence? Who participated in the change process? Toward which aspects of the curriculum were change efforts directed? What have been some consequences of change efforts? What follows is an attempt to identify the major influences in effecting curriculum change in science. The analysis is based on Gordon N. Mackenzie's instrument for conceptualizing the process of curriculum change.[1]

[1] Gordon N. Mackenzie. "Curricular Change: Participants, Power, and Processes." *Innovation in Education*. Matthew B. Miles, editor. New York: Bureau of Publications, Teachers College, Columbia University, 1964. pp. 399-424.

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The change process, as systematized by Mackenzie, defines the curriculum as the engagements of learners with aspects of the environment which have been planned under the direction of the school. The targets for change are the components or determiners of the curriculum: teachers, students, subject matter, methods, materials and facilities, and time. Change takes place in the cultural context of the school; indeed it seems to be increasingly brought about by influences from the culture. Concern with the science curriculum was a national, state, and community concern stemming from a larger concern involving American-Soviet relations. Thus a condition of national insecurity resulted in pressures for curricular change in science.

The individuals and groups who bring about change in the curriculum are the *participants* in change. By their actions they can influence or control the components of the curriculum which determine learners' engagements. Participants in the change process are classified as internal and external. Internal participants are students, teachers, principals, supervisors, superintendents, boards of education, citizens in local communities, state legislatures, state boards or departments of education, and state and federal courts. (It is to be noted that students and teachers play a double role as both determiners of the curriculum and participants in change.)

External participants are noneducationists, foundations, academicians, business and industry, educationists, and the national government. They are able to exert considerable influence (by invoking sanctions and raising expectations) on participants who can influence the determiners of the curriculum directly. The dominant source for curriculum change in the decade from 1958-1968 has been external participants.

A relatively recent development is the combining of resources from groups of external participants to form corporations for developing curriculum materials. Educational Services Incorporated, originally established to administer the Physical Science Study Committee and other curriculum projects, is the largest of these corporations. ESI has merged with a smaller organization, the Institute for Educational Innovation, and has been renamed the Educational Development Center. This is also one of the Regional Educational Laboratories authorized by Title IV of the Elementary and Secondary Education Act of 1965.

The Educational Development Center has received monies from the following donors: the National Science Foundation, the Agency for International Development, the Ford Foundation, the Peace Corps, and the Office of Education.[2] By January of 1968 EDC had 10 curriculum development projects in operation and several more in prospect.

The process of influencing others to change is a political process and is based on power. One of the most important bases of power is the prestige of the individual or group exerting influence for change. Power also accrues from the competence or personality of an individual, the control of money or goods, legal authority in respect to education, and collaboration among individuals and groups having similar assets and objectives. (The curriculum corporation just described is an instance of this last means of extending influence.)

The Power Behind Change

Dissatisfaction with existing conditions in science education and action to remedy the situation became a public policy matter within weeks after the Japanese surrender in 1945. Exerting influence in favor of revising and rejuvenating science education by means of sizeable injections of federal support were the nation's leading scientists, a group newly elevated in prestige because of its members' awesome contribution toward ending the war.[3] A number of scientists and science-administrators, well known for their competency, including Conant, Rabi, Bush, Compton, and Shapley, testified at Congres-

[2] Educational Development Center. *Annual Report, 1967*. Newton, Massachusetts: Educational Development Center, 1967. p. 77.

[3] Ralph E. Lapp. *The New Priesthood*. New York: Harper & Row, Publishers, Inc., 1965. p. 61.

sional hearings on the proposed National Science Foundation that categorical aid should be given to education in science.[4]

The first scientist-scholar to make a specific proposal for curriculum reform in science was Jerrold R. Zacharias, a physicist at the Massachusetts Institute of Technology. With the cooperation of James R. Killian, Jr., President of MIT, Zacharias formed the Physical Science Study Committee. Both Zacharias and Killian are officers of the Educational Development Center which, as was mentioned, was formed in 1958 to administer PSSC and subsequent curriculum projects.

A not insignificant source of their power was that, as members of President Eisenhower's Science Advisory Committee, Killian and Zacharias were ideally situated for influencing the executive branch of the government on matters of science education policy. (In fact, Killian was special assistant to the President for science and technology.) Their influence on the President in this regard is a matter of educational history. In a speech made in Oklahoma City in November 1957, President Eisenhower declared that his scientific advisers were deeply concerned by the rising standards in Soviet science education.[5] "According to my scientific advisers, this is for the American people the most critical problem of all," he said.[6] The President said that we needed "a program to stimulate good-quality teaching of mathematics and science; provision of more laboratory facilities; and measures, including fellowships, to increase the output of qualified citizens."[7] These have been focal points of concern of the National Science Foundation and the National Defense Education Act (which was passed within a few months after the Oklahoma City speech).

In addition to influencing the President, who then exerted pressure on the Congress to pass the legislation, leading scientists also testified about the need for change at hearings on the 1958 legislation. Man's instinct for survival is his most powerful one. Physical scientist witnesses testified that our personal and national survival hinged upon special aid for education in the physical sciences and mathematics. The question of the danger of a possible resulting imbalance in the curriculum was brushed aside as inconsequential in the face of a greater danger.

