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ABSTRACT

Lower-level mathematics courses often become a dead-end for mathematics course-taking among low-achieving students. However, several new upgraded mathematics courses reflecting emerging standards in mathematics are improving students' chances of taking college preparatory mathematics and raising student achievement. California and New York have created "transition courses" to serve as a bridge between basic and college preparatory mathematics. This document focuses on the nature of instruction in transition mathematics courses, the consequences of student placement in the new transition courses, and the linkages among course type, course content, and students achievement. The findings presented here are based on both qualitative and quantitative data gathered from seven high school in San Diego and San Francisco in California and in Buffalo and Rochester in New York. Schools were chosen which had high percentages of minority and low-income students because the problem of dead-end classes for low-achieving students is most severe in such schools. Benefits of the upgrade mathematics courses included students taking more challenging and useful mathematics, students learning more, the material covered was more practical and relevant to real life situations, and students had a better opinion of mathematics and a higher sense of self-esteem. Despite the benefits identified, problems in the implementation of the transition courses included: unclear objectives; a lack of teacher training; problems in course design, student placement and course sequencing; and a differentiated curriculum remains. Findings lead to four policy recommendations: (1) lower-level, general math courses should be eliminated; (2) improve implementation by having clear objectives and staff development; (3) pay more attention to student attendance, mobility patterns and student placement in courses; and (4) while the transition courses represent an improvement, the researchers' data supports eliminating low-level mathematics and requiring all students to take college preparatory math. (MKR)

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CPRE POLICY BRIEFS
Reporting on issues and research in education policy

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Lower level mathematics courses often become a dead-end for math course-taking among low-achieving students. In the vicious cycle of the general track teachers often set low expectations for students in low-level math courses, and students hold low expectations of themselves, continuing to further reduce the expectations held by teachers (Oakes, Gamoran, & Page, 1992).

However, several new upgraded math courses, reflecting emerging standards in mathematics, are improving students' chances of taking college preparatory math and raising student achievement.

California and New York have created "transition courses" to serve as a bridge between basic and college preparatory math. The goal of these courses is to enable students to learn challenging and useful mathematics and to increase their chances of going to college. The new transition courses are consistent with current reforms that set high standards for all students and reflect the National Council of Teachers of Mathematics' ambitious expectations.

This issue of *CPRE Policy Briefs* focuses on the nature of instruction in transition math courses, the consequences of student placement in the new transition courses, and the linkages among course type, course content, and student achievement. The findings presented here are based on both qualitative and quantitative data gathered from seven high schools across four districts in two states.[1]

We studied transition math courses in seven high schools in San Diego and San Francisco in California and in Buffalo and Rochester in New York. We chose schools that had high percentages of minority and low-income students, because the problem of dead-end classes for low-achieving students is most severe in such schools. The transition math courses were initiated as early as 10 years ago in Rochester, New York schools, and 3 to 5 years ago in California schools.

What is Math A?

In California, Math A was introduced as a course designed to upgrade the high school general math courses and serve as a bridge to get more lower-achieving students into college preparatory math courses (California State Department of Education, 1985). In 1985, California high schools began to replace lower-level math courses such as Fundamental Math and General Math with Math A. Topics covered in Math A include integration of functions, spatiality, logic, measurement, combinations, and data collection and analyses.

The strategy behind Math A is to eliminate the ninth-grade General Math classes and replace them with a course that stresses powerful mathematical content, with an emphasis on problem-solving, real-world applications, empirical reasoning, and the use of questioning strategies, manipulatives, calculators, and cooperative learning. Along the lines of the National Council of Teachers of Mathematics (NCTM) Standards, "powerful mathematical content" refers to an emphasis on the more complex cognitive tasks of understanding, application of knowledge, and reasoning, rather than memorization and routine formulae.

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While the original designers intended the course to serve as an alternative sequence for students to bypass algebra and take geometry, visions of the goals of Math A have varied at the district and school site. Some view the course as a place to better prepare students for college preparatory mathematics, some view the course as important "for all students" to improve their understanding of mathematics, some view the course as an alternative method for students to learn mathematical skills, and others view the course as a method to eliminate tracking by requiring all freshmen to take the course regardless of their future career or academic plans. Many variations exist from district to district and from school to school in the implementation of the Math A course including student placement in the course, the instructional materials used, and the math course students pursue following Math A.

