DOCUMENT RESUME

ED 330 103 EA 022 837

AUTHOR	Armstrong, Jane; And Others
TITLE	Designing State Curriculum Frameworks and Assessment Programs To Improve Instruction. ECS Working Papers Series.
INSTITUTION	Education Commission of the States, Denver, Colo.
SPONS AGENCY	National Science Foundation, Washington, D.C.
PUB DATE	Apr 89
CONTRACT	865-0060
NOTE	37p.
PUB TYPE	Reports - Research/Technical (143)
EDRS PRICE	MF01/PC02 Plus Postage.
DESCRIPTORS	*Curriculum Design; Curriculum Development; Educational Assessment; Educational Improvement; Elementary Secondary Education; Evaluation Methods; *Science Curriculum; State Curriculum Guides; State Programs; Textbook Selection

ABSTRACT

In a study designed to determine the impact of state curriculum initiatives on curriculum framework, student assessment, and textbook adoption in the science curriculum, researchers interviewed state education agency staff, completed four case studies in four districts, and surveyed 100 school districts at random in each of the three diverse states sampled. Following a detailed summary of document contents, this document uses the survey results to identify and describe the impacts of state initiatives on science curricula. The development, design and specificity, and dissemination of state curriculum frameworks are discussed and state assessment programs are examined in terms of content alignment, scoring metrics, sampling items, teaching to the test, item content, and investigative instruction. State textbook adoption policies are discussed in terms of curriculum and framework alignment, resources for textbook training and selection, and adoption incentives and five strategies related to curriculum change implementation and technical assistance are described. State initiatives are shown to have either neutral or positive impacts on science curricula. A final section discusses the implications of study results for state policy. (4 references) (CLA)

EA

ecs working papers

Published by the Education Commission of the States

Designing State Curriculum Frameworks and Assessment Programs to Improve Instruction

Designing State Curriculum Frameworks and Assessment Programs to Improve Instruction

By

Jane Armstrong, Education Commission of the States

Alan Davis, RMC Research Corporation

Allan Odden, University of Southern California

James Gallagher, Michigan State University

April 1989

EDUCATION COMMISSION OF THE STATES
1860 Lincoln Street, Suite 300
Denver, Colorado 80295

This report is based on a study by the Education Commission of the States funded by the National Science Foundation (Grant Number 865-0060). The views expressed here do not necessarily represent those of the National Science Foundation.

Copies of this book are available for $6.50 from the ECS Distribution Center, Suite 300, 1860 Lincoln Street, Denver, Colorado 80295, 303-830-3692. Ask for No. SI-89-5.

The Education Commission of the States is a nonprofit, nationwide interstate compact formed in 1965. The primary purpose of the commission is to help governors, state legislators, state education officials and others develop policies to improve the quality of education at all levels. Forty-eight states, the District of Columbia, American Samoa, Puerto Rico and the Virgin Islands are members. The ECS central offices are at 1860 Lincoln Street, Suite 300, Denver, Colorado 80295. The Washington office is in the Hall of the States, 444 North Capitol Street, Suite 248, Washington, D.C. 20001.

It is the policy of the Education Commission of the States to take affirmative action to prevent discrimination in its policies, programs and employment practices.

TABLE OF CONTENTS

SUMMARY

Interest in science education is mounting in the United States and state governments are moving to influence curriculum content, selection of instructional materials, assessment of student achievement and other policies central to the instructional process. Because of this, the National Science Foundation (NSF) funded the Education Commission of the States (ECS) to study the effect of state policies on the science curriculum. ECS studied the design and use of state policies related to curriculum frameworks, student assessment and textbook adoption; state implementation strategies; and the local conditions that facilitated implementation. It also analyzed the implications for state policy.

ECS looked at the impacts of these policies in three states chosen to represent varied mixes of policies and a continuum of state control of education versus local control. Researchers interviewed personnel in each state's department of education and four of its school districts. These interviews became the basis of case studies and cross-site analyses. A survey based on case-study findings subsequently was sent to a random sample of curriculum supervisors in 100 districts in each state.

Impacts of State Initiatives

In the three states studied, there was little evidence that state science activities produced negative impacts. Impacts instead ranged from neutral to positive, and neutral impact was frequently, though not always, found in districts that already had science programs of unusually high quality. Though the researchers expected to hear concern about state control and negative reactions to testing, they found little evidence of either.

- In many districts, state initiatives produced greater local emphasis on science.
- Many districts used state science frameworks to revise their own curricula and to train teachers.
- State involvement either improved the quality of science materials or produced no change.
- State activities strengthened administrative ties between schools and districts.
- State initiatives significantly increased hands-on instruction.
- State testing encouraged districts to emphasize science but did not result in "teaching to the test."

Design of Initiatives

A central finding of the study was that using curriculum frameworks, assess-ment, textbook selection and technical assistance in a highly coordinated and conceptually coherent fashion powerfully affects the quality of instruc-tion. Though the design of particular initiatives in the three states varied significantly, the experience of all three supported that central finding.

Variations in Curriculum Frameworks

Impacts were related to:

- Who was involved in the development of the frameworks
- How many people were involved
- How national resources or expertise was tapped
- How successfully the framework was disseminated

Variations in Assessment

All three states administered multiple-choice tests to students in selected grades. Where two of the states used their curriculum frameworks to guide test construction, the third state instead continued to use a commercially available norm-referenced test less well-fitted to the curriculum. Impacts were related to:

- How well the test content was aligned with the curriculum framework
- Whether the state assessment referenced norming samples or a mastery criterion
- The opportunity to teach to the test

Variations in Textbook Selection

Though one state allowed districts to choose their own textbooks, the other two states centralized the textbook adoption process. Impacts were related to:

- How well the textbook selection criteria supported the curriculum framework
- Available resources and training provided for the selection process

- The provision of financial incentives for districts to select from the state adoption list

Variations in Implementation

Implementation was facilitated in the three states when:

- State curriculum frameworks were widely disseminated to school and district personnel
- Educators throughout the state were involved in the development of the curriculum frameworks or regional conferences related to their use
- States used regional service centers to provide technical assistance to districts to promote implementation over a period of time
- Title II funds were used for teacher training
- Implementation was coordinated with other school improvement or accountability efforts

Local Conditions That Facilitated Impacts

Where the impact of state policies to improve the science curriculum was high, the following conditions tended to prevail.

