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AUTHOR	Blank, Rolf K.
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ABSTRACT

National- and state-level reports on education indicators have been produced since the mid-1980s. However, the debate continues over which education indicators to select and report. This paper outlines the lessons gained by a national organization in building an education indicators system through cooperation with state education agencies and federal agencies. Three issues in the development process for education indicators are emphasized: (1) the role of the consensus process among educators, researchers, and policymakers in selecting and defining indicators; (2) how education indicators can be produced through a cooperative data system with states; and (3) methods for reporting indicators that increase their usefulness by policymakers and educators. The experiences of the Council of Chief State School Officers illustrate the variety of issues that need to be resolved, and the need for careful definition of the indicator areas and the data required. It is essential to involve different interests or perspectives on the indicators system in the development process. Two figures and two tables present information about the process. (Contains 33 references.) (Author/SLD)

DEVELOPING A SYSTEM OF EDUCATION INDICATORS

Selecting, Implementing, and Reporting Indicators

Rolf K. Blank

Council of Chief State School Officers
State Education Assessment Center
One Massachusetts Avenue, Suite 700
Washington, D.C. 20001
202/408-5505
internet/bitnet: gambach@nas.edu

Abstract

National and state-level reports on education indicators have been produced since the mid-1980's. However, the debate continues over which education indicators to select and report. This paper outlines the lessons gained by a national organization in building an education indicators system through cooperation with state education agencies and federal agencies. Three issues in the development process for education indicators are emphasized:

1. The role of a consensus process among educators, researchers, and policymakers in selecting and defining indicators;

2. How education indicators can be produced through a cooperative data system with states; and

3. Methods for reporting indicators that increase their usefulness by policymakers and educators.

DEVELOPING A SYSTEM OF EDUCATION INDICATORS
Selecting, Implementing, and Reporting Indicators

Education policymakers at national, state, and local levels wish to support efforts to develop education indicators that would provide a reliable, periodic snapshot of the condition of education in our schools and could be used to provide a valid basis for assessing educational improvement. National and state-level reports on education indicators have been produced since the mid-1980's. However, the debate continues over which education indicators to select and report.

In 1991, a national panel authorized by Congress recommended that new categories and types of education indicators be developed to replace those currently used. The National Education Goals Panel recommended, and reported, indicators for the six national goals but also identified the need for a variety of new indicators at national and state levels. The National Council on Education Standards and Testing has recommended that new forms of student assessment be developed to determine progress toward national standards for student learning in core academic subjects.

In the recent deliberations about education indicators, emphasis has been placed on determining which indicators should be available and what methods should be used to collect data to measure student, teacher, or school performance. However, the recent attention to indicators includes little discussion of the process for selecting indicators, such as whose interests and needs are represented, and far too little attention to how to obtain cooperation among national, state, and local agencies.

This paper outlines the lessons gained by a national organization in building an

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education indicators system through cooperation with state education agencies and federal agencies. The goal of the paper is to contribute to the understanding of education policymakers, educators, and researchers about how education indicators can be effectively developed and used. Three issues are analyzed:

1. The role of a consensus process among educators, researchers, and policymakers in selecting and defining indicators;

2. How education indicators can be produced through a cooperative data system with states; and

3. Methods for reporting indicators that increase their usefulness by policymakers and educators.

EDUCATION INDICATORS IN THE 1980's and '90's

Education statistics have been reported in the U.S. since the 19th century. Education indicators have become a major issue at national, state, and local levels of education over the past decade. Education "indicators" are selected statistics that are intended to inform policymakers, educators, and the public about the condition of the education system (Oakes, 1986). The indicators focus on key aspects of how the system is currently functioning, whether progress is being made, and where there are problems (Shavelson, McDonnell, Oakes, & Carey, 1987; Horn and Winter, 1989). Education indicators are selected to include statistics that have specific relevance to policies that direct and shape education.

Two trends since the mid 1980's gave rise to the current interest in education indicators: (a) the education reform movement aimed at raising the quality of education in our schools, and (b) a renewed emphasis on accountability in education. Many state policy initiatives in the 1980's aimed at education reform were stimulated by a series of national commissions and reports critical of the quality of education in our schools. Two of the reports--A Nation at Risk (National Commission on Excellence in Education, 1983) and Educating Americans for the 21st Century (National Science Board Commission on Science, Mathematics, and Technology Education, 1983)--outlined needs and strategies for education reform and also highlighted the need for greatly improved capacity for data to assess the quality of education and track the rate of progress. Much of the recent work on education indicators can be traced to these reports.

Following A Nation at Risk, the Department of Education initiated an annual Condition of Education report, which includes national statistics drawn largely from existing departmental surveys (National Center for Education Statistics, 1991). The 1987 Hawkins-Stafford amendments reauthorizing many federal education programs, mandated a national panel to examine the need for national education indicators. The panel's report, Education Counts, outlines a comprehensive model that includes a broad array of indicators and data that go far beyond the current surveys and data collection of the Department of Education (National Study Panel on Education Indicators, 1991). The Hawkins-Stafford amendments also authorized a Trial State Assessment of the National Assessment of Educational Progress (NAEP) which, if fully implemented, would greatly expand the scope and role of NAEP in providing education indicators at state and national levels.

