DOCUMENT RESUME

ED 260 892 SE 045 915

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TITLE	Achievement in Mathematics Education. Information Bulletin No. 2.
INSTITUTION	ERIC Clearinghouse for Science, Mathematics, and Environmental Education, Columbus, Ohio.
SPONS AGENCY	National Inst. of Education (ED), Washington, DC.
PUB DATE	84
CONTRACT	400-78-0004
NOTE	9p.
AVAILABLE FROM	SMEAC Information Reference Center, The Ohio State Univ., 1200 Chambers Rd., 3rd Floor, Columbus, OH 43212 ($1.00).
PUB TYPE	Reports - Research/Technical (143) -- Information Analyses - ERIC Information Analysis Products (071)
EDRS PRICE	MF01/PC01 Plus Postage.
DESCRIPTORS	Academic Achievement; *Educational Assessment; Educational Research; *Educational Trends; Elementary Secondary Education; Graphs; *Mathematics Achievement; *Mathematics Education; Mathematics Instruction; National Competency Tests; *Testing
IDENTIFIERS	*Mathematics Education Research

ABSTRACT

This bulletin reports some of the findings from an analysis of assessments in mathematics that have been conducted in 32 states. Note is made of the variability in state reports, which make data comparisons implausible. Trends, however, could be observed. Each state department was contacted for a copy of the most recent mathematics assessment results; reports from years ranging from 1955 to 1984 were received from 32 states. The overall trend of increased achievement is first noted. Then achievement patterns are presented, with graphs for addition, subtraction, multiplication, and division with whole numbers; fractions; decimals; numeration; measurement; geometry; and problem solving. (MNS)

ERIC®
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Information Bulletin

No. 2, 1984

Achievement in Mathematics Education

Concern about achievement in mathematics is not a recent phenomenon. It is a continuing concern for a subject area that is considered to be at the core of education, but it seems to reach new heights every few decades. The accountability movement that began in the 1970s put new emphasis on testing children, and state after state mandated or legislated that some type of regular assessment must be made of the products of schools.

This bulletin reports some of the findings from an analysis of the assessments of mathematics that have been conducted in 32 states. Additional information, plus tables of the scores from each state on a recent assessment, may be found in an ERIC/SMEAC publication, *Assessing Achievement Across the States: Mathematical Strengths and Weaknesses*. In that document, the amount of variability in the state reports is stressed, for instance:

- Some states use standardized tests; other states have developed their own.
- Some states have tested only (bare) minimum skills; other states have broadened the scope to attempt to ascertain how extensively students have learned a wide range of topics.
- Some tests have focused on knowledge; others have attempted to measure higher levels of learning.
- Some states have involved panels of teachers and other mathematics educators in developing the tests, and have even collected data on the validity and reliability of the tests, while others have used state department personnel.
- Some states have carefully built in comparisons with data from the National Assessment of Educational Progress (including, frequently, using NAEP items for at least a part of their testing), others have run comparisons with norms from one or more standardized tests, while still others have made no comparisons.
- Some have kept track of how the achievement in their state changes from year to year, while others give little indication of prior tests.
- Some have given assessments every ..., on a (somewhat) established time table, while others have given them once or twice—or at an interval of ten years.
- Some few assess every grade level; most assess what they have identified as focal points—but the focal points differ from state to state.

In addition to these variations in how the assessment task was approached, there are decided differences in the way the data are reported. Because of this variability, it is hazardous to make comparisons: the data are not comparable. It seems possible, however, to determine what trends in mathematics achievement are evidenced.

How the Information Was Collected

A search of the ERIC database revealed that reports of state assessments in mathematics either were difficult to locate, largely because most assessments include more than mathematics, or were questionable in terms of recency. Therefore, a letter was sent to each of the state mathematics supervisors, or, in the cases where such a person is not identified, to the state department as an entity. The letter stated the problem and asked that a copy of "the most recent mathematics assessment results" be sent. In all, 38 states responded, three with letters that they had no state assessment, three with test documents but no data, and the remainder (32) with documents containing data.

On Table 1, the information received from each state is summarized. In the column for "type of test", N stands for normed or standardized test and S stands for state-developed test. The date indicates the year when a test was given for which data were sent (it does not indicate all of the times when a test was given in a state).