- An accountability pressure resulting in a district's or school's strong desire to do well on a state assessment
- District leadership and commitment to teaching science
- A match between a state framework and district philosophy or willingness by a district to "buy in" to the state philosophy
- Centralization at the district level of science curriculum and instructional materials
- Teacher involvement in developing curricula to support the state framework
- Availability of textbooks, hands-on materials, activity kits
- The presence of a district science supervisor or of lead teachers
- Training and assistance of teachers

- Monitoring of implementation by district and school leaders

Among the districts where the impact of state policy was low -- where state initiatives caused few changes in curriculum and instruction -- were those that already had very strong science programs, rejected the philosophy of the state framework or were focusing on other priorities.

Implications for State Policy

General Strategies

- Impacts are greatest when states integrate curriculum frameworks, student assessment and textbook selection, with the framework at the core. Curriculum frameworks should be developed first, and revision cycles should begin with the curriculum.
- Direct, regular communication between curriculum units and assessment units is essential. These units should be housed close to each other and placed under a single upper-level administrator.
- Some of the subject-matter experts who develop curriculum frameworks should also develop assessments and criteria for textbook selection.

Curriculum Frameworks

- Frameworks should reflect the thinking of leading national organizations such as the National Science Foundation, American Association for the Advancement of Science and National Science Teachers Association.
- Though the participation of influential districts in the development of frameworks is important, quality should not be compromised to achieve broader participation.
- Objectives must be broad enough to channel instruction, not so specific that instruction becomes atomistic.
- Adherence to frameworks should be optional.

Assessment

- Assessment and state science objectives should be aligned so that impacts are greater and more positive.
- Test results should be reported by schools to provide an appropriate level of accountability.

- To avoid "teaching to the test," test items should not be repeated year after year and tests should be kept secure.

- Performance testing may promote activity-based instruction more effectively than short-answer formats.

Textbook Selection

- States and national organizations should together develop a core curriculum in science.

- Textbooks should reflect the current goals of science, such as everyday applications, technology and society, the process of science and ethical issues.

- Criteria for textbooks should reflect the state curriculum framework.

- Sufficient resources should be allocated to textbook selection.

- Districts should have financial incentives to purchase state-adopted textbooks, which fosters curriculum/state framework alignment.

Dissemination, Implementation, Monitoring

- Strategies for disseminating the state science framework should be comprehensive.

- Districts should receive discretionary resources to aid implementation.

- States should provide districts with technical assistance in teacher training and curriculum implementation.

- States should sponsor regional centers that aid implementation.

- Monitoring should be done through regulations or incentives to promote implementation.

Content

States should:

- Establish broad goals for science education.

- Identify a "core" of science knowledge that should be taught to all students.

- Continue to support the development of new curriculum materials.
- Develop a national directory of exemplary science programs.

Professional Community

The professional education community should:

- Support professional activities and leadership development in the science-education community.
- Develop and support a cadre of district curriculum specialists and lead teachers who can serve as resources in large school districts.
- Fund the development of the component of the National Board for Professional Teaching Standards that assesses science teachers.
- Help make science a high priority by linking it to other formal and informal science activities.

INTRODUCTION

Few policy makers understand how much effect the design of state curriculum frameworks and assessments have on improving curriculum in school districts. Because almost every state has an assessment program and some type of curriculum framework (also known as curriculum guides or objectives), state policy makers must realize the implications of their decisions regarding the development and design of related state initiatives. This analysis for state policy makers presents different design options for curriculum frameworks and assessment programs and examines their impacts on school districts.

Information is based on an ECS study of state initiatives of curriculum frameworks, student assessment and textbook selection in three states. The states were selected to represent state versus local control and different designs of initiatives and strategies for implementation (for anonymity, they will be referred to as the Western State, Midwestern State and Eastern State). Researchers interviewed staff in each state education agency to develop a description of the state initiatives and their intended use by school district personnel.

Case studies were completed in four diverse school districts in each state to understand how the state initiatives were being used, their impacts on improving curriculum and the local conditions that facilitated any impact. One hundred school districts in each state then were randomly surveyed to see if the impacts found in the four districts were prevalent throughout the state.

Science curriculum was chosen as the focus of this study because of its interest to the funding agency, the National Science Foundation; the considerable attention it has received as the cornerstone of the nation's technological and economic competitiveness; and the urgent need to improve the dismal achievement scores of U.S. students on national and international science comparisons.

Science also has a unique place in the K-8 curriculum. Historically, it has taken a back seat to reading and mathematics and is taught by teachers who are frequently not highly trained in science or supported by district expertise. Yet, science is considered by most educators to be an important part of the curriculum. This paradox makes the science curriculum an ideal subject for study because state policies and initiatives have a more visible impact in subject areas in which districts and teachers lack expertise and have a strong self-interest in using state resources to improve their curriculum.

In an era of state reform and an increasingly prominent role in improving education, **the study found that state initiatives had either neutral or positive impacts.** In districts where the state influence was neutral, there frequently were existing programs of unusually high quality and the state initiatives did not prompt improvements. Although researchers expected to hear concern about increasing state control and negative reactions to testing or to the imposition of a state curriculum, there was little evidence to support this. The impacts found were:

- **In many districts, state initiatives produced greater local emphasis on science.**

  No district reported a decrease in elementary science instruction. In the Western State, 69% of survey respondents (directors of instruction) reported increases and attributed them to state action; in the Midwestern State, 39% reported increases, and, in the Eastern State, 23%. None of the three states mandated minimum minutes of science instruction, and none lengthened the school day; increases in science instruction resulted from decreases in other areas of instruction.

- **Many districts used state science frameworks to revise their own curricula and to train teachers.**

  More than one-third of the districts surveyed changed their science curriculum as a result of state frameworks; more than 85% of the districts that made changes reported that they provided training to help teachers make the changes. In the Eastern and Midwestern States, districts with fewer than 3,200 students were less than half as likely to have changed the curriculum as districts with more than 15,000 students. Only one district made no effort to change its own curriculum because it objected to the philosophy of the state framework.

- **State involvement either improved the quality of science materials or produced no change.**

  Seventy-three percent of districts in the Western State associated an improvement in instructional materials with state initiatives. The percentage reporting improvement was smaller in the Midwestern State (39%) and Eastern State (34%), but no respondent reported a decline in quality.

- **State activities strengthened administrative ties between schools and districts.**

In all districts where the impact of state activity was high, staff development was centrally coordinated. Science curriculum specialists generally found themselves empowered by the new importance attached to science. Although the greater influence of state depart-ments of education and science specialists limited the discretion of teachers to some extent, the teachers interviewed generally supported the need for a common basis for staff development, materials acquisition and instruction.

- **State initiatives significantly increased hands-on instruction.**

  Because classroom investigations and development of the "process skills" of observing, measuring and using evidence were curriculum objectives in all three states, the teaching of science through inquiry increased dramatically. In many cases, though, the hands-on activities described by teachers were their own demonstrations rather than student-led inquiry.