The National Science Foundation (NSF) has also given impetus to the development and use of education indicators. Since 1985, the biennial Science Indicators report has expanded the chapter on indicators of the quality of elementary and secondary education (National Science Board, 1991). NSF supported major studies to assess the quality of current data on science and math and to develop models for improving science and mathematics indicators (Raizen and Jones, 1985; Shavelson, et al, 1987; Murnane and Raizen, 1988).

The interest and support of state policymakers for education indicators and accountability increased significantly with the education policy initiatives in the 1980's that were aimed at reforming the quality of education. The changes in state policies also accelerated the already increasing state role in education funding (Doyle and Hartle, 1985). By the end of the 1980's, a majority of states had established a system of indicators that were linked to the state role in education accountability (OERI, 1988). Education accountability was increasingly defined by states as accountability for outcomes (Malen and Fuhrman, 1991), as exemplified by the expansion of statewide student assessment programs to over 40 states (Blank and Schilder, 1991).

The National Education Goals of the President and Governors produced additional visibility and importance for national and state level indicators of education progress. The Goals Panel's first report outlined the desired indicators for each goal, and it showed that valid state-by-state data are not currently available to measure progress toward several of the goals (1991). The report has led to extensive debate about the next steps in establishing standards for, and methods of assessing, student and school progress (National Council on Education Standards and Testing, 1992).

STATE NETWORK FOR EDUCATION INDICATORS

In 1985, the Council of Chief State School Officers changed its policy of opposing state-level education comparisons to approving a plan for a system of state-by-state education indicators. The Council recognized the need for reliable, valid indicators of the condition of education in our schools and took the lead in efforts to develop high quality, comparable indicators, such as the expansion of the National Assessment of Educational Progress to state level reporting. The model for state indicators approved by the Council includes three components: (a) student outcomes, (b) education policies and practices, and (c) state context (CCSSO, 1985, 1990).

The Council received a grant from the National Science Foundation to develop and report state-level and national indicators of science and mathematics education. The project followed the Council's broader goal of working with state departments of education to produce valid, comparable education indicators. The project was a part of NSF's goal of having reliable, periodic indicators of the quality of science and mathematics education at elementary and secondary levels. The Council and NSF staff anticipated that a cooperative state and national effort could produce better information about science and mathematics education that would be very useful to national and state education policymakers. The steps taken in the Council/NSF project in developing and reporting state science and mathematics indicators are likely to be applicable to the development of indicators in a wide range of education areas.

STEPS IN DEVELOPING AN INDICATORS SYSTEM

The process of developing an indicators system can be outlined in nine steps. Particular emphasis is given to those elements of the process can be used for planning and implementing systems of education indicators at national, state, or local levels. The steps are organized under three major categories of activity: selecting indicators; organizing a cooperative system for data; and reporting comparative data on indicators.

Selecting Indicators

1. **Develop a Conceptual Framework Based on Research Results and Interests of Policymakers and Educators.**

The process of selecting state indicators for science and mathematics education began with a paper outlining a conceptual framework (Blank, 1986). The elements of the framework reflected both the results of research on the educational process in science and mathematics and the needs of policymakers and educators for valid, useful data. The interests of state policymakers in education indicators were initially identified from the Council's model for state indicators (CCSSO, 1985), and the report of the National Governors Association, Time for Results (1986), which outlined a series of needed state-level education indicators.

Recent research on the need for education indicators contributed to the conceptual framework. A study by the Rand Corporation recommended that indicators be based on a model of the education system and outlined different approaches for developing indicators, such as a "patchwork approach" that would combine indicators from different sources, including national and state surveys (Shavelson, et al, 1987). An expert panel of the National Research Council recommended that education indicators focus on elements of the education system that can have strong effects on improving education outcomes, including indicators of teaching quality, curriculum content, resources, and new forms of assessment (Murnane and Raizen, 1988). Oakes recommended a multi-tiered system of education indicators comprised of national-level indicators, state-level indicators from data collected by states and local districts, and a subset of indicators from both levels that would provide a basis for valid state-to-state comparisons and national trends (1986).

Indicators in education, as in other fields, can include different kinds of statistics which may be reported at different levels of aggregation. Some indicators are single statistics which are representative indices, some are composites of several statistics, and some are disaggregated statistics, such as by economic sector or by state education system. Indicators can be designed with different levels of complexity and aggregation according to the needs of different audiences.

The conceptual framework outlined six components of an indicators model for science and mathematics at the state and national levels: (a) student outcomes, (b) instructional time/participation, (c) curriculum content, (d) teacher quality, (e) school conditions, and (f) resources (Blank, 1986). A draft paper was reviewed and revised by an advisory panel comprised of state education specialists, scientists, mathematicians, education researchers, and representatives of NSF and the Department of Education. The panel used the framework to outline three to five "ideal" indicators under each of the six components of the model. "Ideal indicators" are those that would be most helpful for assessing the condition of science and mathematics education regardless of the current availability of data.

