

# MINNESOTA 4<sup>th</sup> grade results

THIRD INTERNATIONAL MATHEMATICS AND SCIENCE STUDY (TIMSS)

SciMath<sup>MN</sup>, June 1998

## Overview of Minnesota Participation in TIMSS

The Third International Mathematics and Science Study (TIMSS) is the largest and most thorough international study of mathematics and science ever conducted. During the 1995 school year, 41 countries participated in surveys of school practices and student testing at grades 4, 8, and 12 (final year of secondary school). With sponsorship by SciMath<sup>MN</sup>, the State of Minnesota participated in the TIMSS assessments as a 'mini-nation' at all three grade levels, making it possible to compare Minnesota's results with those from the U.S. as a whole as well as from the other countries that participated in TIMSS.

This report presents a summary of initial findings from the assessments at the fourth grade. Twenty-six nations participated in the fourth grade assessment. This report is the second in a series of public reports by SciMath<sup>MN</sup> on the results of Minnesota's participation in the TIMSS surveys. The first report, released in March 1997, presented findings on student achievement at grade 8. The next report will be released in August 1998 and will present findings from the Minnesota twelfth grade assessment. Future reports will provide additional Minnesota TIMSS findings and synthesis, particularly as this information relates to the current context of implementation of the Minnesota Graduation Standards.

## Summary of Minnesota fourth grade results

**Compared in an international context, Minnesota fourth-graders achieved slightly above average in mathematics and well above average in science.**

- In mathematics, Minnesota fourth-graders performed above the international average of the 26 participating countries and scored about the same as the U.S. Minnesota students scored higher than 11 countries and lower than 6.
- In science, Minnesota fourth-graders performed well above the international average, as did the U.S. as a whole. Fourth-graders in only one country—Korea—significantly outperformed Minnesota (and U.S.) students.
- In mathematics content areas, Minnesota fourth-graders exceeded the international average in four of the six areas tested (whole numbers; data representation, analysis, and probability; geometry; and patterns, relations, and functions). In the other two areas (fractions and proportionality; and measurement, estimation, and number sense), the Minnesota fourth grade average was lower than the international average.
- In science content areas, Minnesota fourth-graders exceeded the international average in all four of the areas tested, as did the U.S. as a whole. In three of the areas (earth science; life science; and environmental issues and the nature of science), Minnesota fourth-graders were among the top group of countries.
- If an international search were to select the top 10 percent of all fourth-graders in the countries participating in TIMSS, 8% of Minnesota fourth-graders would be included for mathematics (as compared to 9% of U.S. students overall), and 17% of Minnesota fourth-graders would be included for science (as compared to 16% of U.S. students overall).

# 4<sup>TH</sup> Grade Mean Scores for Minnesota and Comparisons with Participating Countries

Third International Mathematics and Science Study (TIMSS)

Figure 1. Minnesota's Average Fourth Grade Mathematics Performance Compared to the U.S. and other nations