- **State testing encouraged districts to emphasize science but did not result in "teaching to the test."**

  Testing appeared to affect the broader features of instruction rather than the specifics. Teachers described state science tests as a "placeholder for science," for example, and few of them indicated familiarity with specific test items.

The three states selected for this study represented a range of approaches that states can employ to improve the science literacy and preparation of students. Four aspects of state science initiatives were analyzed: design of curriculum frameworks, science assessment, textbook selection and technical assistance. The study found **that a state effort that employs all four of these elements in a highly coordinated and conceptually coherent fashion is a powerful tool to affect the quality of instruction in schools and districts.** Because of its power, such a state-directed approach has the potential for significant harm as well. While the Western State, for example, appeared to be using directive state leadership in curriculum to bring about substantial improvements in science education, there can be no assurance that this approach would not be harmful if used in a different state context.

State Curriculum Frameworks

Forty-seven states have developed or adapted frameworks that range from very general recommendations to well-articulated and comprehensive guide-lines that integrate curriculum development, textbook adoption and teacher training. The purposes of these frameworks are diverse. Initially, states developed them to provide a basis for uniform instruction and to define some minimal level of curriculum content, quality and appropriateness.

Frameworks have also served as a useful model for small districts which do not have the resources to develop their own. State frameworks help districts plan or revise their curricula with a philosophy of instruction that is consistent with the state's intent. Finally, with the opportunity to align their curriculum with the state assessment, many states have developed frameworks to reflect state-of-the-art trends and "lead" the curriculum, usually emphasizing higher-order skills and assessing a range of skills.

Four events or characteristics of curriculum frameworks had a bearing on their use and impact in the school districts studied. These were development, design, specificity and strategies for dissemination.

Curriculum Framework Development

Two of the states in this study involved many state educators to develop the frameworks. The third state used a more select group of state science educators as well as national experts. Although the involvement of many state educators encouraged "buy-in" to the state framework and aided dissemination, this process also resulted in more of a "consensus" document, one that reflected current practice rather than cutting-edge trends.

The Midwestern State's curriculum framework for science education was developed cooperatively by the state department of education, state affiliate of the National Science Teachers Association (NSTA), local school district personnel and representatives of higher education institutions. A 17-member committee reviewed curricular materials from California, Colorado, North Carolina, the National Assessment of Educational Progress (NAEP) and NSTA. Objectives were developed through meetings over a two-year period, and 600 teachers and supervisors throughout the state reviewed draft copies. Most educators viewed the curriculum framework as of high quality and consistent with current trends in science education.

In the Eastern State, the curriculum framework was developed at the same time as standards in other curriculum areas. Although the state science supervisor led the development of the science standards, the assistant superintendent for curriculum and instruction coordinated development of all subject-area standards. Certain guidelines were suggested for the format of all the standards, which affected both their design and content. One guideline, for example, suggested that 16 objectives be developed for each grade and subject area, regardless of the appropriateness for the subject area.

Almost 100 teachers and curriculum specialists were invited from across the Eastern state to develop the "learner outcomes" (specific content objectives) for science. These committees were asked to review school district curricula, guides from other states and the earlier basic skills objectives and to recommend outcomes for each grade. The result was a set of learner out-comes that reflected current practice in the state. Under the leadership of the state science supervisor, another section was included. Called "program goals and objectives," this section articulated the philosophy, process and concepts of science which were meant to serve as the unifying themes for the learner outcomes.

The Western State's science framework was a revision of an earlier document and was developed by a curriculum committee of 15 science educators. Members were the state's leading experts in science education, including a mixture of classroom teachers, district and county office curriculum coordinators and university professors. The committee's work was coordinated by a state department of education team composed of consul-tants and the state science supervisor. This team articulated the new curriculum agenda and brought in national consultants to interact with the committee. Because a limited number of educators were involved in developing the framework, the result was a state-of-the-art document designed to encourage districts to develop or revise their curricula in light of current thinking in science education.

Design and Specificity of the Framework

The design of each state curriculum framework affected its use. One issue was the level of specificity and coherence of the framework. Most state frameworks describe the philosophy of science education and highlighted the major concepts, processes, content and related issues. The goal was to give curriculum specialists and teachers guidance in the intended and appropriate uses of the framework.

The Western State used two documents to describe its science curriculum. The framework included expectations for student achievement in biological science; earth science; physical science; science, technology and society; and ethical issues. These areas were considered the "knowledge" of science and related to another dimension, the "processes" (observing, communicat-ing, comparing, organizing, relating, inferring and applying). For each "knowledge" objective (which included concepts, ethical concerns and technological applications), corresponding "thinking-process" skills were presented. The second document, a model curriculum guide, supplements the framework and suggested a learning sequence, delineating concepts, skills and activities appropriate for learners in grades K-8.

Teachers in the Western State reacted positively to the model curriculum guide, saying content and model lessons helped them lead discussions, frame questions and design activities that contain multiple levels of learning.
Overall, the design of the Western State's framework was a coherent strategy for teaching and learning. Knowledge and concepts were supported by process skills and teaching strategies. Neither the framework nor the model curriculum guide was mandatory. They did, however, provide guidance to teachers and creative strategies to teach science. Teachers with a strong science background could build on this information. Teachers less sure of their science skills were able to develop an integrated, hands-on curriculum with guidance from the framework, curriculum guide and staff development activities.

The Midwestern State's science curriculum framework approached science instruction by defining a philosophy, a set of broad goals and specific objectives for each goal. The philosophy defined the nature of science and described its relationship with society, the learner and the school curriculum. Broad statements of desired outcomes were organized into seven goals: life science; physical science; earth/space science; science process; science, technology and society; science attitudes; and the nature of science. Each major goal had several subgoals (for example, life science has subgoals of systematics, cellular and molecular biology, heredity, evolution, etc.). Within each subgoal were 5-10 objectives, such as "living things have adaptations which enable them to survive."

The Midwestern State suggested the framework was designed to assist administrators and teachers in planning, developing and implementing K-9 science programs and to provide some guides for grades 10-12 instruction. The state expected districts to compare their existing curricula with the state framework and make adjustments if necessary.

The framework had seven goals and subgoals which covered the major con-tent of science, science processes, the nature of science and societal concerns. The framework did not make the interconnections of content and process found in the Western State's framework, nor did it suggest a series of teaching strategies as found in a model curriculum guide. Although districts found it to be a straightforward process to compare their existing curriculum to the state objectives, they were not provided with additional teaching strategies, links between science content and process or to other subject areas to facilitate instruction.