Tables of the scores were next developed, by item whenever possible. Then scores on topical areas (for instance, addition with whole numbers) were compiled. Finally, items on which students scored low were listed, as an indication of those objectives with which students were having difficulty. However, this list is not included in this bulletin.

TABLE 1
SUMMARY OF DATA RECEIVED

State	Type of Test	Data Given	Levels Tested
Alabama	N	1984	2, 4, 5. 8, 10
	S	1984	3, 6, 9
	S	1983, 1984	12
Arkansas	S	1982-83	3, 6, 8
California	S	1979-1983	3, 6, 12
Connecticut	S	1980-1983	9
Delaware	N	1981-1983	1-8, 11
	N	1984	1-8, 11
Florida	S	1982	3, 5, 8, 10
Hawaii	N	1981-1983	2, 4, 6
Idaho	S	1984	8, 9
Illinois	S	1976-1983	4, 8, 11
Indiana	N	1980-1982	all
Iowa	S	1975-76	5, 8
	N	1955-1977	3-8, 9-12
Kansas	S	1982-83	2, 4, 6, 8, 11
Louisiana	S	1982-1984	7, 10
Michigan	S	1980-81	4, 7, 10
Minnesota	S	1982-83	4, 8, 11
Mississippi	N	1977-1983	4, 6, 8
Montana	S	198_	6, 11
Nevada	S	1979-1983	9
	N	1979-1983	3, 6
New Hampshire	S	1980	5, 9, 12
New Jersey	S	1977-1983	9, 10
New Mexico	N	1984	3, 5, 8
North Carolina	N	1983	1, 2
	N	1983	3, 6, 9
North Dakota	S	1975-1979	4, 6, 8, 11
Ohio	S	1977, 1978	4, 8, 12
Oregon	S	1982	4, 7, 11
Pennsylvania	S	1983	5, 8, 11
Texas	S	1980-1983	3, 5, 9, 10, 11, 12
Virginia	N	1981-1984	4, 8, 11
Washington	N	1979-1983	4, 8, 11
West Virginia	N	1976-1980	3, 6, 9, 11
Wisconsin	S	1976-1982	4, 8, 12
Wyoming	S	1977	12

Caution must be taken in evaluating the results. Not only did most objectives differ in their level of inclusion or exclusion, the items written to test even the same objective differed. Seemingly small differences in the wording of an item, or in a diagram, can result in markedly different scores. Differences in difficulty level of items also occurred as grade level increased. This report therefore attempts to look at broad topics, rather than at specific objectives. In order to improve instruction, it is imperative that scores on specific objectives be analyzed The intent here is merely to step back and determine the broader trends and patterns that occur.

Trends in Achievement

The general trend in mathematics achievement is upward, at least since the beginning of the 1980s, as indicated by the state assessment results. Table 2 depicts the patterns indicated by data from 17 states for which data from two or more assessment years were received In 33 instances, scores rose between assessments In 11 instances, scores declined, while in 19 instances, they remained approximately the same. Caution must be taken, however, since dates as well as type of test are varied. This is illustrated, for instance, in the case of Iowa. The table indicates that scores in Iowa declined between assessments. However, the data received from Iowa were for tests given between 1955 and 1977. A recent document from Iowa in which trends were analyzed for the period from 1955 through 1984 indicates that:

> The achievement trend reached its minimum in the 1974-75 school year. Since that time, achievement has increased slowly but consistently. During the past year, achievement was at or near an all-time high in Grades 3-6 in most test areas. In Grades 7-8, achievement is still below the 1965 level but has been steadily improving. (Hoover, 1985, p. 1)

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Patricia E. Blosser
Bulletin Editor

TABLE 2
TRENDS IN ACHIEVEMENT

State	Grade 3	4	5	6	7	8	9	10	11	12
Arkansas	↑			↑		↑				
California	↑			=						=
Connecticut							↑			
Delaware	↓	↑	↑	↑	↑	↑			=	
Hawaii		=		↓						
Illinois		↑				↑			↑	
Indiana	=	=	=	=	=	=	=	=	=	=
Iowa	=	↓	↓	↓	↓	↓				
Louisiana					↑			↑		
Minnesota		=				↑			↑	
Mississippi		↑		↑		↑				
Nevada	↓			↓			↓		↑	
New Jersey							↑			
Texas	↑		↑				↑	↑	=	
Virginia		↑				↑			↑	
West Virginia	↑			↑			↑		↑	
Wisconsin		↓				=				=

Achievement Patterns by Topic

To illustrate how well students are scoring on particular topics, the data from the latest state-developed test received were collated. Only those points at which there were sufficient data being reported (by a number of states, on a number of items) were included. Topics meeting this criterion, at varying grade levels, are. addition, subtraction. multiplication, and division with whole numbers, fractions, decimals, numeration, geometry, measurement; and problem solving.