What is Stretch Regents?

In Rochester, the two-year version of the college preparatory Regents courses, or "Stretch" Regents courses, cover the same integrated material as the Regents courses, but at a slower pace. Topics covered in Stretch Regents include algebra, geometry, trigonometry, probability, and statistics. In the Stretch Regents courses, material that is normally taught in one year is stretched over two years, enabling low-achieving math students to study Regents-level math. In the 1987-88 school year, Rochester mandated that each high school in the district offer the Stretch Regents courses. Prior to Stretch Regents, entering freshman who enrolled in General Math would then enroll in a non-Regent sequence such as Business Math or Consumer Math. In Stretch Regents courses, students are exposed to challenging and useful math and earn Regents credits.

What Is UCSMP?

In Buffalo, University of Chicago School Math Project (UCSMP) courses serve as an alternative college preparatory sequence to the Regents courses. Due to high failure rates in the Regents math courses, schools in the Buffalo school district introduced the UCSMP courses as an alternative to both the lower and upper math track. Entering high school students enroll in General Math, Regents Course I, or the new alternative UCSMP Transition Math course. While UCSMP was not designed specifically as a bridge program, the first course in the sequence (UCSMP Transition Mathematics) does provide a bridge between lower-level math and college preparatory math. Topics covered in UCSMP Transition Math include applied arithmetic, algebra, geometry, logic, probability, and statistics with an emphasis on problem-solving, word problems, and real-world applications. Students are placed in the UCSMP sequence based on teacher recommendation or student preference.

The UCSMP was designed as a six-year (grades 7-12) mathematics curriculum. However, in Buffalo, students may enroll in the first course in the sequence (Transition Mathematics) as late as 9th, 10th, 11th, or even 12th grade. The hope is that students will continue on with the UCSMP sequence of courses at a higher rate than in the Regents-level courses, where the failure rate was high and many students were dropping out after only two years of math.

Math Innovations and Classroom Practice

Transition math courses have resulted in changes in content and pedagogy. The following exam-

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ples from our research depict innovative strategies and variations within the transition courses:

Use of manipulatives. While the traditional, general math classes stressed paper and pencil computations, the Math A and UCSMP courses emphasized the use of manipulatives such as dice, cubes, blocks, and tiles, and hands-on activities. (The Stretch Regents courses did not emphasize the use of manipulatives.) Algebraic tiles were used in both Math A and UCSMP classes to solve polynomial functions. In the Math A unit on Growth and Decay, thermometers and calculators were used to get students to learn that items such as temperatures, shapes, and lines expand and contract.

A more integrated curriculum. The philosophy behind integrating math topics is that the material is more comprehensible and better presented as integrated units that compliment one another rather than as isolated, unrelated topics. This is the area where the New York schools in our sample had progressed the furthest. While most states are only beginning to talk about integrating math topics, for as long as 10 years, both Regents Math and Stretch Regents courses have integrated algebra, geometry, trigonometry, probability and statistics, as well as problem-solving. Several of the Math A and UCSMP units integrated not only various math topics, but also science, geography, history, and language arts.

A focus on the infusion of technology. All of the transition math classes encouraged students to use calculators to make computations. Interview respondents reported that the transition courses aimed to incorporate computer technology, and that sessions were held in the computer lab. However, this goal was most evident in the UCSMP courses. For example, students in one UCSMP Transition Math course were assigned to write a computer program that would compute the area and perimeter of a rectangle.

Active participation of students, working together in groups. The Math A and UCSMP courses stressed group work more than the traditional, lower-level math classes or the Stretch Regents courses. In the traditional, lower-level math courses, students did independent seatwork with the teacher lecturing from the front of the room. Teachers in the Math A and UCSMP courses spent much less time lecturing and more time with students working together to solve problems and equations.

An emphasis on problem-solving. Along the lines of the NCTM standards, the transition math courses stressed "powerful mathematical content," including the use of questioning strategies, reasoning, and communicating, with less emphasis on answers to computation problems and more emphasis on process and open-ended questions. The pedagogical emphasis in the Math A and UCSMP sections was on coaching, leading discussion, and exploring alternative solutions and less on direct instruction. Students in the Stretch Regents courses were asked to solve large numbers of problems in a specific order and hierarchy whereas the Math A and UCSMP courses focussed on fewer problems in more depth.