The Eastern State's science curriculum framework, developed by almost 100 state educators and administrators, was organized into four parts: program goals, objectives, guidelines and learner outcomes. Program goals and objectives had their foundation in the state's quality standards for schools and NSTA's "Position Statement for School Science."

The framework was organized by four program goals exemplified by program objectives. For example, objectives under the one goal, the nature of science, included process skills, conceptual themes, career information and the developmental appropriateness of the objectives. Program objectives were further defined by guidelines. One guideline describing a conceptual theme was: "Provide experiences in which students investigate the interrelationships which exist among living and non-living things and their environments."

The second part of the Eastern State's framework presented about 15 learner outcomes for each grade, K-12. With such a small number of outcomes, these were intended to be illustrative rather than comprehensive.

The illustrative nature of the learner outcomes, coupled with the state accreditation requirement that teachers must document when they taught each outcome, led to a diversity in science program quality. The 15 or so illustrative outcomes for each grade were not intended to provide a "conceptual whole" of what science should be at that grade. School districts or teachers were expected to embed these outcomes in their science units or lessons. In districts where there was leadership and expertise in science education, the state curriculum framework was integrated into a thoughtful, well-articulated and frequently integrated science program. However, in small districts where curricular leadership in science was limited, teaching of the state objectives was left to the discretion of individual teachers, often resulting in a discrepancy between the state's intent and actual implementation.

The accreditation requirement also focused teachers' attention on the learner outcomes rather than the program goals and guidelines -- the most instructionally coherent and comprehensive part of the framework. Thus, the framework design resulted in different impacts in two types of districts. Where the district had expertise or access to expertise, the framework had a positive impact on the content of science curricula. In other districts, where science was not a priority, the state framework had very little impact on improving science instruction because it was not readily usable by educators unfamiliar with science education.

Dissemination of State Frameworks to Local Educators

Strategies for disseminating state frameworks varied greatly among the three states studied. Both the Midwestern and Eastern States involved many state educators during the development phase to promote buy-in and dissemina-tion of the state frameworks. The Western State promoted understanding and implementation of the framework by sponsoring a series of regional workshops, developing a three-year cycle of implementation and providing ongoing technical assistance through regional centers.

The Midwestern State sponsored about 15 regional workshops to promote use of the state framework. Limited resources prohibited dissemination of the framework to every school. Although a copy was sent to the superintendent of every school district, many teachers did not see or receive a copy of the state objectives prior to the administration of the state assessment.

The Eastern State was more successful in disseminating its framework to school districts and teachers. First, the science standards were part of a larger package of state objectives in several learning areas. Second, the framework grew out of quality standards for schools, and the accreditation standards required teachers to document use of the learner outcomes. Third, the involvement of almost 100 educators from half of the state's school districts helped communicate the nature of the framework to most of the districts. Finally, the state department of education sponsored a series of regional workshops to explain the framework to local educators. Uniquely, the state also worked with the institutes of higher education to provide a course in the use of the science framework as part of undergraduate teacher training.

Although the Western State involved the fewest number of educators in the development of the science framework, it was, perhaps, the most successful state in disseminating the framework. The small size of the development committee and the coordinating efforts of the state department of educa-tion staff allowed a more directive approach to the development process. The result was a state-of-the-art, comprehensive and highly usable set of documents to help districts improve science instruction.

Because the curriculum frameworks were at the heart of the state's educa-tional reforms, the state provided resources for regional workshops and technical assistance through its regional centers. Although the curriculum framework and guides were recommended rather than required, districts chose to use them because they were of such high quality and were the basis for the mandated state testing and the textbook selection process.

State Assessment Programs

Statewide assessments of science achievement were important elements of efforts to improve science education in each of the three states studied. In each case, pencil-and-paper tests with multiple-choice formats were administered to students in selected grades. Beyond this fundamental similarity, differences in the design and implementation of the assessments were associated with how they were perceived and how they affected local science education. These differences fell into four categories: content alignment, scoring metric, item sampling and implications of item content for inquiry activities.

Content Alignment

Content alignment refers to the match between the items making up the assessment and the curriculum framework developed by the state. The Western and Midwestern States developed tests to reflect their curriculum frameworks, while the Eastern State purchased a commercially published standardized test and later developed a curriculum framework independently. The contrast between these approaches resulted in strong differences in the perceived content validity of the tests in the schools visited.

In the Western and Midwestern States, the development of the curriculum frameworks preceded test development and the frameworks provided the content map that subsequently guided test construction. The Midwestern State sampled 30 to 32 objectives at each of the tested grades from the curriculum framework. Three items were constructed to measure each one. In the Western State, a much larger item pool was developed, similarly derived from the curriculum.

The approach in these two states contrasted with that employed in the Eastern State. That state adopted a nationally normed, commercially published test. The science framework was subsequently developed, without directly referencing the test. The state department of education reportedly examined the match between test items and state science objectives and found that a large proportion (more than 75%) of the items corresponded to state objectives.

However, teachers and science curriculum coordinators throughout the Eastern State reported that the test did not match either the state or local objectives and was therefore not useful to them. When students did poorly on the test, teachers attributed the low scores to the lack of fit between assessment and instruction. In the absence of any direct pressure to raise science scores, teachers did not report changing their instructional practices on the basis of test results.

In the Western and Midwestern States, the fit between test items and state curriculum was perceived to be high. As a consequence, districts that undertook to implement the state curriculum frameworks were more likely to view the test as a valid indication of their success. Central office administrators in half of the eight districts studied in these two states planned to use the recent science scores as a baseline for charting science improvement. Several teachers voiced similar intentions. For these districts, the test served in part as a motivator, a means of keeping score. On the other hand, the test was dismissed as invalid by the science coordinator in one district in the Midwestern State where the local curriculum was significantly different from the state guidelines.

Scoring Metric

Among the three states studied, the Western and Eastern States referenced norming samples in reporting scores, while the Midwestern State referenced a mastery criterion. In the Western State, results from the first-year assessment were used as the baseline or reference point. A mastery criterion used in the Midwestern state was a predetermined guideline that required students to answer correctly at least two of the questions on each objective to achieve mastery. The criterion-referenced scoring produced extremely low scores and came as a significant shock to most districts, including high-income districts. Norm-referenced scoring, particularly when based on state norms as in the Western State, produced fewer surprises.

The Midwestern State set out mastery criteria for its science assessment based on tradition and professional judgment rather than empirical methods. Each objective was measured by three items; two out of three correct indicated mastery. Scores were classified into four groups according to the percent of objectives mastered, with 75% required for the top, or mastery, category.