Addition with Whole Numbers

For addition with whole numbers, data for grades 3, 4, 5, 8, and 9 are displayed in Figure 1. Note that almost no scores are below the 80 percent level, and that in all instances they approach the 100 percent level. The range in each case is narrow, and most of the scores on individual items are in the 90s (indicated by the heavier band).

By grade 3, most students are at a high level of proficiency on addition computation, and they retain that proficiency through the grades. This same pattern is true at other grade levels not included in Figure 1.

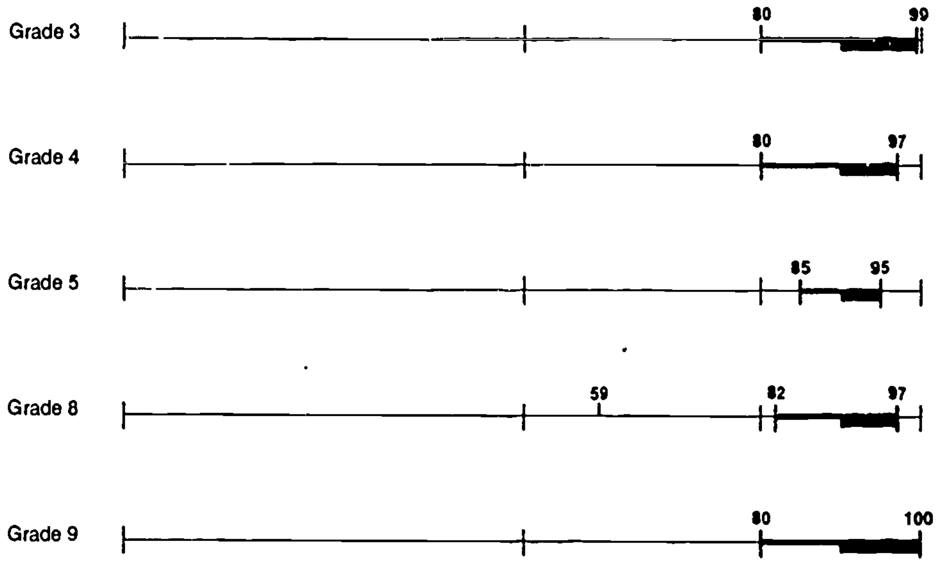

Figure 1. Addition with Whole Numbers

Subtraction with Whole Numbers

The picture for subtraction with whole numbers is one of greater variability, especially in grades 3, 4, and 5 (see Figure 2). By grades 8 and 9, however, most students have reached about the same level of proficiency with subtraction as they have attained with addition. Moreover, the same pattern prevails at other grade levels.