Math problems based on "real life situations." The transition math courses introduced practical problems related to everyday life such as using a dictionary, calculating taxes, reading a newspaper, and conducting surveys. While this was a focus of the Math A and UCSMP courses, it was not a focus of the Stretch Regents courses. For example, in one Math A unit assignment entitled "What are my chances?" students learned to apply probability concepts to their own lives by predicting, experimenting, and analyzing the chances of particular events occurring. Similarly, in the UCSMP courses, students worked on problems related to taxes, reading the newspaper, taking surveys, and developing charts and graphs.

Benefits of the Upgraded Math Courses

We examined the impact of transition math courses on student outcomes using data from high school transcripts, classroom observations, achievement tests, and interviews. We identified four primary improvements related to the transition math courses:

1. Students were taking more challenging and useful math. In each of the seven high schools studied, the introduction of the transition math courses resulted in more students taking more challenging and useful math courses. Six of the seven high schools in our study eliminated general math classes and reduced the number of pre-algebra sections. The number of students taking college preparatory math increased. All students in the two Rochester high schools were enrolled in Regents-level math courses, as a result of the elimination of general math classes and the introduction of Stretch Regents. In one of the San Diego high schools in our study, administrators indicated that since the introduction of Math A, the number of students taking algebra increased by 35 percent. Buffalo teacher and administrator respondents indicated that the UCSMP courses have succeeded in more students studying a higher level of math. In the Rochester schools,

where the math transition courses have been in place longer, teachers also indicated that more students were taking college preparatory math. As two Rochester teachers stated:

You get a lot more students through that would never have gotten through Regents Math otherwise (Math Teacher, School 6, Rochester).

Many students who would have taken pre-algebra and applied math, are now taking the IA-IB [Stretch Regents] sequence, exposing more students to algebra in high school math (Math Teacher, School 5, Rochester).

Data based on 4,800 student transcripts from seven high schools in four school districts across two states indicate that students in the transition math courses (Math A, Stretch Regents, and UCSMP) are much more successful than those in the general math track in obtaining college preparatory math credits. This pattern persisted even when differences among students in prior test scores or grades were statistically controlled. However, students who enter the transition math courses do not take nearly as many college preparatory credits as those who begin in regular college preparatory courses.

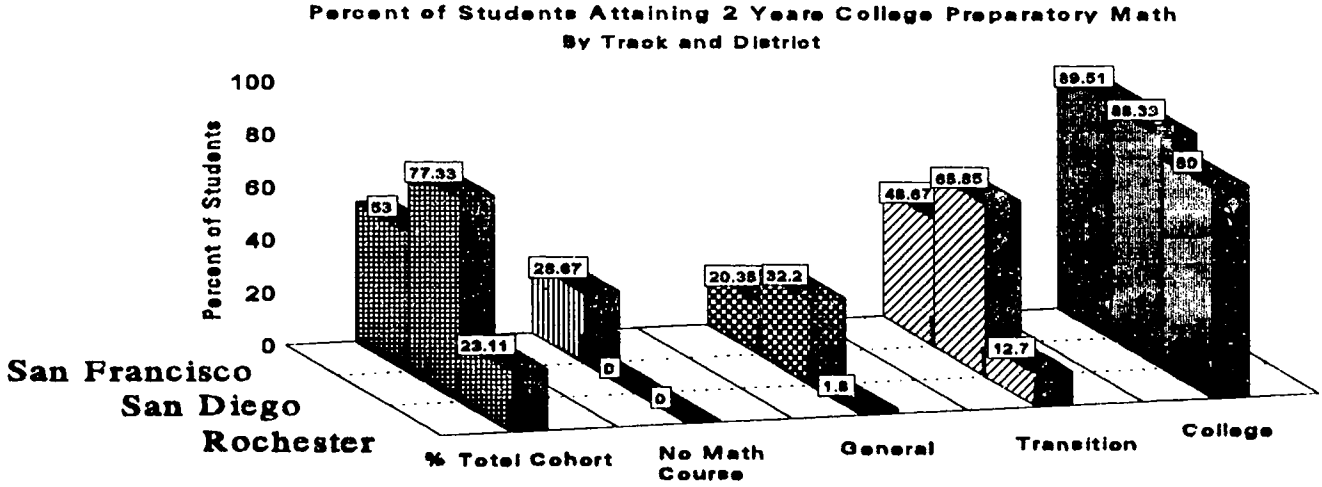
Figure 1 shows raw differences in rates of completing at least two years of college-preparatory math, for students who began high school in different types of courses, in the three districts for which we have four years of transcript data. Further analyses in Rochester and San Diego controlling for prior student performance revealed the same pattern of results (White et al. 1996).