In a state accustomed to having well over 80% of students showing mastery of reading, mathematics and language arts in the 4th grade, it came as a shock that only 39% of students qualified in science on the recent assessment. Mastery percentages in grades 7 and 10 were still lower. Several superintendents protested the test, fueled by the discovery that three items had been miskeyed. Several districts began self-examinations which led to efforts to improve science. In the end, the state department of education chose to defuse the situation by de-emphasizing the importance of the science test and by making participation in the science assessment voluntary. (Almost a year later the state board reversed itself and made the test mandatory again.)

The political impact of the Midwestern State's assessment was very directly associated with its criterion-referenced scoring. Had scores been norm- referenced, a majority of districts likely would not have found themselves below an established point of reference, such as a national or state average. On the other hand, the power of the test to dramatize the need to improve science education would have been greatly reduced. The case emphasizes the need to conduct an empirical piloting of a criterion-referenced test to avoid setting a criterion too high to be politically tenable.

Sampling Items and Teaching to the Test

It is widely known that pressures to increase scores can result in the teaching of particular test items rather than the broader objectives that underlie them. When this occurs, assessment can serve to restrict instruction rather than improve it. One partial solution to this problem is to vary the items on a test from year to year by creating multiple forms, writing new items or by sampl-ing from a large item pool. Among the three states studied, one created a single form of its science test, one employed two parallel forms, and one created multiple forms by sampling items from a large pool.

The state curriculum frameworks in the three states did not provide long, specific lists of knowledge and skills to be taught. Instead, they provided lists of 15 to 100 objectives per grade, some of which were quite broad. For example, one objective for 6th-grade science in the Midwestern State was: "The learner will gain understandings of the major structures found in the universe, including the sun and its planets." To test this objective in a multiple-choice format, it was necessary to narrow the focus. A 7th grader could demonstrate "mastery" of the objective by responding correctly that Jupiter was the largest planet, and that the universe was larger than a galaxy or a constellation. Obviously, the state intended for instruction to touch on far more than the content of these test items.

The Midwestern State produced only one version of its science test, which was intended to be used annually. Only one teacher explicitly indicated that he intended to teach specific items of the test that his students had missed the previous year. Knowing that several principals and super-intendents had been embarrassed by very low scores, it is likely that other teachers might have been motivated to become familiar with easily instructed test items and teach their content explicitly. Once this practice became widespread, the test would no longer serve as a valid measure of the general achievement of the broader objectives.

The Western State approached the problem of limited test items by creating 36 different forms of the 8th-grade science test. Each form contained 15 science questions, drawn from a pool of 540 items. The same items were used year after year, but test design discouraged attempts to teach to specific items. It would be unlikely that a teacher would collect all 36 forms and reconstruct the complete test. Even so, the test represented a much broader range of content than found in the Eastern State's standardized test (40 items on each of two forms) or the Midwestern State's test (96 items). The use of multiple forms represented a positive solution to the problem of teaching to test items.

Item Content and Investigative Instruction

In each state, science frameworks included objectives dealing with the investigative processes of science. State science coordinators believed that these processes were under-emphasized in K-8 science instruction. They also agreed that these objectives were best approached through hands-on classroom activities rather than through direct lecture or reading. The assessment of these "science process" objectives posed significant questions: Can science process objectives be validly assessed in multiple-choice tests? Can multiple-choice assessments of science process objectives encourage hands-on instruction? Answers to these questions were largely outside the scope of the present study, but some observations can be made within the limitations of the data.

Assessments in each state included items designed to measure science pro-cess objectives in multiple-choice format. The Midwestern State's and Eastern State's tests were analyzed for content at the 7th- and 8th-grade levels to examine the tests' instructional implications. (The Western State's items were not available for analysis). Three questions were examined: (a) What proportion of questions measures knowledge that potentially could be taught in association with classroom or outdoor investigations at school? (b) What proportion of questions asks a child to predict what will happen in an empirical trial, to design an experiment or to identify needed information to resolve a question? (c) What proportion of questions asks a child to arrive at a conclusion or infer a rule from evidence provided?

To examine the proportion of questions measuring knowledge that could potentially be taught through school investigations, items were rejected if they were primarily definitional (e.g., "The material that makes up the cell wall of a plant is cellulose") or if their subject could not be examined or practiced first-hand by most students (e.g., "Which of the following is an effect of the moon on the earth?") For both tests, less than half the items were judged to be conducive to instruction through investigation (see Table 1).

Both tests contained questions that asked children to predict the outcome of an empirical trial (e.g., "Which of the bottles pictured will produce the highest-pitched sound when you blow across the mouth?" "Which of the following mixtures will result in a solution?") These were included in the count only if students could conduct the trial themselves. These questions were combined to ask students to choose the best design for a study to test a hypothesis (e.g., "You want to determine if light-colored objects absorb more heat than dark-colored objects. Which investigation pictured below will solve this problem?") Such questions, combined, made up 12% of both the Midwestern and Eastern State's test items.

Table 1

Percentage of Assessment Questions Conducive To Instruction By Investigation

Question Type	Percent of Items: Midwestern State	Percent of Items: Eastern State
Could Instruct by Investigation	45%	45%
Predict Outcome or Design Trial	12%	12%
Infer Rule From Evidence	17%	13%

A third category of questions provided children with data, often in a table or graph or with a sequence of pictures, and asked them to infer a rule from the evidence. For example, one item displayed a line graph relating the amount of time water is heated with the temperature of the water. It asked: "From the information given in the graph, select a rule which describes the changes." Of the Midwestern State's test items, 17% were of this type; of the Eastern State's test, 13%.

In addition, both tests contained items identified by the test designers as measuring science process, but which essentially measured definitional knowledge or concepts that could be readily conveyed in readings or lec-ture (e.g., "The seismograph is an instrument that detects vibration." "Most scientists consider scientific theories to be explanations that may be revised.") For this reason, the proportion of items that the test authors considered to measure science process did not appear to indicate whether a test would in fact promote investigative activities in instruction.

From this cursory analysis, it would appear that both tests encouraged instruction in the design and carrying out of investigations, reading tables and graphs and inferring rules from patterns of numbers or events. One district in the Eastern State, which had an activity-based science curriculum and also obtained high scores on the state test, provided evidence that such a combination is not impossible, at least for a high-income district. On the other hand, the great majority of items on both tests could be successfully instructed through traditional lecture and text methods.

It is doubtful that even well-designed multiple-choice items can promote an activity-based curriculum as effectively as applied performance tests. The Eastern State developed optional assessment strategies for teachers to accompany its curriculum framework. They called for students to do such things as conduct an experiment or diagram and construct a simple circuit while being observed and rated by the teacher. The Western State is pro-ceeding to incorporate similar performance items in its mandated assess-ment. While such assessments are potentially expensive, they appear to be more successful at providing students hands-on experience in conducting inquiry than are multiple-choice measures.