Physicist Lee DuBridge, then President of the California Institute of Technology (and now Richard Nixon's science adviser), and M. L. Trytten, also a physicist and Director of the Office of Scientific Personnel, National Academy of Sciences, spoke of "soft spots" and "rotten spots" in the existing curriculum.[8] Both urged that Congress provide funds to stimulate learning in the sciences. DuBridge urged the Congress "not to be misled by fears that are unfounded or, at least, very remote" that "we may get too much emphasis on science."[9] Trytten testified that federal support was needed and well-justified for science teaching facilities and that support for teacher training programs at the secondary school level should be confined to programs in science, mathematics, and foreign languages.[10]

The bases of power of those advocating change in the science curriculum were their prestige and competence. The former gained them the ear of the executive and legislative branches of the federal government, as well as the large foundations, which appropriated the support needed to carry out change on a

[4] United States Congress, Senate, Military Affairs Committee. *Hearings on Science Legislation.* Hearings before Subcommittee, 79th Congress, 1st Session, on S. 1297 and Related Bills. Washington, D.C.: Superintendent of Documents, U.S. Government Printing Office, 1945.

[5] "Our Future Security." Address by President Eisenhower at Oklahoma City, Oklahoma, November 13, 1957. In: *Science and Education for National Defense.* U.S. Congress, Senate, Hearings before the Committee on Labor and Public Welfare, 85th Congress, 2nd Session, on Science and Education for National Defense. Washington, D.C.: Superintendent of Documents, U.S. Government Printing Office, 1958. pp. 1357-61.

[6] *Ibid.*

[7] *Ibid.*

[8] United States Congress, Senate, Labor and Public Welfare Committee. *Science and Education for National Defense.* Hearings before Committee on Labor and Public Welfare, 85th Congress, 2nd Session, on Science and Education for National Defense. Washington, D.C.: Superintendent of Documents, U.S. Government Printing Office, 1958. p. 53 and p. 577.

[9] *Ibid.*, p. 42.

[10] *Ibid.*, pp. 580-84.

mass basis. By cooperation and collaboration, those advocating change were able to engage in corporate ventures for developing science curricula. Thus their power for influencing persons directly connected with the curriculum was strengthened.

Focal Points for Change

Change efforts in science have been directed at all six determiners of the curriculum. No determiner has been regarded as the single key to changing the curriculum by those exerting efforts for change in science by means of federal resources. The approach to change at the national level reflects the view that the determiners of the curriculum are interrelated and that this interrelationship must be considered in programs to effect change.

Thus the two-pronged attack has been focused on two combinations of determiners: teachers, students, methods, subject matter, and time, on the one hand (NSF); and teachers, students, methods, materials and facilities, and time on the other hand (NDEA). The major emphasis of the first effort has been on teachers, subject matter, and methods, and emphasis of the second has been on students and equipment (materials). And of no small importance to both efforts was the legal designation of science as a "critical area" for our nation's defense—thus making change in the science curriculum the law of the land.

Some Unanticipated Effects

One not unimportant outcome of the change process is that frequently there are consequences other than the purpose for which change was intended.[11] Perhaps the most widely known of these in connection with change in science is that, despite vast sums invested in changing traditional high school physics programs and attempts to induce youth to embark upon careers in science, enrollments in physics are dropping. U.S. Office of Education figures (1966) reveal that 19.6 percent of all public school twelfth graders were enrolled in a first year physics course in 1964-1965, whereas 21.2 percent were so enrolled in 1960-1961 and 25.8 percent in 1948-1949.[12,13]

This unplanned-for outcome of the "revolution" in physics is evidence that curricular change, particularly the kind involving such deeply-ingrained traditions as freedom of career choice, involves specific culture change. Since cultures are systems of interdependent forces, those seeking change in one part of the system must move with caution, lest a favorable change in one area result in adverse side effects in other areas. Those initiating change in physics proceeded to alter specific aspects and objectives without bothering to consider that something else might result that could leave conditions worse than they were in the beginning.

A second side effect is that the dominant initiators of "the curriculum reform movement" now hold the mandate for change. Each succeeding year of collaboration between research scientists, mathematicians, and other academicians, on the one hand, and large private foundations, federal educational agencies, textbook publishers, and testing organizations, on the other hand, has further institutionalized this approach to curricular change.

In 1959 Campbell observed: "We may be delegating our long-range planning to those who give grants and who cannot really be held publicly accountable."[14] This is precisely what has happened. Because they have no legal connection with the educational system, those who now hold the mandate for change cannot be held accountable for the results of their efforts. □

[11] Mackenzie, *op. cit.*

[12] F. Boercker. "Enrollments in Public High School Science by Type of Course and by Sex, 1964-1965" (preliminary data). Washington, D.C.: National Center for Educational Statistics, November 1966.

[13] U.S. Office of Education. *Digest of Educational Statistics*. Washington, D.C.: Superintendent of Documents, U.S. Government Printing Office, 1967. p. 32.

[14] Roald F. Campbell. "Antecedents and Expressions of Educational Policy at the National Level." *Educational Research Bulletin* 38: 150; September 9, 1959.