2. Students were learning more. The interview responses and math achievement tests indicated that as a result of the transition math courses, students had more opportunity to master challenging material and were learning more than students in lower-level math. Our analysis of student achievement based on a math test[2] which was administered to our student sample at three different points in time throughout the 1992-93 school year, supports teachers' perceptions that students in the transition math courses made gains in achievement and that these gains were higher than in the more traditional general math courses.

The left side Figure 2 shows differences in achievement growth among students in Regents, Algebra, Math A, Stretch Regents, and General Math classes. (A total of 48 classes were included in this analysis. Due to the relatively small number, UCSMP transition classes were combined with Math A classes.) Regents classes exhibited the most growth (about 2.25 points on our 26-point test), and General Math classes the least (about 1.25 points). This contrast is statistically significant. Achievement growth for students in Algebra, Math A, and Stretch Regents classes fell in between that of Regents and General Math. These estimates control for initial achievement, prior grades in math, sex, race, ethnicity, and family background (see Gamoran et al., 1996, for further details).

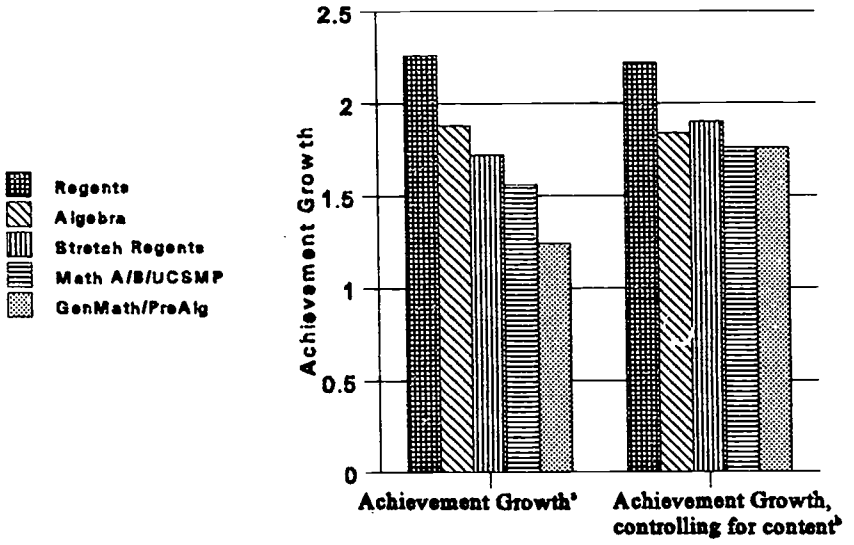
A substantial portion of the differences among these lines can be attributed to a difference among the types of courses in the coverage of math content. We created an indicator of content coverage using as a benchmark our achievement test, which was constructed from public-release NAEP items selected to reflect reform-minded math content. We compared topics and cognitive demands made by teachers to those on our test.

Figure 1. Four Year Cohorts



Note: Placement into the categories "No Math Course", "General", "Transition", and "College" is based upon math courses taken by students as high school freshmen. Thus, all students in San Diego and Rochester took some math as freshmen, while almost 27% of students in San Francisco took no math during their freshman year.

Figure 2. Estimated Learning Gains by Course Type



Note: Achievement growth represents the gain in achievement scores on a 26-point test over one school year.
[a]Adjusted for student initial score, race/ethnicity, previous grade and class socio-economic status.
[b]Simulated to have the same level of content coverage as the Regents classes.

We found the most content coverage in Regents and Algebra classes and the least in General Math, with the transition classes in between. The right side of Figure 2 simulates growth in achievement for the same set of classes, if all classes had the same level of coverage as the Regents classes. One can see that if content coverage were equalized, achievement growth would be nearly equal. (It would still be highest in Regent classes, for reasons unexplained by our model.) Greater content coverage is part of the reason students learn more in transition than general classes, but the most coverage—and the most learning—occurs in the college preparatory classes. Importantly, this was true when controlling for differences in prior achievement and social background conditions.