State Textbook Adoption Policies

The Western and Eastern States had policies related to textbook adoption. Their use and impact in school districts were affected by four features: the alignment of the textbook selection criteria with the state curriculum frame-work, the degree to which existing instructional materials met the selection criteria, the resources allocated to the development of a state adoption list and the incentives given school districts to select instructional materials from the state list.

Curriculum and Framework Alignment

The Western State assured alignment between the curriculum frameworks and the instructional materials by having the committee members who developed the state curriculum framework also develop criteria for selecting materials. These criteria were shared with textbook publishers to ensure textbooks would be developed to cover the content and intent of the state framework.

The Eastern State's reviewers used general textbook adoption criteria supplemented by criteria specific to science. Evaluators completed a single-page evaluation summary for each text reviewed. The summary required brief comments on strengths, limitations, applications, correlation to the state framework and comments. The limited amount of evaluative information made it difficult for publishers to understand why their books were not put on the state adoption list.

To complement the general evaluation form, the state science supervisor produced more specific criteria. These emphasized fit with the state framework and its major goals and philosophy. They also promoted the inclusion of laboratory manuals and activity guides as an integral part of the textbook adoption process. (Since the completion of this study, these selection criteria have gained national attention for their utility and thoughtfulness.)

Resources for Textbook Training and Selection

Frequent criticisms of the process focused on the lack of time allowed for selection committees to review as many as 2,000 different texts and ancillary materials. The result was sometimes the use of the "thumb test," where a reviewer quickly fanned through the text or gave a cursory glance at the table of contents. In the Western State, the committee that developed the state framework also developed the textbook selection criteria. Reviewers were trained as a group, in the use of the criteria, reviewed the materials independently, then made joint recommendations to the state board of education.

In the Eastern State, a textbook review committee met for two weeks during the summer to review instructional materials. Teachers received $50 per day to serve on the committee. On the first day, the committee was oriented to state science standards and selection criteria. The remainder of the time was spent reviewing materials based on the generic and science-specific criteria and making recommendations to place books on the state adoption list.

Adoption Incentives

The Western State encouraged districts to adopt instructional materials from the state adoption list by providing districts about $25 per pupil annually to select state-approved textbooks. To assist districts in choosing materials, the state published a price list and order form and sent these to every county office, district and school. County offices assisted schools and districts in ordering textbooks and organizing instructional materials display centers.

The Eastern State had a flexible policy toward textbook adoption. First, it provided few resources (about $2 per pupil) to school divisions to purchase materials from the state list. Second, the state allowed school districts to petition the state board to select books not on the state adoption list. Many school districts took advantage of this opportunity and were usually success-ful. This set of policies was designed to provide state guidance, yet allow school districts some autonomy to meet their local needs.

Implementation Strategies and Technical Assistance

Implementation is the essence of change. Efforts to improve the scientific literacy of students, like any efforts at educational improvement, will have little impact unless they change what takes place between teachers and students in classrooms. It is a well-known irony, says researcher Michael Fullan, that educational innovations have often failed because they concentrated on development at the expense of implementation.

Impacts were highly related to the context of the school district and the existence of favorable local conditions. A 1987 analysis of policy implementation by Milbrey McLaughlin suggested that policy success depends critically on two broad factors: local capacity and will. "Capacity . . . is something that policy can address. Training can be offered. Dollars can be provided. Consultants can be engaged to furnish missing expertise. But will, or the attitudes, motivation and beliefs that underlie an implementor response to a policy's goals or strategies, is less amenable to policy intervention." It is the facet of "will" found in districts and schools that is described here.

If effective change is to result, implementation must not be equated with compliance. Districts can "adopt" a state curriculum framework, and teachers may even report to principals the objectives they plan to teach on given days, without any effective change having taken place. If teachers do not understand or accept the premises underlying a curriculum, if they lack resources to support it, if they lack the expertise to translate it into daily activities, or if they are constrained by such things as time, class size or other demands for change, it is unlikely that changes in the quality of practice will come about.

Districts must have certain factors or conditions present to implement successfully science curricula based on state science frameworks.

These conditions include:

- District leadership and commitment to teach science
- A match between the state framework and district philosophy of science or buy-in by the district of the state framework
- An accountability pressure resulting in a strong desire for a district or school to do well on the state assessment
- Centralization of the science curriculum and instructional materials at the district level
- Teacher involvement in the revision or development of curricula to support the state frameworks
- Available resources for textbooks, hands-on materials or activity kits

- The existence of a district-level science supervisor or lead teachers in each school

- Staff development, training and ongoing assistance for teachers

- District and school-level leadership, monitoring implementation

State strategies to support these factors helped bring about quality implementation in the states studied.

Strategies to Create a Consensus View of Science Education

Teachers and district administrators will not effectively implement a change that they do not understand or that conflicts with their beliefs about instruction. In all three states, state officials addressed this dimension at several levels. (a) Influential science educators, including local district representatives, were involved in the development of curriculum frameworks. (b) Large regional conferences were held to introduce the frameworks and explain them to administrators. (c) State science coordinators worked actively to shape local debates on the content and purpose of science education. They published articles, spoke at local and national conferences of science educators and maintained active ties to professional organizations. States were able to attract visible and respected experts in science education to leadership positions in the state educational agencies. (d) In the Western State, the frameworks were incorporated into the curriculum of the regional administrator training centers. (e) In the Midwestern State, science consultants worked informally to link districts that had strong science programs with nearby districts that were beginning to make changes.

Strategies for Assisting Curriculum Development

The Western State developed lesson strategies to expand upon the science curriculum framework and provide teachers options in teaching specific objectives. All three states encouraged local districts to develop their own expanded curriculum guides based upon state frameworks. They employed several techniques to assist in this process. (a) The Western State formalized a three-year adoption process tied both to textbook adoption and to the cycle for revising state frameworks. Local educators were familiar with the cycle and used it. (b) States exerted influence on the use of federal funds from Title II of the Education and Economic Security Act (EESA). This act, administered by the states, provides grants to local and intermediate districts to improve science and mathematics instruction. States specified that the funds be used for release time to support curriculum or staff development to implement state science or math frameworks.

Creation of District Science Specialist Positions

For small districts, the absence of an individual with primary responsibility for implementing the science program was a significant handicap. Likewise, the designation of a lead science teacher in elementary schools contributed appreciably to the implementation of a quality science program. In one district, Title II funds were used to purchase release time for one teacher at each elementary school one day a week to serve this function.