2. Obtain Commitment and Cooperation of Leaders.

The Council's role in leading the indicators project provided an entree to each state. A written agreement to participate in the project was formally obtained from each state superintendent or commissioner. The state's chief state school officer selected staff to participate in a project network, including representatives from science and math curriculum, student assessment, and information systems. The state superintendents and commissioners reviewed the plans for indicator selection, development, and reporting through committees, and at their annual meeting. Having top-level commitment to the project from the outset eased the work with state staff on subsequent project steps.

The policy and program uses of the education indicators were emphasized with state leaders and state education staff to illustrate the benefits of cooperation. From the initial stages, the project was explained as a way for states to improve understanding of their education systems, both through useful comparisons with other states and through new ideas for analyzing state-collected data and national surveys. The Council helped state staff organize regional workshops on science and math indicators. Uses of proposed indicators in policy analysis, program planning, and problem identification were outlined and discussed with the state representatives. Each workshop was led by national experts on indicators and state leaders in science and mathematics education. The state network members were invited to participate in several national conferences on science and mathematics indicators, including a conference on alternative methods of assessment and another on measures of curriculum content. Finally, the detailed work in developing common definitions and data categories for reporting state data was completed with teams of state staff, in order to have the system designed to maximize usefulness for states.

3. Involve Policymakers, Educators, Researchers, and Data Managers in Selecting Priority Indicators.

The process of selecting education indicators requires interaction and consensus among different kinds of experts. The selection process should bring together the different interests in indicators as well as the expertise needed to organize an indicators system based on reliable, valid data. Education policymakers and educators have interests in assessing the effects of policies and programs and identifying the nature of problems in the education system. Researchers are needed to identify variables that are central and critical for determining how the system is operating and to pinpoint sources of data that will provide valid indicators. Finally, data managers need to participate to ensure that data will be available for selected indicators and that the data can be aggregated and reported to meet the needs for indicators.

The process of selecting and developing indicators in other fields has involved interaction and consensus building. In analyzing the history of economic indicators, Horn and Winter (1989) found that economic indicators were developed during an extensive period of interaction among economists, policymakers, and staff of government agencies, during which multiple sources of data with different levels of aggregation and complexity became important. The process of development and interaction proceeded both prior to and after the initiation of data collection and indicators reporting.

The Council's efforts toward selecting indicators were begun by identifying possible sources of data and determining the various needs and interests in state and national indicators. All existing national surveys that produce state-level data were reviewed. A survey was conducted with all 50 state departments of education to identify sources of state data and state needs and interests in indicators (CCSSO, 1988). The state survey asked about the availability of state data on each of the "ideal indicators," and the survey was completed by a team of representatives from each State Department of Education.

The survey responses from states and the information on national surveys were tabulated by ideal indicator. Data on many of the ideal indicators were available in only a portion of states. For a few indicators, data were available from every state (such as number of science and mathematics teachers). For others, no comparable data were available from states but data from a national survey could provide data by state (such as student achievement data from the National Assessment of Educational Progress (NCES, 1991)). A consensus process was needed to weigh the need and importance of proposed indicators against data availability and effort required to produce state-by-state indicators.

A task force was convened comprised of researchers on education indicators, state education specialists, state data managers, and federal officials. The group analyzed the available data by indicator, and the various interested participants presented their views on which indicators should be given highest priority. Three criteria were used in evaluating and prioritizing indicators:

a. Importance/usefulness of the indicator,

b. Technical quality of the data (available or expected),

c. Feasibility of obtaining state-by-state data.

All three criteria were used to evaluate each possible indicator, but the criterion of "importance/usefulness" was considered first. Priority on this criterion is consistent with the definition of indicator as having policy or program relevance for the education system. The consensus list of priority indicators for science and mathematics included indicators that had very high ratings on importance/usefulness but lower ratings on "feasibility" because data are not presently available. This principle is important. For example, in 1985 when the Council members approved the initial recommendations for state-by-state indicators, comparable data were not available by state for several indicators, including student achievement. At the time, many states had achievement tests in the same subjects and grade levels, but the variety of items used on the tests prevented valid state-to-state comparisons. However, the decision by the chief state school officers to work toward a state-by-state indicator of student achievement became a major factor supporting expansion of the National Assessment of Educational Progress (NAEP) to the state level, which began in 1990. Even though the development process was lengthy, it was critical that the chief state school officers agreed upon the importance of an indicator of student achievement.

4. Select a Limited Number of Indicators and Hold Down Complexity in Reporting.

The task force recommended 12 priority state science/math indicators across six components of the indicator model, and the indicators are shown in Figure 1. The group decided that, if possible, each of the model components should have at least one priority indicator. At the same time, the task force wanted to hold down the total number of indicators. This strategy would hold the length of reports on the indicators and it would focus resources on a small number of critical indicators that can realistically be developed at an early point in the process. For the Council's project, it was important to have a combination of priority indicators that included some which could be reported with existing state data. This approach allowed the users and potential users of indicators to see the results of indicators work by their states and the benefits of a state and national indicators system.