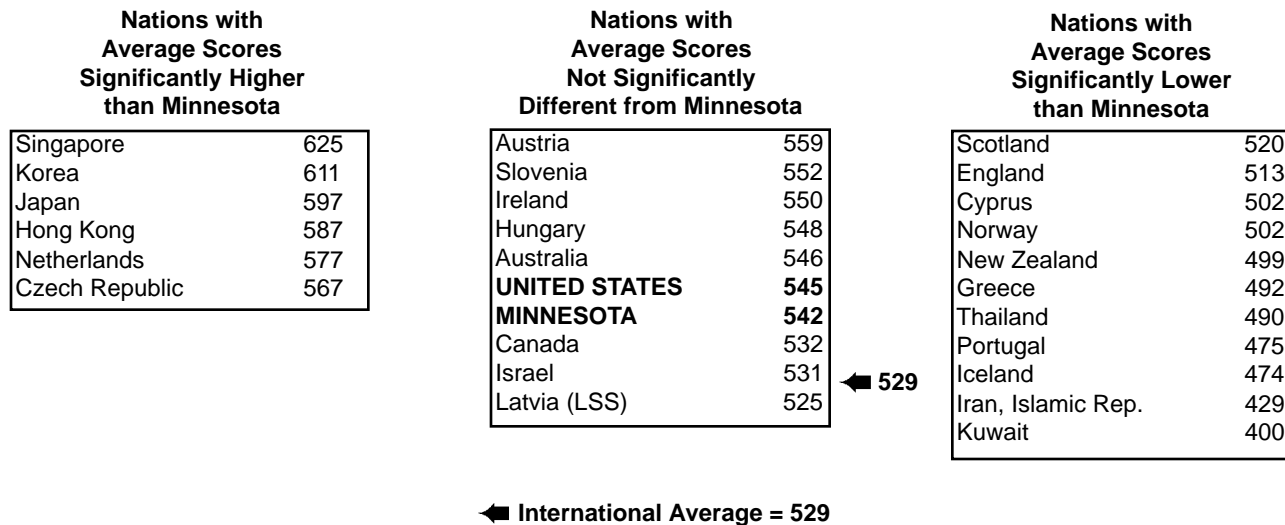
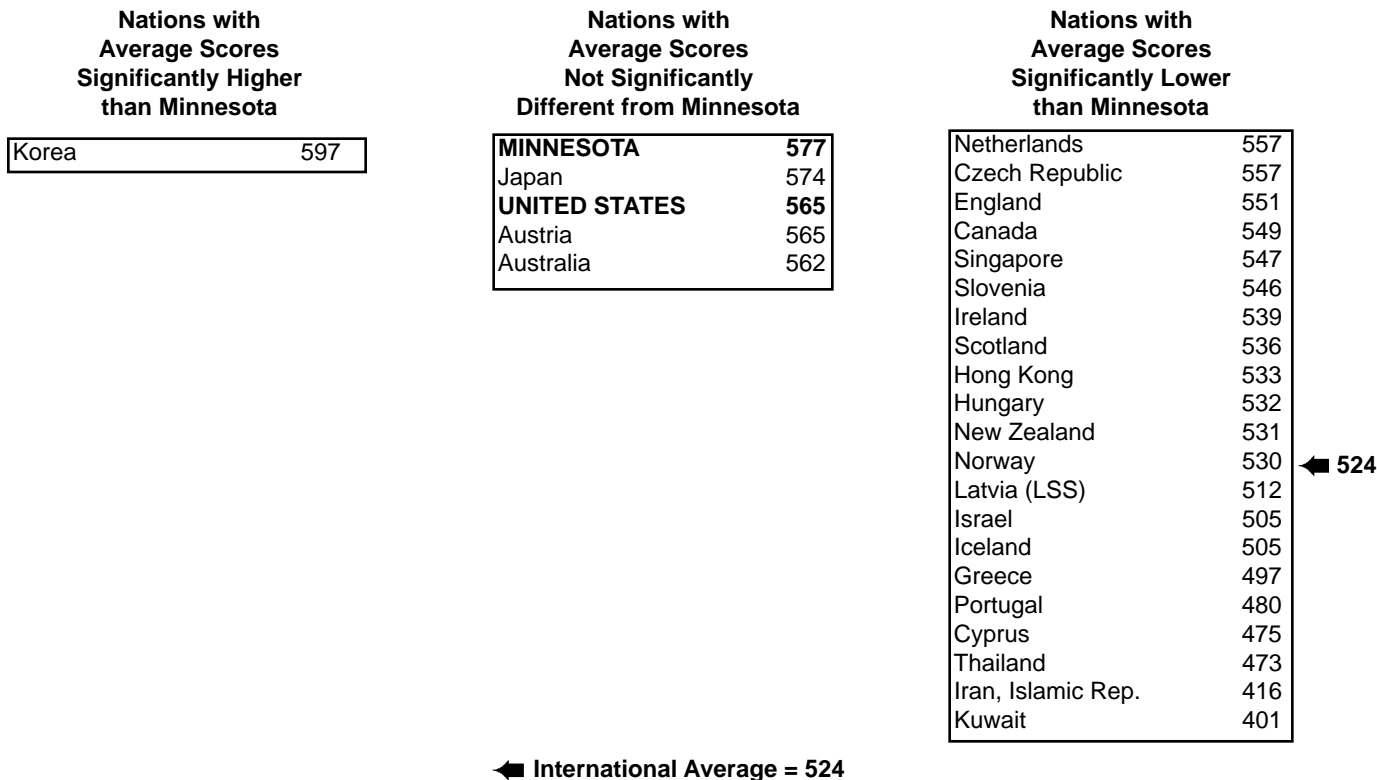


Figure 2. Minnesota's Average Fourth Grade Science Performance Compared to the U.S. and other nations



# Achievement Comparisons between 4th and 8th Grades

Comparing the performance of Minnesota students at grades 4 and 8, the TIMSS results show that the international standing of Minnesota students is about the same at both grade levels, whereas the U.S. average achievement falls in international standing from grade 4 to grade 8.