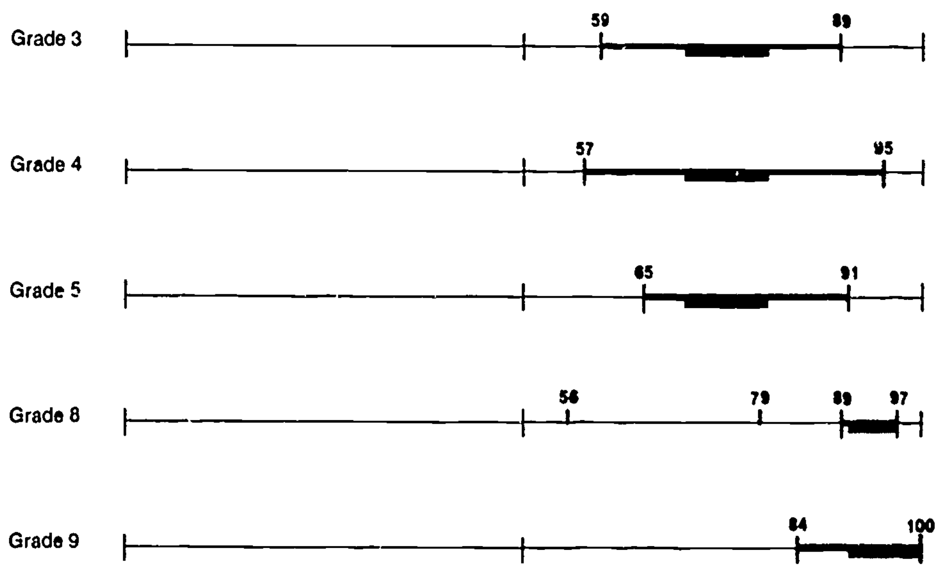

Figure 2. Subtraction with Whole Numbers

Multiplication with Whole Numbers

For multiplication with whole numbers, the range of scores is also rather broad in grades 4, 5, and 6, but the upper limits are higher than for subtraction at the lower grade levels (see Figure 3). By grade 9, the scores of most of the students indicate mastery, and this is verified by the limited data for grades 10-12.

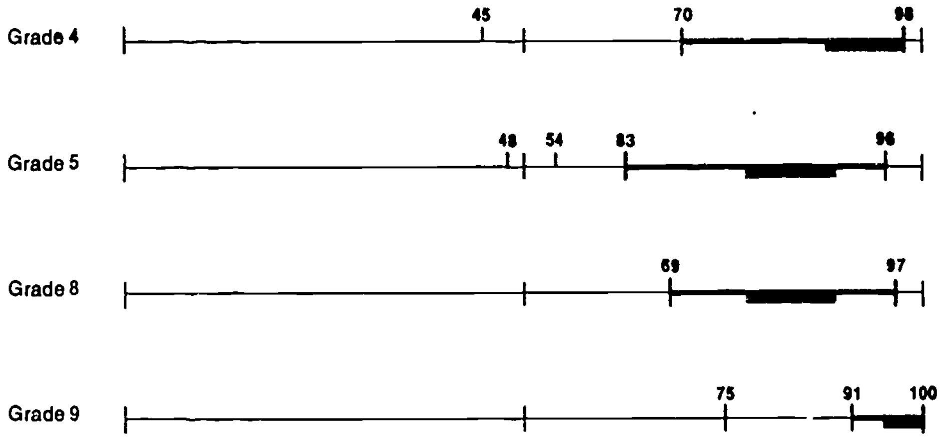

Figure 3. Multiplication with Whole Numbers

Division with Whole Numbers

Not unexpectedly, the ranges of scores for division with whole numbers are broad and tend to remain so across grade levels, although in grades 4, 8, and 9 the upper limit is high and in grade 5 it would appear acceptable (see Figure 4). The band indicating where the most scores at each grade level lie is lower, however—in the 70s at the lower levels and in the 80s at grade 9. (For addition, the band was in the 90s at all grade levels; for subtraction and multiplication, it rose to the 90s by grade 9.) Division is of continuing difficulty for many students. However, division is the last of the four operations to be introduced to students, and they have had less time to practice and master the algorithm. This time factor combines with the difficulty of the algorithm to depress achievement. Scores do tend to improve in grades 10-12, although they do not reach the high levels attained with the other operations.