The recommendations for priority indicators also included limiting the amount of detail to be reported on any one indicator.[1] Indicators should be reported in a format that is straight-forward and understandable by different audiences, including educators and policymakers, and the indicators should provide representative or summary statistics about the condition of schooling. The indicators may stimulate further analyses and interpretation for different specific purposes. The role of indicators was well stated by a committee of educators in one state:

> Indicators can provide valuable information to guide the debate and dialogue about schooling. But judgements about the health of the educational system can only be made by interpreting indicator data in the context of educational values and experience with schooling. When we track changes [through indicators] its does not imply that we have established cause and effect because there are multiple causes. Tracking changes may stimulate an hypothesis about the cause and identify areas for further investigation... (Massachusetts Association of School Superintendents, 1991, p. 23).

<u>Organizing a Cooperative Data System</u>

5. **Decide Method of Collecting Data.**

A critical juncture in development of an indicators system is moving from consensus on a desired set of indicators to specifying the measures or data sources for reporting the indicators. There are two methodological options for collecting data and reporting statistical indicators that are comparable from state to state:

a. Use the same data collection instrument in all states, or

b. Implement common standards for categorizing and reporting data, with each state using its own data collection instrument.

Use of the same data collection instrument, which applies the same items and wording, is essential whenever the information being collected is of a subjective nature and is likely to be influenced by the wording or context of the questions themselves. Examples of such indicators are student knowledge or skills, student and teacher attitudes, instructional methods, school organization, and school processes (Porter, 1991; Oakes, 1989).

The second option is to apply common standards for data reporting to the different organizations or agencies that collect data. Many of our national education, health, and labor statistics are based on state and federal cooperation in data collection. The NCES Common Core of Data on elementary and secondary education is comprised of a universe of data on students, teachers, and schools that are collected by states and districts through their management information systems. These state and district data are sometimes called "administrative records." Comparability across states is attained not through a survey instrument, but rather through common definitions of variables, or data elements, and common categories for aggregating and reporting the data.

One of the priority science and math indicators from state education information systems was secondary course enrollments. At the start of the Council project, less than 35 states collected these data. However, the project moved ahead with data collection and reporting with these states, and project staff worked with the remaining states to assist in adapting their information systems to obtain course enrollment data. Step 6 describes how a cooperative state data system was organized to produce an indicator of course enrollments in secondary science and math.

6. Work with Data Users and Providers to Establish Standards for Producing Comparable Data.

State representatives worked with project staff to set common standards for aggregating and reporting state-collected data on course enrollments in science and mathematics. There were two main dimensions to the process for setting data reporting standards:

a. To establish common course categories and definitions that would incorporate, or provide a link to, most states existing data categories; and

b. To ensure that the common categories would provide statistics that are useful for policymakers and educators.

For example, it was found that states were very interested in comparing rates of enrollment in advanced courses. The project staff and state representatives had to arrive at a definition of "advanced" that would allow states to aggregate and report their different courses under a common category.

The process involved extensive cooperation among state managers of information systems (data providers) and state science and mathematics specialists (data users). First, the project staff determined the extent of variation in course enrollment data by collecting and reviewing all of the state data collection forms. The collected forms were analyzed to determine state differences in: (a) course categories and definitions; (b) level of intended respondent--teacher, school, district; and (c) other data collected, e.g., student gender and race/ethnicity, grade level, course difficulty. Tabulations were completed to determine the extent of commonality and variation across states. For example, the number of states collecting data on high school biology was determined, as well as the number using the same course categories or codes, e.g., "general biology," "basic biology," "college biology," or "honors biology."

A planning meeting was held with state representatives during which several key decisions were made. For state and national indicators, the group felt it was most important to report and compare enrollment across common "levels" of science and math courses, not enrollment by course title (or textbook). For example, in science, courses in major subjects of biology, chemistry, and physics should be reported at four levels per subject: first year basic, first year general, second year advanced, and second year advanced placement.

The group also decided that categories should be forward-looking to anticipate the data needs of policymakers and educators regarding possible changes in science and mathematics curriculum. For example, mathematics curriculum is undergoing reform in many states, and thus, the high school mathematics categories were created with levels that provide tracking of course enrollment in traditional courses (e.g., algebra, geometry, trigonometry), as well as enrollment in newer "integrated mathematics" courses. A third decision was that the common data categories for state indicators should be sufficiently broad to maximize the possibility of matching each state's data to common categories, while ensuring comparability and policy relevance. The group also decided that the data system should not be modeled after the state with the most detailed data categories nor the one with the fewest categories and most simple definitions.

Reporting Comparative Data on Indicators

7. Design Data Forms and Cross-Walk Procedure.

The Council staff used the state representatives' decisions and recommendations to develop a data reporting form that would give states a common set of instructions and specifications for aggregating and reporting their data on science and mathematics. The form included a taxonomy of categories for course enrollments with typical course titles under each category and written definitions for each category. The definitions were written by teams of state specialists in science and mathematics. A draft of the course category taxonomy and definitions was circulated to all the state participants in the project network for review and comment. Finally, the data reporting design, instructions and forms, and cross-walk procedure were tested through a pilot study with eight states. The pilot study results were used to refine and clarify the data forms and instructions (CCSSO, 1989).