- In mathematics, Minnesota scored above the international average at both grade levels, whereas the U.S. fell from above the international average at grade 4 to below the international average at grade 8.
- In science, both Minnesota and the U.S. scored well above the international average at grade 4, but at grade 8 the U.S. performance fell significantly below that of Minnesota while remaining above the international average.
- Minnesota students perform relatively better in science than in mathematics at both the fourth and eighth grades on the TIMSS assessments.
- In mathematics, the performance of Minnesota students showed no significant gender differences at either fourth or eighth grade. In science, the performance of Minnesota students showed a small gap at grade 4 and a 16-point gap at grade 8, but neither were statistically significant.

## Contextual factors impacting 4th grade student achievement

From the survey data gathered by the TIMSS questionnaires administered to teachers, students, and parents, we learn the importance of focus and coherence in curricular materials and instructional patterns and strategies.

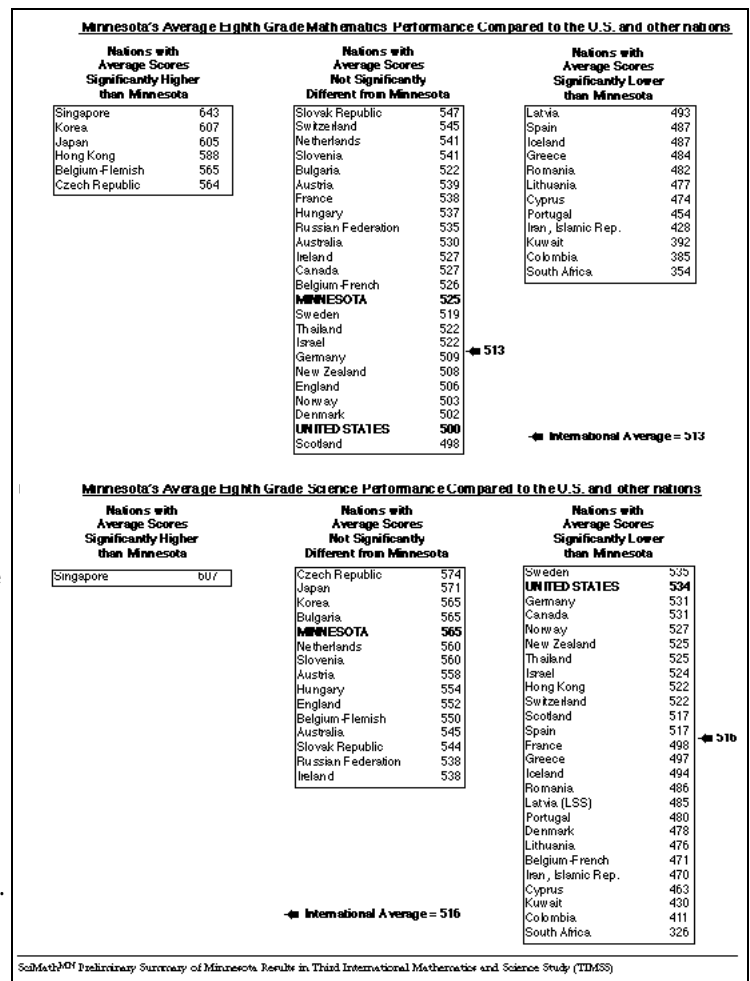
- Curricular scope: In Minnesota, as in the U.S. generally, the number of topics intended (as indicated in curriculum guides, etc.) for coverage at the fourth grade level was above the international average in mathematics and somewhat below the international average in science. However, data for actual teacher practices are not yet available for the other TIMSS countries, so no comparison of actual or "delivered" curriculum (versus "intended" curriculum) can be made at this time.
- Curricular focus: By and large, Minnesota fourth-graders perform best in those areas of the mathematics and science curriculum which are emphasized by teachers at this grade level. For example, the weakest areas of Minnesota student performance in fourth grade mathematics are fractions and

proportionality, and estimation-areas least emphasized by Minnesota fourth grade teachers. In the same vein, the weakest area of Minnesota student performance in fourth grade science is the physical sciences, an area not emphasized by most Minnesota fourth grade teachers.