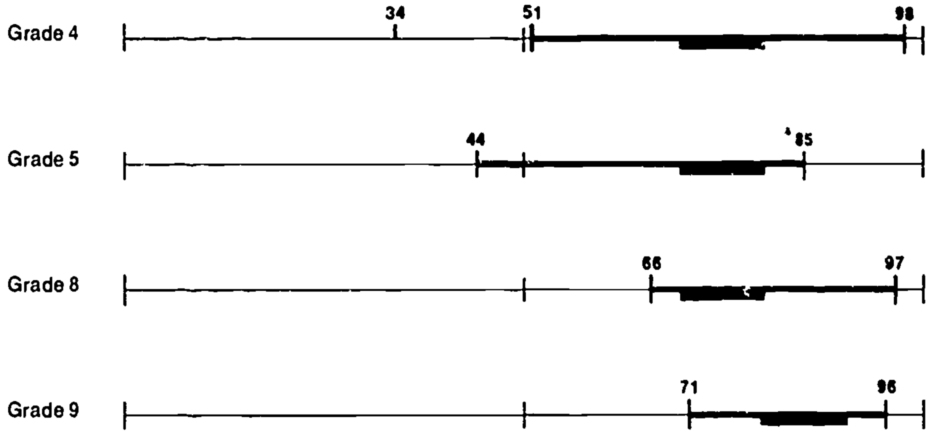

Figure 4. Division with Whole Numbers

Fractions

A certain consistency seems to characterize the scores for achievement on fractions (see Figure 5). Depicted are scores of concepts of, for instance, equivalence, as well as scores for computation. In each instance, one or more scores is markedly deviant from the others; in some cases these may indicate that the item was either very difficult or was faulty. The lower limit of scores at most grade levels is around the 50 percent level; while the upper limit is near or in the 90s, the band indicating where most scores lie is between 75% and 85% only in grade 11. Achievement with fractions for most students is clearly below their level of achievement with whole numbers.

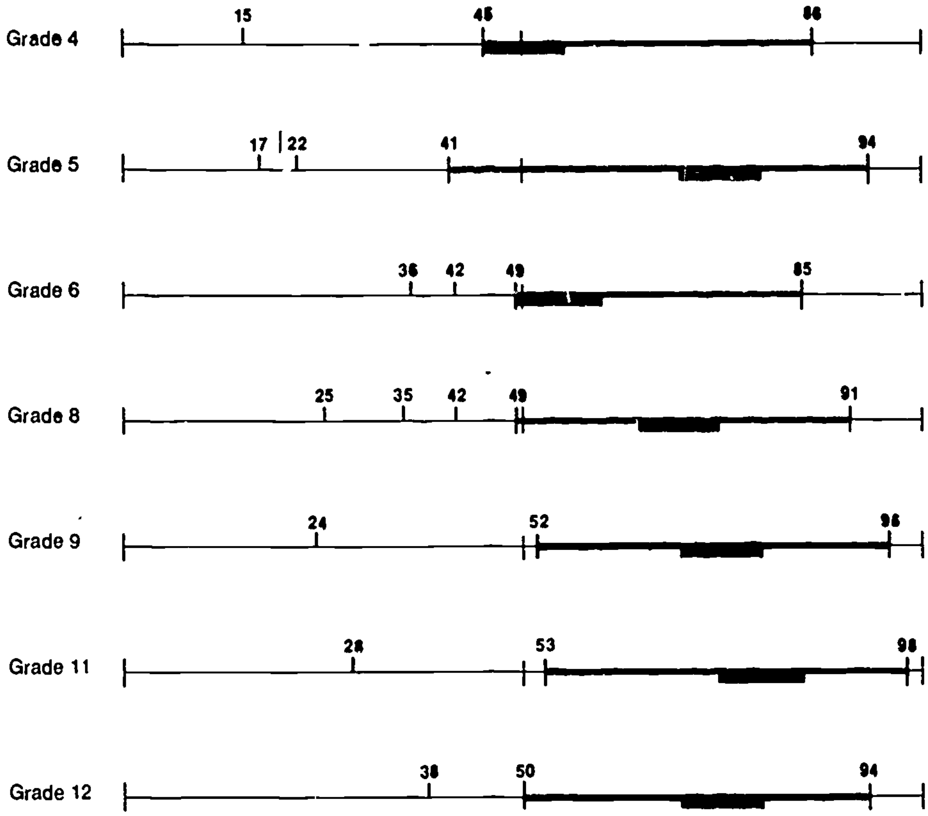

Figure 5. Fractions

Decimals

For decimals, a somewhat variable picture is again presented (see Figure 6). Except for the unexplainable case of grade 11, the band where most scores lie is in the 80s, indicating an acceptable level of achievement. However, for many students, on many objectives for work with decimals, difficulties persist through the grades.