For each of the participating states, Council project staff completed a "cross-walk," or matching of the common categories, with the state's course codes. For example, a cross-walk for one state's data codes with the reporting categories for biology was as follows:

Common Categories	(A State's) Courses/Codes
Biology, 1st Year, Basic/Applied	Basic Biology
Biology, 1st Year	General Biology; College Preparatory Biology
Biology, 2nd Year, Advanced	Genetics; Anatomy; Anatomy and Physiology
Biology, 2nd Year, Advanced Placement	Advanced Placement Biology
Biology, 2nd Year, Other	Botany; Ecology; Marine Biology; Zoology

8. Collect and Edit Data

Council staff are responsible for central management of all aspects of the data collection from states, including quality control, data editing, and follow-up to obtain timely responses from states. Federal funding through the National Science Foundation has made possible the central support of the indicators system at the Council. A state contact person is responsible for aggregating data, validating the cross-walk procedure, reporting data, and verifying and correcting the data upon return from the Council data coordinator.

In the first year of the science and math indicators system (1989-90), data on course enrollments were reported by 36 states. The Council assisted states to increase their data collection capacity to provide indicators data, and Council staff edited state data to increase the quality and accuracy of data. In successive rounds of data reporting through the cooperative system, more states will report data as decision-makers see the benefits of having the state indicators. Council staff also provide technical assistance and small grants of financial support for indicators development through the federal National Science Foundation funds.

9. Report State-by-State Indicators: Example of Course Enrollments in Science and Math

The first state-by-state report on science and math indicators, including course enrollments, comparative state statistics and national totals (Blank and Dalkilic, 1990). The first report emphasized reporting individual indicators and establishing baseline numbers for later trends analysis. States were encouraged to compare their numbers on a variety of indicators with states in their region, states of similar size, and with national averages. The state network and advisory panel did not favor combining indicators into a total "score" for each state, and the ranking of states according to indicators was not emphasized. The format and design for reporting the indicators reflected important input from state representatives and project advisers. Some examples of statistics from the first report illustrate the rationale and key decisions about reporting the state indicators.

- Table 1 shows the proportion of public high school students, by state, that were estimated to take mathematics at three levels by the time they graduate. Nationally, 81 percent of students took a course at Formal Math Level 1 (e.g., algebra 1), 49 percent took a course at Formal Math Level 3 (e.g., algebra 2), and 9 percent took a course at Level 5 (e.g., calculus).

- Table 2 shows the proportion of public high school students, by state, that were estimated to take science at three levels by the time they graduate. Nationally, over 95 percent of students took a first-year Biology course, 45 percent took first-year Chemistry, and 20 percent took first-year Physics.

The data were reported by state according to course levels, not course title. This provided a way to compare course-taking across states. It also reduced the amount of detail that needed to be reported to have a summary indicator of student participation in high school science and mathematics. The course-taking rates by state provide comparisons of how far students are progressing through the high school curriculum, but they do not provide comparisons of course content.

The selection of three levels for inclusion in each table was based on an interest in key gatekeeper courses for science and mathematics. For example, in mathematics, Formal Math Level 1 (usually algebra 1) is a gatekeeper for students who wish to complete a formal mathematics sequence in high school; Formal Math Level 3 (usually algebra 2) indicates the proportion of students who take three years of "high school mathematics;" and, Formal Math Level 5 (usually calculus) indicates the proportion of students preparing for science, mathematics, or engineering majors in college.

The rates of course enrollment by state are expressed as the "estimated proportion of students taking (a course) by graduation." The percentages are estimates based on the actual state enrollments for students in grades 9-12 during one year.[2] The estimates of course-taking over a four-year high school career were computed because responses to draft reports indicated that most readers are used to analyzing course-taking rates over a four year period. National studies using high school transcripts used this statistic (Kolstad and Thorne, 1989; Educational Testing Service, 1989), and the state data could be related to the national averages from earlier periods of time.

The national averages for course enrollments shown in Tables 1 and 2 were computed with imputation for missing states. The project is working with the remaining 14 states to obtain course enrollment data, and the succeeding report for 1992 will have more states reporting on this indicator.[3] The cooperative state data system for science and math indicators is a voluntary system. States pay all of the costs of collecting, aggregating, editing, and reporting the data to the Council, and the central management of the system is from federal support. One strategy of the project is to encourage full participation by beginning to report state-by-state indicators and to demonstrate how these data can be useful to states. State involvement should be a decision based on the needs and interests of each state, not because of a national-level requirement or expectation.

Early dissemination of draft reports was important for producing a final report that was useful to policymakers and educators. State participants and project advisers were given several opportunities to check the accuracy of the data and to review how the results were presented in tables and graphs. Through this process, feedback was received on organizing and formatting state-by-state statistics to improve their usefulness. For example, state science and math supervisors prefer to have comparative statistics presented in bar graphs which can be used as transparencies for presentations to groups of educators and decision-makers. Suggestions were also made about highlighting certain analyses of course enrollment, such as rates of enrollment according to changes in state graduation requirements. Some of the uses of the initial report on science and math indicators by states include analyzing student course taking patterns, identifying teacher shortages in specific fields and focusing teacher training programs, and planning curriculum changes.