- Repetition: One major weakness of the U.S. mathematics curriculum as reflected in the TIMSS findings is the amount of repetition of topics across the elementary mathematics curriculum. The Minnesota TIMSS data show the same trend at the fourth grade level, the topics most likely to be taught (whole numbers, number sense, measurement, data representation, and geometry) were those also taught the year before; new topics (fractions, estimation and error measurement, and ratio and proportion) are the least likely topics to be taught at grade 4.

(continued on next page)

Figure 3. Minnesota's Average 8th Grade Performance Compared to U.S. and Other Nations



## Contextual factors impacting 4th grade student achievement, (continued from page 3)

- Homework: The majority of grade 4 Minnesota students reported spending less than one hour per day on mathematics homework; this is consistent with the international average. Minnesota fourth grade students reported spending about half an hour per day studying science or doing science homework; this is consistent with international patterns as well.
- Time spent in class on mathematics and science: Minnesota and U.S. fourth grade teachers spend slightly more time in class per week teaching mathematics and science than their international counterparts. In fact, four of the seven countries which significantly outperformed the U.S. in mathematics at grade four spend less time in class per week than the U.S.
- Class size: The Minnesota average class size at fourth grade (28 students) and the U.S. average class size (24) are close to the international average (25). Of the six countries that outperformed Minnesota in mathematics at fourth grade, four (all Asian) have much larger average class sizes, ranging between 36 and 43 students per class.
- Instructional approaches: Typical practices in Minnesota (and U.S.) fourth grade classrooms are generally similar to those in other TIMSS countries at that grade level. Like their U.S. counterparts, Minnesota teachers report that their two most common patterns for organizing mathematics instruction are to teach the class as a whole, and to have the students work individually with assistance from the teacher. However, fourth grade science instruction in the Minnesota (and the U.S.) is different from mathematics because the second most common pattern of instruction is to have the students work together as a class with students responding to each other, rather than working individually.
- Educational technology: U.S. fourth-graders use calculators and computers in mathematics classrooms more frequently than do students in other TIMSS countries. However, use of calculators in Minnesota fourth grade classrooms is about the international average, whereas calculator use in the U.S. as a whole is about twice the international average. With regard to computers, the majority of students in all TIMSS countries reported that they rarely used computers in mathematics classes (they were not asked about computer use in science instruction), although students in the U.S. and Canada were the most likely to report some use of computers in mathematics classes, and Minnesota fourth-graders reported higher-than-the-U.S.-average use of computers in mathematics class.
- Teaching challenges: Minnesota and U.S. fourth grade teachers, like their counterparts in a majority of the TIMSS countries, most frequently cite "varying academic abilities of students" and a "high student-teacher ratio" as factors that limit how they teach their class. The U.S. is actually below the international average in the percentage of teachers who report that their teaching is limited by these challenges, including classroom discipline.
- Student attitudes: The majority of Minnesota and U.S. fourth grade students believe that they are doing well in mathematics and science. The results for the top-performing TIMSS countries in mathematics are interesting in this regard since their actual student performance indicates very high achievement, yet close to one-quarter of students in these countries did not believe that they do well in mathematics.
- Impact of national standards: Although there has been some speculation that the U.S. fourth grade TIMSS scores in mathematics were influenced by local implementation of the national math standards (produced by NCTM), the case in Minnesota is not clear, at least based on the Minnesota fourth grade TIMSS data. On the one hand, more than one-half of Minnesota fourth grade teachers reported that they were "not familiar" with national curriculum guides (including the NCTM standards). On the other hand, Minnesota fourth grade teachers reported teaching practices which may (at least indirectly, via textbooks) reflect the influence of the national standards, such as including problem solving strategies as one of the most often taught topics in mathematics at this grade, and teaching reasoning tasks in at least some lessons.