Strategies for Assisting with Teacher Training

Each state provided some teacher training directly through the state educa-tion department, but none of these efforts was well funded. The Western State used regional centers to promote the implementation cycle, but these were later disbanded because of funding reductions. In the Eastern State, state science consultants offered cccasional courses and regional workshops within a travel budget of less than $2,500 per person. In the Midwestern State, the one state science consultant provided on-site technical assistance to a few districts upon request, within extreme limitations on time and budget.

Given these restraints, districts relied heavily on university professors and their own expertise for teacher training to support the implementation of new science frameworks. As pointed out previously, the activity and science-process focus of all three state frameworks presented a significant change for many districts and a clear need for training. At least one state made an active if informal effort to identify university and district consultants whose view of science instruction corresponded with that expressed in the state frameworks and to form a network of trainers.

The states also used EESA Title II money for local training to support the implementation of the curriculum frameworks.

Strategies for Assisting With Monitoring and Evaluation

Each state used a different approach to monitor the implementation of science education improvements. In the Eastern State, the one state that required use of the state framework "or equivalent," school accreditation teams checked for documentation, usually in the form of skeletal lesson plans, that prescribed objectives were being taught. While this practice could not establish the quality of implementation, and could potentially interfere with it, it did maintain awareness of the state framework and was generally supported by the teachers interviewed.

To examine program quality in greater depth, the Eastern State developed a science education program assessment inventory, a set of extensive questionnaires for parents, teachers, students and administrators. These were to be used in conjunction with an on-site visit by a team of science educators from other districts. The approach had not been implemented at the time of the study.

In the Western State, program review was coordinated with the state's school improvement program. One step of this process involved an on-site program review by a visiting team. District review teams were made up of educators from outside a district who had been trained and certified by the state; training focused on implementation of the state curriculum frameworks. In addition, the improvement process included an internal review focusing on subject areas in a cycle coordinated with that of textbook adoption and curriculum revision.

The evidence examined in this study, on balance, supports state efforts to improve science education in the elementary grades (K-8) through the use of curriculum frameworks, student assessment and textbook selection criteria. Analysts Linda McNeil and Arthur Wise recently have raised concerns that such initiatives undermine the professionalism of teachers and result in superficial texts and fragmented or narrowly focused instruction. Such concerns should be examined seriously, but they were not supported by this survey and case studies of science education in three diverse states.

State science curriculum frameworks, varied as they were, were valued by teachers and administrators because they fulfilled a need to define the domain and goals of science education. Mandated assessments acknowledged the importance of science instruction, contributed to new efforts in some districts to strengthen science instruction, and reinforced the new focus of curriculum frameworks on the social consequences of technology and the process of scientific investigation.

While it was difficult to assess the impacts of textbook selection criteria directly, district curriculum experts perceived improvements in the materials available to them, and supported the practice of first defining what should be taught and then selecting materials accordingly. The emphasis in state curriculum frameworks on investigative activities was reflected in the selection of texts providing support for such activities, including software and equipment.

The positive nature of these findings may reflect the status of elementary science education in ways that may not generalize to other areas of the curriculum. Elementary teachers are in general less well trained in science and less comfortable teaching science than, say, reading or social studies. Student achievement in science is not assessed in most districts apart from state assessments. Many districts do not have the resources and expertise to develop science curricula apart from textbooks, and consequently can provide little support for activity-based instruction. Moreover, earlier state policies emphasizing the importance of reading and mathematics have contributed to a de-emphasis of science until very recently. For such reasons, it is quite possible that state curriculum frameworks and assessment activities could have a more positive and substantial effect in science than in some other subject area because they address a more substantial need.

The impact of state efforts to improve instruction and curriculum are greatest when curriculum frameworks, student assessment and textbook criteria are approached together as an integrated strategy, with the curriculum frame-work at the core. Case studies indicated that the tailoring of assessment to reflect the curriculum framework was important to district decisions to change. Integration of this sort has organizational implications for departments of education. General recommendations are:

- **The development of curriculum frameworks should precede the development of assessment instruments or selection criteria for materials. Cycles of revision should also begin with curriculum.**

- **Direct and regular communication between curriculum units and assessment units is essential. Consideration should be given to housing these units close to each other and placing them under a single upper-level administrator.**

- **Some subject-matter experts involved in the development of curriculum frameworks should also play a direct role in the development of assessments and of textbook selection criteria.**

Curriculum Frameworks

Two primary local purposes were served by the curriculum frameworks in the states studied. They provided an optional definition to local districts of what science education ought to be which often extended well beyond what districts had implemented in classrooms previously. In this respect, they served an educational function in themselves. They also facilitated district decision-making regarding the content of staff training, the purchasing of materials and equipment, program review and the like.

At the state level, they served as the basis for other state actions. Taken together, these purposes suggest that the quality of the science framework is particularly important. Several suggestions flow from the experience of the states and districts in this study.

- **To insure an acceptable level of quality, the framework should reflect the thinking of leading national organizations such as the National Science Foundation, the American Association for the Advancement of Science and the National Science Teachers Association.** As these organizations become more involved in goal setting for science education, these trends should be incorporated into state curriculum frameworks.

- **The participation of influential districts in the development of frameworks is important for buy-in, but quality should not be compromised to achieve broader participation.** The Eastern State was not able to achieve greater acceptance of its framework than the Western State, yet its objectives were authored by 96 individuals from across the state, compared to the Western State's committee of 14.

- **Objectives must be broad enough to give direction to instruction, but not so specific that instruction becomes atomistic.** For example, one objective that students "use data to reach conclusions" was identified by some teachers as too broad to guide either instruction or assessment.

- **Adherence to frameworks should be optional.** Some districts had curriculum frameworks that were significantly different from the state's. Some of these districts had well-conceived and well-implemented pro-grams in place, reflecting years of staff development and large investments in support structures and materials. To demand the restructuring of such a program because it does not correspond to a state framework implies that there is only one correct approach to science curriculum, an idea foreign to the tentative nature of science itself.

Assessment

Assessment was an important element in each district that underwent significant change in science instruction following state actions. In these districts, assessment or the anticipation of assessment brought attention and resources to science because district administrators wanted to avoid the embarrassment of having low scores publicly reported. When tests were ongoing, they served as an annual scorecard, an indication of whether a school or district was doing better or worse. In this respect, they were also a formal, if tacit, indication of what really mattered to a district. When science was tested, it mattered more than when it was not tested. In subjects that had been tested for years and clearly mattered, such as mathematics, test scores were frequently analyzed to identify particular skills needing greater emphasis or revised teaching strategies.