The nine steps in developing education indicators are summarized in Figure 2. Even though the development process described in these steps was for a state-based system, these steps can be used to plan to indicators systems at local, state, and national levels.

UNRESOLVED ISSUES WITH STATE EDUCATION INDICATORS

The results from developing a system of state science and math indicators has shown that a cooperative state system can produce comparable, useful indicators. The experience with science-math indicators has also shown that some specific questions related to indicators based on data from state systems are not totally resolved. Three of these issues are: (a) At what levels should the indicators data be aggregated and reported? (b) How can comparability be assured with data collected by different agencies with different collection instruments and varying data definitions? (c) How can quality control be maintained with a cooperative data system?

The science-math indicators system with states did design a plan and reporting system that addressed these questions, but more work is yet to be done on each issue. On the first issue of level of reporting, a decision was made early in the development of state science-math indicators to focus on collecting and reporting state and national totals. However, many policymakers and educators argue that further disaggregation is needed to district and school levels. State averages can mask large variations in the condition and quality of education. Also, indicators are typically reported as univariate statistics, such as a state average, but important differences require cross-tabulations, such as average class size by course level. The Council has begun to do further analysis of the state indicators after the initial reporting, and these results will be reported. Workshops are also being held with state education agency staff to demonstrate how state data files can be analyzed to produce district and school-level indicators.

One strategy for addressing the issue of comparability with the science-math indicators was to keep the indicators categories relatively broad and inclusive. For example, with the course taking indicator, it was decided the primary use would be for assessing major differences among states in course taking levels, not to assess differences in curriculum content. The indicator was developed through comparing state definitions and arriving at a common definition through a consensus process. Each state's courses are placed in categories through review of the title and brief descriptions. This process produces considerable variation in the courses and curriculum classified within each category. The degree of variation in classification needs to be analyzed through validation research studies, and some research is being done on coursework indicators through support of the National Science Foundation (Burstein, et al, 1993; Smithson, 1993: Stecher, 1992).

Quality control in the cooperative state system relies heavily on the states. The Council staff do central data checking and editing with state totals, and check the response rates of the states. This quality control helps to improve comparability between states, but the state numbers still rely on the accuracy of reporting by teachers, schools, and districts, as well as data checks and editing by states. Most states conduct computer edits for data reliability and reasonableness. A major question is the accuracy with which rates of course enrollment, for example, are placed in the appropriate categories. Another question concerns the use of state data files on teachers. For example, some states lack resources to maintain accurate, up-to-date records on current teachers. At the aggregate level, the Council staff check state totals with other known data sources, such as at NCES, but cross-tabular analyses of teachers from state files do reveal missing and incomplete data. In reporting state indicators on science-math teachers, the Council has refrained from publishing state numbers that were biased by missing data. Further work is needed by states in auditing data reporting and cleaning and updating data files.

CONCLUSIONS

At all levels of our education system the topic of education indicators has taken on increased attention and significance. Policymakers, educators, and the public want better information about the quality of education in our schools. As efforts to collect and report data on a set of education indicators have moved forward, the demand has increased for more indicators and indicators with greater validity and usefulness. The push to develop a system of education indicators at national and state levels that meet policymakers' interests in national goals and educational accountability has stimulated educators to ask for indicators that are more directly useful in assisting the process of educational improvement.

This paper has outlined the process and results of developing a set of education indicators system developed through a cooperative data system with states. The experience of developing a state education indicators system revealed that their are a variety of issues that need to be resolved, and some lessons were gained for others developing indicators. Several broad issues have been addressed that apply to any indicators system: (1) Who should be involved in selecting the indicators and how can a consensus process be used to select and prioritize indicators? (2) How can a cooperative data system be organized to produced education indicators? and (3) How should indicators be reported to meet needs of users?

The state science and math indicators were selected through a consensus process that involved several interest groups of state policymakers, educators, data managers, and researchers. The indicators were designed from a research-based model but also carefully considered the needs of users of indicators. A consensus approach to selecting education indicators is consistent with the position that both rationality and participatory democracy must have a part in the formulation of an indicators system (Ruby, 1991). Representatives of state policymakers and educators, researchers in science and math education, and state and national data managers had a part in determining the indicators that would be given priority, as well as in their design, data collection, and reporting.

There are three important steps in selecting indicators by a consensus process. First, the broad areas or categories of indicators need to be defined. Second, the kinds of data required for the desired indicators need to be identified, and an analysis must be made to see if the data are available, valid, and reliable. Then, the critical third step in the process is to involve the different interests or perspectives on the indicators system in moving from desired or potential indicators to selecting a smaller set of priority indicators for implementation. With the state science-math indicators, the state representatives provided practical judgements of which indicators would be most informative and useful for policymakers and educators. The data mangers provided input on existing and planned data systems and surveys that would provide data for indicators. The researchers analyzed potential indicators in terms of their reliability, validity, and significance for measuring improvement in education.