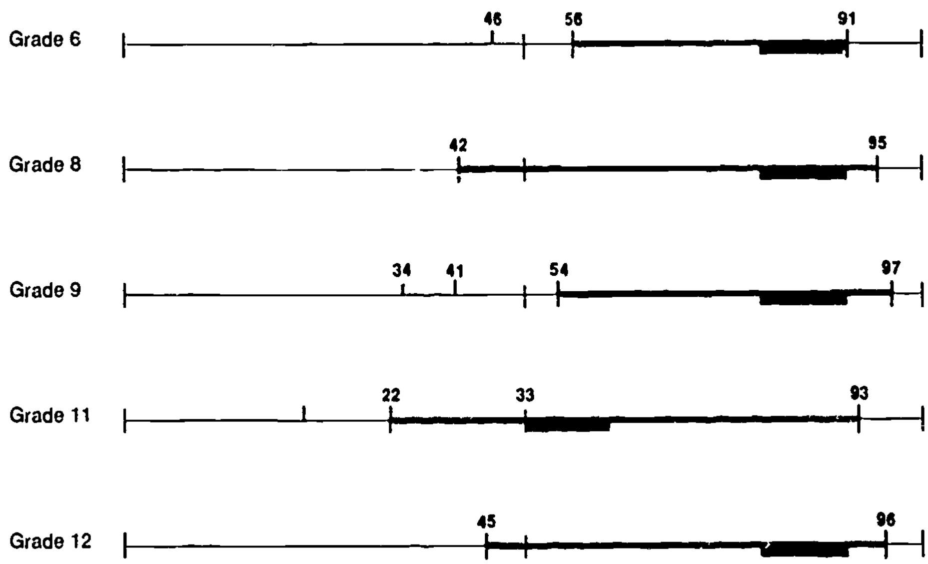

Figure 6. Decimals

Numeration

On numeration, attainment on most items is acceptable, as shown by the bands in the 90s in grades 3, 4, and 5 and in the 80s in grade 8 (see Figure 7). Why this drops is uncertain, but it may be that concepts taught earlier have not been retained, or it may be that the objectives being tested have expanded to include many topics beyond the place value emphasis in the early years. The limited data for grades 11 and 12 show continued variability, although the band where most students score is in the 90s by grade 12.

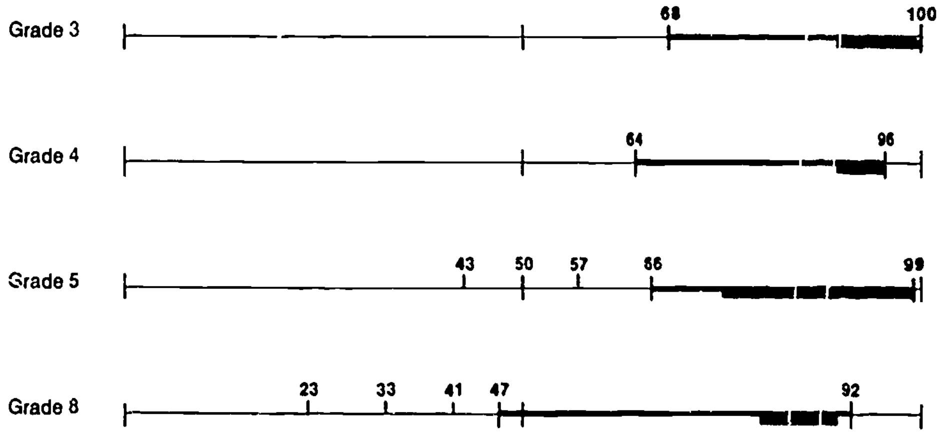

Figure 7. Numeration

Measurement

Variability also characterizes the measurement scores (see Figure 9). It is apparent from the data that items assessing skills or understanding with the common English measurement system are easier for students than are items dealing with metric measurement. The bands depict three instances where the same number of items were being answered correctly at two points—at grade 5 in the 30s and 90s, at grade 9 in the 60s and 90s, and at grade 12 in the 70s and 80s. An extended look at the curriculum, at what is actually being taught, and at the test items seems needed.