## summary of timss findings for fourth grade

Viewed in an international context, the Minnesota TIMSS results for the fourth grade show some of the relative strengths and weaknesses of elementary mathematics and science education in Minnesota, particularly as it existed in the spring of 1995. Perhaps more than any other single finding, the TIMSS results at both grade 4 and 8 show the importance of curricular focus and coherence in producing strong, system-wide student achievement in school mathematics and science. In other words, the overall focus and coherence of the delivery system (the curriculum, the instruction, and the assessments), not any one part of the system, make the difference in how Minnesota performs as a whole.

The Minnesota TIMSS results also show that it is not who is taking the test, or how much time on task or how much homework students have, or length of school day or school year, or class size that makes the biggest difference in student performance. But what gets taught and how it is taught make a significant difference in student achievement, particularly by grade 8.

The scale scores for each country need to be understood in context and judged in relative terms. Thus for example, the fact that Minnesota's score (542) in mathematics at grade four is slightly below the U.S. national average (545) has less significance than the fact that Minnesota's score is "in the middle of the middle group" of countries which essentially performed about the same, statistically speaking. By the same token, Minnesota's fourth grade science score (577), though higher than the U.S. average (565), is not different from the U.S. score when considered in light of statistical significance.

Another caution with scores stems from the fact that a single average score for a country or for an entity such as the State of Minnesota masks a great range of individual school and student performances. Thus for example, we know that although Minnesota students perform very well on average in science at grade 4 when judged by the TIMSS sample, we also know from other data that there are a number of elementary schools in Minnesota where science is rarely taught. And there is some concern that the current emphasis on reading and mathematics in the elementary grades which stems from implementation of the Minnesota eighth grade basic skills statewide tests will further discourage the teaching of science in some elementary schools in the state.

On the other hand, the Minnesota TIMSS results for grades 4 and 8 provide a relevant and timely baseline of data on existing curricular approaches and instructional practices. This information can be helpful at the district, building, and classroom level as schools move forward with implementation of the Minnesota Graduation Standards. Never before have we as a state had such extensive data on what mathematics and science is being taught and how it is being taught, as well as how it is being learned, at key grade levels throughout the districts of Minnesota.

The TIMSS findings together with the Minnesota standards (and the newly available state curriculum frameworks in mathematics and science) provide ample material for guiding local districts and school sites in reviewing their local standards, in adjusting the scope and sequence of their own programs, and for curriculum material review and selection where appropriate. The TIMSS data on Minnesota teachers and teaching practices at grades 4 and 8 also provide a "needs assessment" and a context for designing standards-appropriate professional development activities.

**Figure 4. 4<sup>TH</sup> Grade Average Percent Correct for Mathematics Content Areas for Minnesota and Participating Countries**  
Third International Mathematics and Science Study (TIMSS)