Any system of education indicators is likely to be built from different kinds of data sources. Some indicators can be taken directly from large, multi-purpose data bases with multiple purposes, such as from the U.S. Census. Other indicators can be obtained from large-scale sample surveys that have sufficient size to provide disaggregation to different levels of the education system, such as from NAEP. The state science and math indicators described here provide an example of indicators that rely on existing state data systems and the commitment and participation of state staff and resources in implementing the indicators. For many states, the use of existing state data was important to show that the large amount of resources expended to maintain the systems could have uses beyond the immediate monitoring and reporting functions within states. In the Council project, the development of common reporting definitions and categories and a national cooperative data system produced a way to use state administrative records for comparative education indicators.

A critical step in developing a cooperative data system was agreeing on common standards for aggregating and reporting data that are collected by different agencies. The data categories may have to incorporate different kinds of concerns. For example, the categories for course enrollments on science and math had to be both "practical," to provide a way to compare data between existing state data files, and "meaningful," to portray the data in terms that give important information on the status of science and math education.

The users of indicators were a key consideration in the design of the state science and math indicators. They were designed for use primarily at state and national levels. For example, a decision was made initially to aggregate and report only state-level and national statistics, but to also assist states in developing their own indicators that could be reported at district or school levels. The state indicators were reported according to data categories that would be meaningful to state policymakers and educators, such as advanced vs. introductory levels of course enrollments. The initial report on science-math indicators emphasized disaggregation of data for basic analyses of equity, such as course enrollments by gender and teacher supply and qualifications by gender and race/ethnicity. An iterative process was used to give indicators users, data providers, and other advisers an opportunity to review the indicators being selected, the data to be reported, and the formats and categories in which indicators would be reported. These steps provided a mechanism for sharpening the organization and display of indicators to meet the interests and needs of primary audiences.

Notes

1. This recommendation concerned reporting of the indicators, not collection of data. More detailed data related to characteristics of the main indicator, such as student, teacher, or school demographics, can be available for use in further analyses.

2. Each state proportion is a statistical estimate of the course-taking of high school students by the time they graduate based on the total course enrollment in grades 9-12 in Fall 1989 divided by the estimated number of students in a grade cohort during four years of high school. The statistical estimating method is imprecise above the 95 percent course-taking rate. See Blank and Dalkilic (1990) for further explanation.

3. A total of 47 states reported state data in 1989-90 for one or more of the indicators in the cooperative system, which also included data on science and math teacher characteristics and qualifications.

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Figure 1
Priority State Indicators of Science and Mathematics Education*

PRIORITY SCIENCE/MATHEMATICS INDICATOR	DATA SOURCE
Student Outcomes	
STUDENT ACHIEVEMENT	NAEP
STUDENT ATTITUDES/INTENTIONS	NAEP
Instructional Time/Participation	
GRADES 7-12 COURSE ENROLLMENT	STATE DATA (CCSSO)
ELEMENTARY MINUTES PER WEEK	SCHOOLS/STAFFING SURVEY (SASS) (NCES)
Curriculum Content	
STUDENTS' "OPPORTUNITY-TO-LEARN"	Data not available
School Conditions	
CLASS SIZE by Subject/Course	SASS (NCES) or
NO. of COURSE PREPARATIONS PER TEACHER	STATE DATA (Available in some states)
COURSE OFFERINGS PER SCHOOL	
Teacher Quality	
COURSES/CREDITS IN SCIENCE/MATHEMATICS	SASS (NCES)
TEACHING ASSIGNMENTS BY FIELD/SUBJECT By Age, Gender, Race/Ethnicity	STATE DATA (CCSSO)
TEACHING ASSIGNMENTS BY CERTIFICATION FIELD/SUBJECT (Number of Teachers Out-of-Field)	STATE DATA (CCSSO)
Equity	
GENDER AND RACE/ETHNICITY by Student or Teacher	STATE DATA (CCSSO)

*Approved by CCSSO, November 1987.