3. The material covered was more practical and relevant to real life situations. Respondents from both the California and New York schools indicated that the transition courses gave students practical math experience. For example, Buffalo teachers saw the strengths of the UCSMP courses as including math projects which were more relevant to students' everyday life such as work with taxes, the use of applications, and the interdisciplinary nature of the material. Math A and UCSMP teachers indicated the benefits of incorporating problem-solving and hands-on activities based on real-life situations. Respondents commented:

Math A's hands-on activities and real life ideas help students to become interested in math and prepares them to go on to higher levels (Math Teacher, School 2, San Francisco).

They [the students] like the real world problems which are incorporated into the UCSMP materials (District Administrator, School 7, Buffalo).

4. Students had a better opinion of math and a higher sense of self-esteem. We interviewed teachers who said that since the introduction of the transition math courses, students had a better opinion of math. Rochester teachers indicated that student self-esteem had benefitted by the fact that students in the Stretch Regents courses used the same textbooks as in the one year Regents courses. Rochester teachers also indicated that students liked the material on logic since they did not think of it as math. As a Math A teacher indicated, "Students are no longer afraid of math. Kids who thought they were poor math students now can see that they can do these things. They're finding they have a talent for it." San Francisco and San Diego math teachers indicated that Math A students were glad not to be doing drill and practice.

Teachers commented:

It [Stretch Regents] gives students a better chance of doing math and not getting discouraged and giving up, which is typical of the kids we deal with (Math Teacher, School 6, Rochester).

Students' interests in math are changing since they have taken the Math A course. They realize that they can do the math and they are willing to stick to it (Math Teacher, School 2, San Francisco).

Challenges in Upgrading High School Mathematics

Despite the benefits we identified, our interviews, observations, and transcript analyses also highlighted problems in the implementation of the transition courses. These difficulties may have prevented the transition courses from achieving even greater success. The most salient problems were:

Unclear objectives. The objectives of the courses were not well communicated, and in some cases they conflicted with one another. The degree to which district and school administrators, counselors and math chairpersons were in-

volved in the introduction of the transition math courses influenced math teachers' knowledge and support of the courses. Some teachers and administrators viewed the courses as preparation for college preparatory math, whereas others believed the courses were "for all students" to improve students' problem-solving and questioning techniques.

A lack of teacher training. Teaching the transition courses required a change in traditional views of how math should be taught. Respondents from each school indicated a need for additional staff development specific to the transition courses. The extent of training received by the transition math teachers varied from school to school.

The UCSMP math teachers in Buffalo received training in the form of monthly group meetings. Very few teachers from Rochester's schools in our sample received any kind of training for the Stretch Regents courses. Most of the training in Rochester was conducted as the courses were first adopted in 1984, prior to our math teachers' experience with teaching the stretch courses.

While training was more extensive for Math A teachers in California, respondents from the California schools indicated that math teachers are still discovering how Math A should be taught. Some teachers felt uncomfortable with open-ended questions and math units which often were not accompanied by an answer key.

Problems in course design. While respondents indicated that the transition math courses were an improvement over the courses they replaced, respondents complained of problems in the design of the transition courses. The State Department of Education in both California and New York originally conceived the purpose of the transition courses as preparing students for college preparatory math. However, teacher respondents at each school expressed the belief that the transition courses did not prepare students adequately with algebra skills. Since the Regents Math I-II-III courses integrated many topics including algebra, geometry, trigonometry, problem-solving and logic, a high percentage of students who did not complete the three year sequence did not get a full year of algebra.

According to a Rochester teacher:

I don't like the two-year [Stretch Regents] course, to be honest. It is divided up poorly. The IA now is a hodgepodge. You do a little bit of this, a little bit of that.... After covering the easier material in each chapter in IA, you come back in IB and the assumption is that they know the easier stuff, but it doesn't happen. I have to reteach everything in IB (Math Teacher, School 5, Rochester).

Problems in student placement and course sequencing. Student placement was based on a variety of factors including students' grades in previous math courses, previous math experience, test scores, and recommendations from the student's middle school counselor. Teachers indicated that the math department established criteria by which students should be placed in the transition math courses, however, respondents did not believe counselors followed these procedures. Our analyses of grades received and math scores showed big overlaps in distribution across course types in the distribution of these criteria.