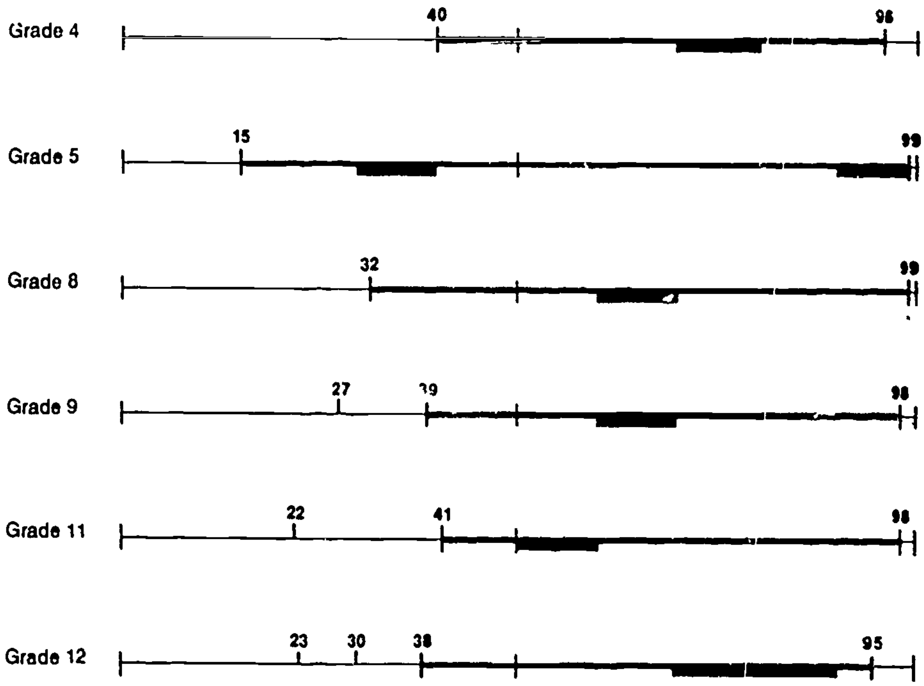

Figure 8. Measurement

Geometry

Fewer grade levels are depicted for geometry scores, largely because most tests contain few geometry objectives and some tests contain none (see Figure 8). The range of content being tested may account for the variability in scores, especially in grade 5, or the scores may reflect a lack of emphasis in the instructional program. At any rate, the scores approach acceptability in grade 5, but in both grade 8 and grade 11 many items are being answered correctly by only 40% to 50% of the students.

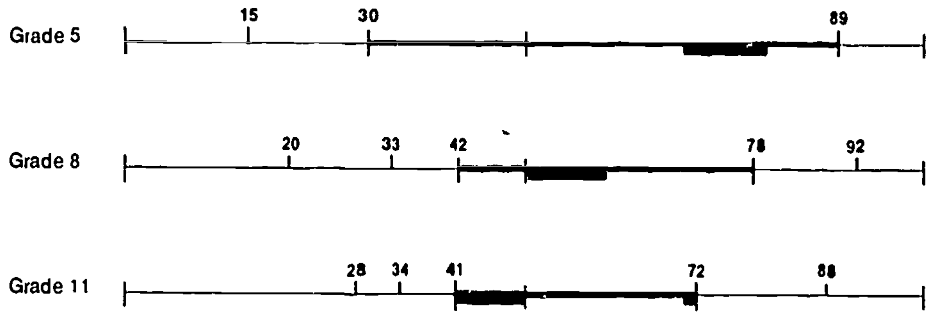

Figure 9. Geometry

Problem Solving

The great variability of the content included in problems, and the resulting variability in difficulty level, makes graphic display of the data virtually meaningless. Figure 10 presents the scores for each grade level. No clear patterns emerge, except for the broad range of scores at most grade levels, and the varying points at which most scores cluster.

Scores on problems with each operation with each topic are generally lower than scores on the topics alone, when items are parallel. Since the tests were not usually developed to check this conclusion, parallel items seldom occur. The National Assessments do provide support for this idea, however, when parallel items were specifically developed. In addition, some support is generated by the data from standardized tests, on which problem-solving scores generally lie below computation scores.

On most problems focusing on problem-solving strategies (such as guess and test, look for a pattern, or find relevant data), scores tended to cluster around the 60 percent level, with a range of 22 to 96. Scores on consumer or career application items ranged from 14 to 97, with a large cluster in the 80s.