Figure 2

STEPS IN DEVELOPING AN INDICATORS SYSTEM

Selecting Indicators

1. Develop a Conceptual Framework Based on Research Results and Interests of Policymakers and Educators.

2. Obtain Commitment and Cooperation of Leaders.

3. Involve Policymakers, Educators, Researchers, and Data Managers in Selecting Priority Indicators.

4. Select a Limited Number of Indicators and Hold Down Complexity in Reporting.

Organizing a Cooperative Data System

5. Decide Method of Collecting Data.

6. Work with Data Users and Providers to Establish Standards for Producing Comparable Data.

Reporting Comparative Data on Indicators

7. Design Data Forms and Cross-Walk Procedure.

8. Collect and Edit Data.

9. Report Indicators.

Table 1

ESTIMATED PROPORTION OF PUBLIC SCHOOL STUDENTS TAKING SELECTED MATHEMATICS COURSES BY GRADUATION

STATE	ALGEBRA 1 (Formal Math Level 1)	ALGEBRA 2 (Formal Math Level 3)	CALCULUS (Formal Math Level 5)
ALABAMA	70%	46%	6%
ALASKA	—	—	—
ARIZONA	—	—	—
ARKANSAS	88	48	5
CALIFORNIA	92	44	9
COLORADO	—	—	—
CONNECTICUT	74	61	14
DELAWARE	73	43	17
DC	65	39	3
FLORIDA	78	42	9
GEORGIA	—	—	—
HAWAII	52	33	4
IDAHO	95+	64	6
ILLINOIS	77	39	9
INDIANA	60	45	8
IOWA	92	50	9
KANSAS	66	47	9
KENTUCKY	81	54	6
LOUISIANA	95+	64	4
MAINE	84	64	—
MARYLAND	94	51	13
MASSACHUSETTS	—	—	—
MICHIGAN	—	—	—
MINNESOTA	90	55	12
MISSISSIPPI	85	58	3
MISSOURI	95	58	8
MONTANA	94	65	6
NEBRASKA	75	54	6
NEVADA	90	32	5
NEW HAMPSHIRE	—	—	—
NEW JERSEY	—	—	—
NEW MEXICO	95+	47	8
NEW YORK	69	46	12
NORTH CAROLINA	67	51	8
NORTH DAKOTA	95	64	3
OHIO	80	47	8
OKLAHOMA	95+	60	8
OREGON	—	—	—
PENNSYLVANIA	88	57	16
RHODE ISLAND	—	—	—
SOUTH CAROLINA	69	55	7
SOUTH DAKOTA	—	—	—
TENNESSEE	79	54	4
TEXAS	82	54	5
UTAH	82	63	13
VERMONT	—	—	—
VIRGINIA	81	55	11
WASHINGTON	—	—	—
WEST VIRGINIA	73	42	2
WISCONSIN	79	36	9
WYOMING	73	29	8
U.S. TOTAL	81%	49%	9%

Note: Each state proportion is a statistical estimate of course taking of high school students by the time they graduate based on the total course enrollment in grades 9-12 in Fall 1989 (See Appendix Table A-5) divided by the estimated number of students in a grade cohort during four years of high school. The statistical estimating method is imprecise above 95 percent course taking rate. (see Appendix C for further explanation)

Algebra 1 percentages include grade 8.

—Data not available

U.S. Total=Proportion of all high school students estimated to take each course, including imputation for non-reporting states.

Source: State Departments of Education, Data on Public Schools, Fall 1989; N. Carolina and Wisconsin, Fall 1988

Council of Chief State School Officers, State Education Assessment Center, Washington, DC, 1990

Table 2

ESTIMATED PROPORTION OF PUBLIC HIGH SCHOOL STUDENTS TAKING SELECTED SCIENCE COURSES BY GRADUATION

STATE	BIOLOGY 1st Year	CHEMISTRY 1st Year	PHYSICS 1st Year
ALABAMA	95+%	38%	21%
ALASKA	—	—	—
ARIZONA	—	—	—
ARKANSAS	95+	33	13
CALIFORNIA	91	33	16
COLORADO	—	—	—
CONNECTICUT	95+	62	36
DELAWARE	95+	48	19
DC	75	46	13
FLORIDA	95+	44	19
GEORGIA	—	—	—
HAWAII	88	40	21
IDAHO	80	26	15
ILLINOIS	78	40	20
INDIANA	95+	42	19
IOWA	95+	57	27
KANSAS	95+	45	17
KENTUCKY	95+	45	14
LOUISIANA	90	50	21
MAINE	94	58	—
MARYLAND	95+	61	27
MASSACHUSETTS	—	—	—
MICHIGAN	—	—	—
MINNESOTA	95+	44	23
MISSISSIPPI	95+	55	17
MISSOURI	86	41	16
MONTANA	95+	48	24
NEBRASKA	95+	46	21
NEVADA	65	33	13
NEW HAMPSHIRE	—	—	—
NEW JERSEY	—	—	—
NEW MEXICO	95+	33	15
NEW YORK	95+	56	28
NORTH CAROLINA	95+	47	15
NORTH DAKOTA	95+	54	24
OHIO	95+	49	20
OKLAHOMA	93	37	10
OREGON	—	—	—
PENNSYLVANIA	95+	56	29
RHODE ISLAND	—	—	—
SOUTH CAROLINA	95+	51	16
SOUTH DAKOTA	—	—	—
TENNESSEE	88	42	11
TEXAS	95+	40	12
UTAH	80	37	20
VERMONT	—	—	—
VIRGINIA	95+	57	23
WASHINGTON	—	—	—
WEST VIRGINIA	95+	40	11
WISCONSIN	95+	51	25
WYOMING	86	36	16
U.S. TOTAL	95+%	45%	20%

Note: Each state proportion is a statistical estimate of course taking of high school students by the time they graduate based on the total course enrollment in grades 9–12 in Fall 1989 (See Appendix Table A-6) divided by the estimated number of students in a grade cohort during four years of high school. The statistical estimating method is imprecise above 95 percent course taking rate. (see Appendix C for further explanation)

—Data not available

U.S. Total=Proportion of all high school students estimated to take each course, including imputation for non-reporting states.

Source: State Departments of Education, Data on Public Schools, Fall 1989; N. Carolina and Wisconsin, Fall 1988

Council of Chief State School Officers, State Education Assessment Center, Washington, DC, 1990