In each of the seven high schools, the transition math courses (Math A, Math IA and UCSMP Transition Math) were designed primarily for 9th graders. However, in each of the schools, 10th, 11th, and occasionally 12th graders were placed in these courses. For example, at one of the Rochester schools in our sample, only 35 percent of the students enrolled in Stretch Regents IA were in 9th grade.

A failing grade in transition math was the most common explanation for students other than 9th graders to be enrolled in the transition courses. However, other patterns also explain the tendency. For example, at School 4 in San Diego, students generally enrolled in Math A following pre-algebra. At School 3 in San Diego, some students took Math A in ninth grade and then pre-algebra in tenth grade, while others took the courses in the reverse order. DeLany (1991) reports that student placement is often based more on school scheduling issues than on intentional choices made by teachers or students.

A differentiated curriculum remains. In spite of the efforts to upgrade the math curriculum in these states, a differentiated curriculum remained very much in existence. For example, in San Francisco, students with severe math deficiencies or problems with English language may be placed in remedial math classes which use mastery learning techniques to teach elementary school arithmetic. The NCTM-like Math A required higher levels of language proficiency than the more formal mathematics courses.

In all seven high schools, the traditional college preparatory curriculum remained the "fast track," although there was a clear tendency to get alternative math sequences approved for college entrance because these courses were perceived to be more motivating for many students who were discouraged by formal math.

Policy Recommendations

Our findings lead to four policy recommendations for high school and local district leaders and state policymakers. First, the lower-level, general math courses are a dead-end and should be eliminated. The transition math courses represent an improvement over the lower-level math courses they replaced. As a result of the transition math courses, students were learning more, taking more difficult math, and had a better opinion of math.

Second, problems in course design and course sequencing present constraints, and from what we have observed in the schools, clear objectives and staff development would improve implementation. Teacher involvement in the development of the upgraded courses, as in the case of Math A, helps to get teacher buy-in. In addition, teacher networking, as in the case of Math A and the UCSMP courses, allows for special sessions for teachers to meet to review instructional practices and compare notes on effective methods.

Third, more attention most be given to student attendance and mobility patterns and student placement in courses. In schools serving high concentrations of poor and low-achieving students, high student mobility and low student attendance create problems for any type of regular school-based course work, and students end up in courses for a variety of reasons including chance.

Finally, while the transition courses represent an improvement over the courses they replaced, they are not as effective as the college preparatory math courses. A number of school districts around the country are attempting to eliminate low-level mathematics and to require all students to take college preparatory math. Our data are supportive of this approach. Our findings indicate that regardless of prior achievement, students did the best when taking college preparatory mathematics. However, we had no opportunity to observe what would happen to college preparatory mathematics courses if all students were required to take them. Porter et al. (1993) indicate that the content of high school mathematics and science college preparatory courses are not compromised when required of all students.

Endnotes

1. The work reported here is part of a larger study at the Consortium for Policy Research in Education which explores course-taking patterns, students' attitudes and achievement, and student attendance and mobility (see White, 1996; White et al., 1996; Gamoran et al., 1996).

Data collection included both qualitative and quantitative data gathered from seven high schools across four districts (San Diego, San Francisco, Buffalo, and Rochester) in two states. Researchers conducted 54 interviews with state and district administrators, principals, math teachers, and counselors and performed classroom observations of 55 math sections three times each in the 1992-93 school year. They also reviewed 4,800 student transcripts; attendance data for 1,200 students; responses to 3,400 math tests and student questionnaires; and 160 teacher questionnaires.

2. Our main concern in creating a mathematics test was for the validity of a single exam to test achievement across a wide variety of mathematics courses of varying levels of difficulty and course content. We created a test from National Assessment of Educational Progress (NAEP) public-release items that was oriented toward higher-order thinking and problem-solving skills rather than computation skills, and designed for administration to a general population of students. The test consisted of problems in the following content areas: 15 percent arithmetic, 20 percent measurement, 15 percent algebra, 20 percent geometry, 20 percent probability, and 10 percent numbers and sets. Types of problems included were 30 percent concepts, 15 percent procedures, 20 percent data interpretation, 27 percent routine word problems, and 8 percent novel word problems. These content areas and problem types are consistent with the NCTM call for rigorous mathematics content that promotes understanding and emphasizes problem-solving.

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