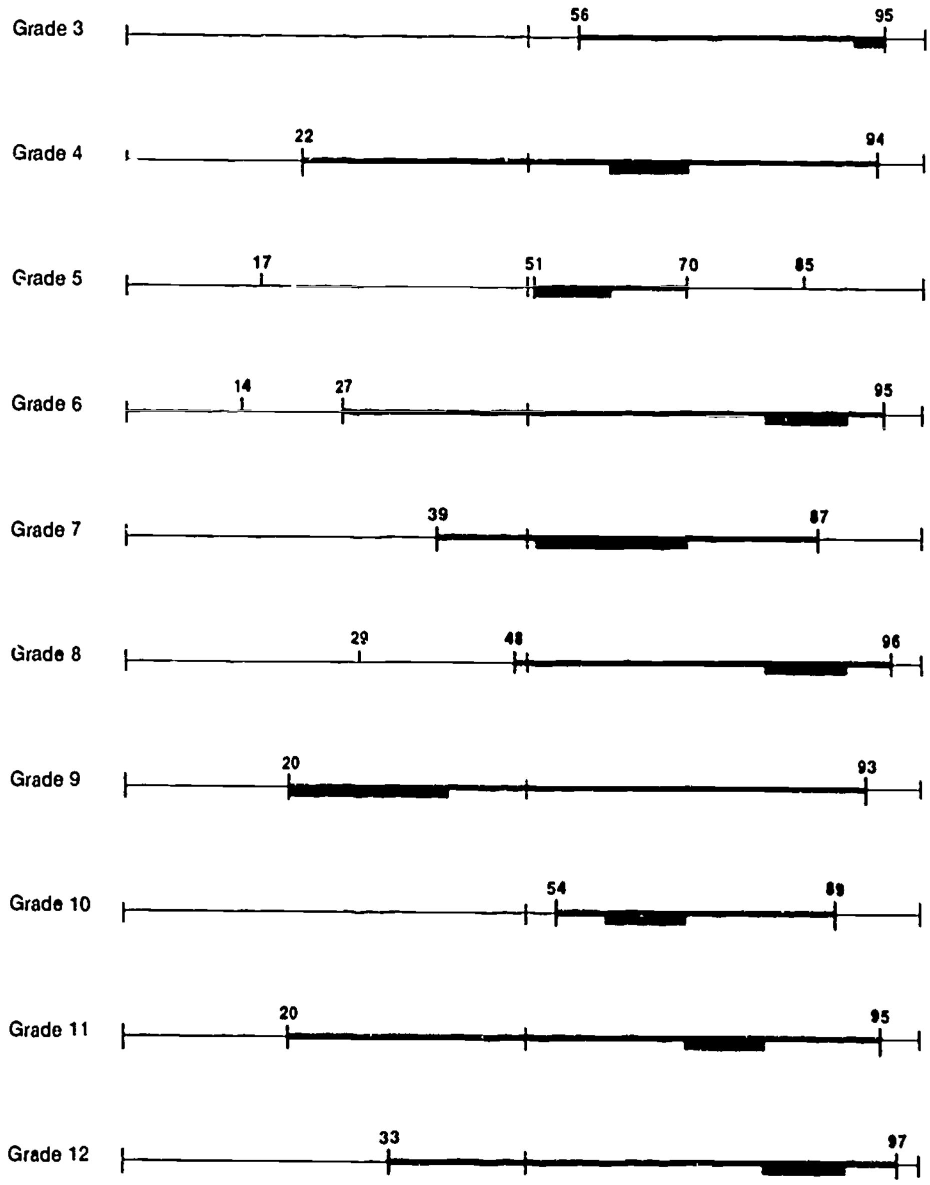

Figure 10. Problem Solving

General Conclusion on Achievement

It should be apparent from the data displayed that children are scoring well on items dealing with computation, especially with whole numbers. However, scores on items dealing with concepts and problem solving are not as high. The statements from state report after state report are very clear on this; for instance, here is an excerpt from the California report:

> schools are doing a good job of teaching tasks requiring computation and recognition. However, increases were relatively small on problem solving and application questions, which require students to think. This weaker growth pattern led the committee to believe that such skills are not being reinforced in classrooms. Simply teaching students low-level knowledge and skills is unlikely to improve substantially higher-level cognitive skills and understanding. Improvements in higher cognitive skills will occur only when higher-level problem solving becomes a curricular and instructional focus. (California, 1984, p. 51).

The National Assessment of Educational Progress, dealing with a nationwide sample of students, provides data on their achievement on common sets of items. The same concern expressed by many of the states individually is reflected in the report on the third national assessment in mathematics (as it also has been in reports of the first two assessments):

> .. it appears that American schools have been reasonably successful in teaching students to perform routine computational and measurement skills, and to answer questions assessing superficial knowledge about numbers and geometry. It is encouraging to note positive change on items assessing knowledge and skills not only in numerical computation, but also in geometry and measurement. On the other hand, it appears from the low percentages of success on some items that schools have thus far taught only a small percentage of students how to analyze mathematical problems or apply mathematics to nonroutine situations. (NAEP, 1983, pp. 2-3)

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