Whole Numbers	Fractions and Proportionality	Measurement, Estimation, and Number Sense	Data Representation, Analysis, and Probability	Geometry	Patterns, Relationships, and Functions
Korea 88	Singapore 74	Japan 72	Singapore 81	Hong Kong 74	Korea 83
Singapore 83	Hong Kong 66	Korea 72	Korea 80	Australia 74	Japan 76
Japan 82	Japan 65	Netherlands 70	Japan 79	England 74	Singapore 76
Hong Kong 79	Korea 65	Austria 69	Hong Kong 76	<b>MINNESOTA</b> 72	Hong Kong 73
Hungary 76	Netherlands 60	Hong Kong 69	Netherlands 75	Scotland 72	Hungary 69
Netherlands 75	Czech Republic 58	Czech Republic 68	<b>UNITED STATES</b> 73	Japan 72	Slovenia 68
Czech Republic 75	Czech Republic 53	Singapore 67	<b>MINNESOTA</b> 72	Singapore 72	Czech Republic 67
Austria 74	Austria 51	Hungary 64	Ireland 69	Korea 72	<b>UNITED STATES</b> 66
Slovenia 74	Australia 51	Slovenia 64	Canada 68	Canada 72	<b>MINNESOTA</b> 65
Israel 71	<b>UNITED STATES</b> 51	Latvia (LSS) 60	Australia 67	Slovenia 72	Latvia (LSS) 65
<b>UNITED STATES</b> 71	Slovenia 50	Australia 60	Czech Republic 67	Netherlands 72	Netherlands 65
<b>MINNESOTA</b> 71	Hungary 49	Ireland 56	Austria 66	<b>UNITED STATES</b> 71	Austria 64
Ireland 70	<b>MINNESOTA</b> 48	Norway 56	Scotland 66	Czech Republic 71	Australia 64
Canada 68	Cyprus 48	<b>MINNESOTA</b> 54	England 64	Austria 67	Ireland 64
Latvia (LSS) 68	Israel 48	Canada 54	Israel 64	Latvia (LSS) 67	Canada 62
Australia 67	Canada 48	Israel 54	Slovenia 64	Ireland 66	Israel 60
Cyprus 65	Scotland 46	Scotland 53	New Zealand 61	New Zealand 66	Scotland 57
Greece 62	England 45	<b>UNITED STATES</b> 53	Hungary 60	Hungary 66	Cyprus 55
Scotland 61	Latvia (LSS) 44	England 52	Norway 59	Israel 63	England 55
Norway 61	Thailand 44	Portugal 49	Iceland 58	Israel 62	New Zealand 52
Thailand 58	Greece 42	New Zealand 49	Thailand 56	Norway 58	Norway 50
England 58	New Zealand 41	Greece 48	Latvia (LSS) 54	Greece 53	Thailand 50
Portugal 57	Norway 38	Cyprus 48	Cyprus 52	Thailand 53	Iceland 48
New Zealand 57	Portugal 38	Iceland 44	Greece 50	Cyprus 53	Portugal 47
Iceland 56	Iceland 36	Thailand 44	Portugal 48	Portugal 52	Greece 47
Iran, Islamic Rep. 51	Iran, Islamic Rep. 32	Iran, Islamic Rep. 36	Kuwait 26	Iran, Islamic Rep. 42	Iran, Islamic Rep. 40
Kuwait 36	Kuwait 25	Kuwait 35	Iran, Islamic Rep. 23	Kuwait 36	Kuwait 33

Symbols in the same row that are not bolded indicate that the difference between the two countries is not statistically significant.

