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Achievement Results for Second and Third Graders Using the *Standards*-Based Curriculum *Everyday Mathematics*

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Students using *Everyday Mathematics* (EM), developed to incorporate ideas from the NCTM [illegible] *Standards*, were at normative U.S. levels on multidigit addition and subtraction symbolic computation on traditional, reform-based, and EM-specific test items. Heterogeneous EM 2nd [illegible] graders scored higher than middle- to upper-middle-class U.S. traditional students on 2 number [illegible]

ematics curricula in higher achieving nations and that instruction in the United States is still more likely to focus on practice of skills than on understanding (McKnight et al., 1989; Peak, 1996; Stigler, 1997).

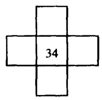
A number of U.S. researchers investigating the progress of students experiencing meaning-based instruction have reported positive effects on students' understanding and achievement (Carpenter, Franke, Jacobs, Fennema, & Empson, 1998; Cobb, Wood, Yackel, & Perlwitz, 1992; Fuson, Smith, & Lo Cicero, 1997; Fuson, Wearne, et al., 1997). For example, when compared with students in traditional textbook-based classes, students in Cobb et al.'s Problem-Centered Mathematics Project scored significantly higher on measures of conceptual understanding as well as on standardized tests (Wood & Sellers, 1997). These students also saw mathematics as a more purposeful and understandable activity than did students using traditional approaches. Carpenter, Fennema, and colleagues have reported similar gains for Cognitively Guided Instruction in problem solving and conceptual understanding (Carpenter et al., 1998). Others have reported strong gains in students' conceptual understanding and use of calculation methods when students are actively involved [illegible]

Fuson, Wearne, et al., 1997; Hiebert & Wearne, 1993).

With support from the National Science Foundation and other sources, a number of mathematics educators have developed elementary mathematics programs to attempt to incorporate this research on learning and teaching into a full-scale

Francisco area and 33 Japanese second grade students attending a middle class one of these ways. The only other question answered correctly by fewer than 40% of the EM students was "How much is 301 – 7?" However, this percentage correct was higher than for either the U.S. comparison or Japanese students. Results on the mathematics-achievement test showed a pattern different from the number-sense results, with the Japanese students scoring near ceiling on most items and the EM students scoring between the Japanese and the U.S. comparison students (see Table 2). The Japanese students scored significantly higher than the EM students

Table 3
Grade 2: Percentages Correct on Additional Items From EM Test

Question	EM $n = 343$
Place value	
1. Write the number *five thousand four.*	76
2. Write the number *three hundred twenty-six.*	85
3. Write the number that is 10 more than 57.	85
4. Write the number that is 100 less than 465.	71
5. Write the number that has 6 tens, 3 ones, 5 hundreds.	66
6. Write the number that has 7 thousands, 8 tens, 5 ten thousands, 1 one, 0 hundreds.	38
7. What is the number that is the same as ten tens?	62
8. Complete the number grid: "Here is a piece of the hundreds grid. Fill in the missing numbers on the grid." 	84
Computation	
9. 36 + 47 (vertical format, no context)	65
10. 72 – 26 (vertical format, no context)	38

curriculum was allotted to discussion of students' strategies, such as various counting strategies. These ideas and skills also were reinforced and practiced through counting exercises (e.g., "Write 10 more than 43") and regular activities involving computation and number comparisons on number lines and number grids. EM students also explored fractions in everyday situations from kindergarten onward. In contrast, the EM curriculum had fewer examples of vertical context-free symbolic computations, items on which the EM students did not outperform traditional U.S. samples.

STUDY 2

Comparison computation problems in Study 1 were largely symbolic because the comparison items were originally presented in that way. However, computation in the EM curriculum is usually embedded in a context such as a story problem or a larger problem-solving activity, so the Grade 2 symbolic items did not present a complete picture of the computational abilities of EM students. Study 2 included both symbolic and contextualized computation problems as well as questions in [illegible]

[illegible] & Silver, 1989; Kouba, Carpenter, & Swafford, 1989; Lindquist & Kouba, 1989a, 1989b) and from a cognitively based test for Grade 3 (Wood & Cobb, 1989) were used for comparative purposes. Because of the nature of the tests and their construction by experts in the field, they provided items considered to be important both in new and in traditional U.S. mathematics curricula.

Method

Participants

Testing was planned so that each question was given to students from the whole range of achievement levels and SES backgrounds.

Of the total 64 questions, 22 were taken from the fourth NAEP for the purpose of comparison. Nine were taken from a third-grade cognitively based mathematics test (Wood & Cobb, 1989) given at the same time of the school year. The results for the Wood and Cobb sample are for traditional and problem-centered students combined, as reported by Wood and Cobb. Additional questions were follow-ups to the second-grade tests or were taken from the third-grade EM curriculum. Several performance-based items reflective of the curriculum were included (e.g., drawing or measuring a line segment of a given length).

The 22 NAEP questions were divided into two subtests for analysis: a Number Concepts and Computation subtest and a Geometry, Data, and Reasoning subtest. Each of these subtests contained 11 questions. These questions were presented in the same format as on the NAEP, either multiple choice or open-ended. Chi-square tests were used to compare performance on all NAEP and Wood and Cobb [illegible]

significance was used (instead of .05), $\chi^2(1) \geq 6.64$. Because between 10% and 15% of the 18,033 students were tested on each NAEP item (Carpenter, 1989), the NAEP sample was assumed to be 1,800 on each question.