- **Tests shall explicitly measure the attainment of state science objectives.** In the Eastern State, where the assessment was not perceived to match state objectives, teachers ignored the results of the science test. In the Western State, where test and objectives were aligned, teachers were more inclined to view the test as an indication of how well students were learning science.

- **School-level reporting should be used to bring an appropriate level of accountability pressure.** While district administrators and principals often expressed resentment regarding school-level reporting of test results, it appeared that the consequences of these pressures were positive. Sensitivity to test publicity motivated principals and central administrators to attend to test results and to bring them to the attention of teachers. In the Western State, reporting scores within ranges achieved by schools of similar socioeconomic status appropriately prevented schools serving low-income students from experiencing undue pressures. At the same time, the fact that student and classroom scores were not published and that decisions about individual students were not made on the basis of test scores insulated teachers from pressures to raise scores at the expense of sound educational practice.

- **To avoid narrow teaching to particular test items, a known set of test items should not be repeated year after year.** In the Midwestern and Eastern States, teachers indicated high familiarity with state test items in language arts because the scores were important and the same items were repeated over a period of years. The possibility existed that improved scores came about because teachers taught narrowly to the topics tested. The Western State avoided this problem by sampling test items, creating 35 forms of the 8th-grade science test.

- **Performance testing should be considered to promote activity-based instruction.** In the Midwestern State, test developers made a concerted effort to develop multiple-choice items to measure science process skills that would be perceived by teachers as encouraging hands-on instruction. Teachers were not sufficiently familiar with the items for researchers to evaluate them effectively. The evidence was neutral in balance: while some teachers believed that students would perform better on the test if they had engaged in activities, some also believed that activities were a more time-consuming way to com-municate information. Direct assessments of students' performance in conducting an observation or testing a hypothesis, while considerably more expensive, would have unambiguous implications for instruction.

Textbook Selection

The effect of the "dumbing down" of textbooks had a more negative impact on the Western State than the Eastern State. Because the Western State's science framework was innovative and state-of-the-art, existing textbooks (based on consensus objectives from other states) did not reflect the state's new framework or model curriculum guide. Pressure was placed on publishers to revise the texts to match the state framework. Although the state role in the textbook issue is thorny and complex, this study supports the following conclusions:

- **States and national organizations should work together to develop a curriculum "core" in science which becomes the basis of content included in textbooks.** By defining a common core of content, textbooks can move away from "mentioning" topics and treating them superficially. Fewer concepts and topics could be covered in greater depth, aiding student understanding and learning of science.

- **Textbooks should reflect the current goals of science, including applications of science to everyday life; science, technology and society; the nature and process of science and ethical issues.** Although there is no national or professional consensus on what the goals of science should be, texts still reflect a content and knowledge orientation to presenting science to students.

- **Textbook adoption criteria should reflect the state curriculum framework.** Criteria should facilitate the selection of high-quality textbooks to support the curriculum. Although correlational analysis will indicate the framework content covered by a text, more important is the approach, writing and presentation of the subject matter. Weight should be given to the book's overall academic integrity, its clarity, quality of writing, factual accuracy, its interest to students and capacity to motivate and stimulate them. If a "hands-on" approach to teaching science is desired, then supplemental materials like activity kits and the orientation of the textbook to "hands-on" learning should be part of the selection criteria.

- **Sufficient resources should be dedicated to the selection process.** Reviewing existing textbook series is a massive task. The selection committee should be paid and allowed enough time to be appropriately trained to do a thoughtful review of all instructional materials considered.

- **Financial incentives should be provided to encourage districts to purchase textbooks on the state adoption list, thus fostering curriculum alignment with the state framework.** The Western State encouraged districts to select books on the state adoption list by reimbursing them for most of the per-pupil cost of textbooks. Because this state selected a limited list of acceptable textbooks, congruence with the state framework was virtually guaranteed. However, in the Eastern State, where alignment of the curriculum, assessment and textbook list was purposely loose, it seemed appropriate to allow districts to select books not on the state adoption list to provide some local control and discretion.

Dissemination, Implementation and Monitoring

The use of comprehensive dissemination strategies greatly influenced the use of state frameworks in districts. The first task was to get the frameworks into the hands of local educators. The second task was to get educators to buy into and understand the philosophy, approach and content of the framework to facilitate their use and implementation.

- **Dissemination of the state science framework should be accomplished through the use of multiple, comprehensive strategies.**

These could include regional conferences sponsored by the state education agency, the mailing of the state frameworks to every school in the state, media reports, dissemination through state professional associa-tions like the state affiliates for NSTA and the involvement of local educators in the development process.

- **States should provide both pressure and support to school districts to facilitate implementation.** Pressure can come in the form of an accountability pressure, public reporting of test scores, accreditation requirements or school improvement evaluation criteria. Support can be discretionary resources or technical assistance.

- **Discretionary resources should be provided to give districts flexibility during implementation.** Resources, in the form of Title II funds, school improvement funds, teacher training funds or other discretionary funds are necessary for districts to buy instructional materials, release time for teachers, outside expertise or provide additional stipends for lead teachers.

- **Technical assistance, in the form of teacher training, curriculum implementation or the development of mentor or lead teachers should be made available to school districts.** Most districts have limited resources in terms of science curriculum expertise and staff development opportunities. To the extent the state can provide technical assistance to build capacity in a district, implementation is facilitated.

- **State-sponsored regional centers should provide ongoing assistance to districts to promote curriculum implementation.** In the Western State, regional centers played a major role in helping districts implement the three-year cycle of curriculum implementation. The availability of assistance on an ongoing basis is critical to fidelity and completeness of implementation.

- **Monitoring, in the form of regulations or incentives, should be carried out to promote implementation.** In the Eastern State, tying the teaching of the learner outcomes to the state accreditation requirements forced the teaching of the state framework. In the Western State, program review criteria for a school improvement program (which had financial incentives) were keyed to the implementation of the state curriculum frameworks.

In short, science curriculum improvement occurs when there is a careful articulation of state policies related to assessment, curriculum, instructional materials and school improvement and when there is both pressure and support to implement the policies.

NOTES

Michael Fullan. The Meaning of Educational Change. New York: Teachers College Press, 1982.

Linda McNeil. Contradictions of Control: School Structure and School Knowledge. New York: Methuen/Routledge & Kegan Paul, 1986.

Milbrey McLaughlin. "Learning from experience: Lessons from policy implementation," Educational Evaluation and Policy Analysis, Summer 1987, pp. 171-178.

Arthur Wise. "Legislated learning," Phi Delta Kappan, January 1988, pp. 328-333.