Table 4
EM Grade 3 and NAEP Grade 4: Percentages Correct on NAEP Number and Computation Items

Question	EM Grade 3 n = 107 to 119[a]	NAEP Grade 4 n = 1,800[b]
Place value		
1. What digit is in the thousands place in the number 43,486?	67*	45
2. What number is 100 more than 498?	80*	43
Symbolic computation (Vertical form except Question 8, which was horizontal)		
3. 57 + 35	79	84
4. [illegible]	[illegible]	[illegible]
5. 54 – 37	72	70
6. 504 – 306	38	45
7. 242 – 178	62	50
8. If 49 + 83 = 132, which of the following is true? (132 – 49 = 83 is the answer)	56*	29
Computation in number stories		
9. Robert spends 94 cents. How much change should he get back from $1.00?	85*	68
10. Chris buys a pencil for 35 cents and a soda for 59 cents. How much change does she get back from $1.00?	59*	29
11. At the store, a package of screws costs 30 cents, a role [illegible] What is the cost of a roll of tape and a package of screws?	77*	58

Table [illegible]

Grade 3: Percentages Correct on Items From Wood and Cobb Test

Question	EM n = 107 to 119[a]	Wood & Cobb n = 191
Number stories		
1. Paul planted 46 tulips. His dog dug up some of them. Now there are 27 tulips left. How many tulips did Paul's dog dig up?	68*	49
2. Sue had some crayons. Then her mother gave her 14 more crayons. Now Sue has 33 crayons. How many crayons did Sue have in the beginning?	76*	50
3. Ann and Stacy picked 31 roses altogether. Ann picked 17 roses. How many roses did Stacy pick?	79*	52
4. Mary, Sue, and Ann sold 12 boxes of candy each. How many boxes of candy did they sell in all?	74*	49
5. There were 48 birds in a tree. Then, 14 flew away and 8 more arrived. How many birds are in the tree?	70*	51
6. In school, 24 children play soccer. Each soccer team has 6 players. How many teams are there?	88*	60
Place value and conceptual addition/subtraction		
1. There are 12 cubes hidden in the box. How many cubes are there altogether? (Drawing shows 4 ten-longs, 7 unit-cubes [base-10 blocks], and a box.)	77	67
2. Some cubes are hidden in the box. There are 57 cubes altogether. How many cubes are hidden? (Drawing shows 2 ten-longs, 2 unit-cubes [base-10 blocks], and a box.)	73*	50
Multiplication and division computation		
1. 3 * ___ = 27	80*	59

[a] [illegible]

vs. 45% of the seventh graders). EM students scored a mean of 23% higher on the three significant data and graphing items.

Table 7
EM Grade 3 and NAEP Grade 4:
Percentages Correct on Geometry, Data, and Reasoning Items

Question	EM Grade 3 $n = 107$[a]	NAEP Grade 4 $n = 1{,}800$[b]
Geometry		
1. What is the area of this rectangle?		

distance around) that involve area and perimeter, these students are less likely to confuse the two concepts.

SUMMARY

Various efforts are underway nationally to improve the mathematics achievement of U.S. students. The approach taken in the University of Chicago School Mathematics Project and similar meaning-based projects and curricula is an attempt [illegible]

to replace the "underachieving curriculum" (McKnight et al., 1989) with a more ambitious and meaningful mathematics program grounded in solving problems in contexts (rather than mostly symbolic problems), using manipulatives and tools to facilitate children's thinking, and fostering children's mathematical thinking by teachers. Whereas traditional U.S. primary programs have focused on practice of facts and of whole number algorithms, the EM curriculum and other reform programs also include a wider range of mathematical topics as envisioned by the NCTM *Standards* (1989).

Results from the two studies here show positive results for this approach. EM students at Grades 2 and 3 were at normative U.S. levels on multidigit addition and subtraction symbolic computation. On a test of number sense, the heterogeneous EM Grade 2 students scored higher than middle-class to upper-middle-class U.S. traditional-textbook students on two items and matched them on the remaining items, [illegible] sible if students try to understand the underlying situation instead of focusing on key words or on the sizes of numbers (shallow strategies frequently used by students using traditional textbooks).

Children's opportunity to learn was an important issue in interpreting the results of this study. However, several other issues relate to opportunity to learn. EM developers recommend 60 minutes of class time a day, and schools in the study reported [illegible]

scheduling that much time for math—exceeding the more common 45-minute mathematics period. However, this greater time for learning was accompanied by two other important changes: the inclusion of more ambitious topics and the support of learning in the new ways discussed in this report. Topics generally underrepre- [illegible] in the first three grades, the one or two teachers in whose classrooms we saw in-depth discussion of student thinking articulated their vision of the curriculum as consisting of a progression or range of solution methods through which they helped all children move (what Simon, 1995, called a "learning trajectory"); they did not view the curriculum as being composed just of the content of the EM lessons. These teachers looked for ways to help children move along throughout the year rather than just in the EM lessons focused on these topics, and they felt comfort-

that they felt considerable pressure to "cover" or "get through" the EM curriculum because there were so many lessons; in fact, no teacher taught all lessons in any year. Thus, there is conflict resulting from at the same time increased breadth of a curriculum that includes more advanced new topics and the depth required in allowing time for children to discuss their thinking. The trade-offs need to be examined in future research.

One alternative that might be explored in such research is the approach taken in the *Children's Math Worlds* project: Concentrate on more ambitious grade-level

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