→ 67

→ 49

→ 56

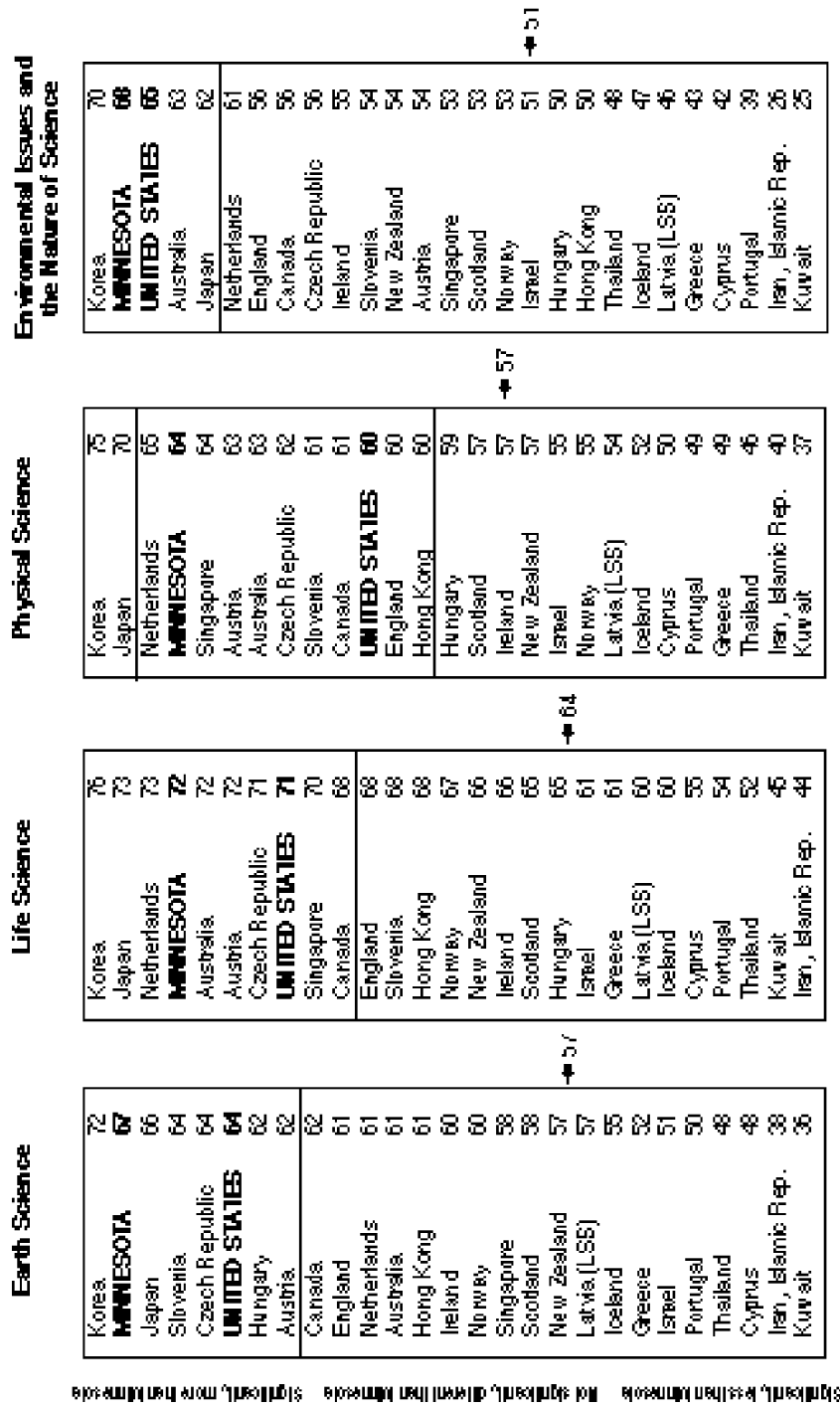
→ 62

→ 64

→ 60

→ International Average Percent

**Figure 5. 4TH Grade Average Percent Correct for Science Content Areas for Minnesota and Participating Countries**  
Third International Mathematics and Science Study (TIMSS)



## summary of Contextual factors impacting mathematics achievement in 4th grade

At the primary level, mathematics in Minnesota is very much like mathematics in other parts of the United States, and not terribly different from mathematics in other countries participating in the Third International Mathematics and Science Study. In the U. S., teachers use the same textbooks in most schools, have similar preparation for teaching at colleges and universities, and have work lives that are more alike than different. In states like Minnesota, which have had no firm state guidelines to dictate curriculum goals, textbooks often provide the outline for instructional goals and practices.

The achievement results for Minnesota fourth-graders in mathematics indicate that about the same number of countries, and in many cases, the same countries, performed above Minnesota students as at the eighth grade level. Like their eighth grade counterparts, Minnesota students at fourth grade performed above the international average in mathematics, and at about the same level as the U. S. There are differences between the two grades, however. While Minnesota fourth-graders were at about the same relative place as eighth-graders, U. S. students in general fell from above the international average in mathematics at fourth grade to below that average at eighth grade, the only country to do so.

One component that might enter into an explanation of these similarities and differences is teacher preparation. The pre-service preparation in mathematics of Minnesota elementary teachers looks much like that of teachers in other states. On the other hand, virtually all Minnesota eighth grade students are currently taught by teachers licensed in mathematics. This licensing includes strong content preparation. In some states more than half of the eighth grade teachers are licensed as elementary generalists, who are prepared to teach all subjects rather than specializing in mathematics. A fourth or more of the teachers of eighth grade students in several states are not even licensed to teach.

The teacher and student questionnaires give us additional insights into elementary mathematics classrooms.

### Findings Related to Content:

**Finding:** Those topics taught most frequently in third grade were also those most likely to be studied again in depth in fourth grade. These included: whole numbers, estimation and number sense, strategies for problem solving, and measurement units and processes.

**Finding:** Topics which are new at the fourth grade level are most likely to be covered in fewer than five lessons.

**Finding:** At least half of the teachers reported that the following topics were not covered in third grade and would not be covered in the fourth grade: percentages, number sets and concepts, ratio and proportion, three dimensional figures and constructions, and sets and logic.

### Findings Related to Instructional Activities and Homework:

**Finding:** According to students, the most frequent classroom activities are teacher demonstration of problems, beginning homework in class, and working on worksheets and individual work.

**Finding:** Students report that the least frequent classroom activities are working with computers, discussing completed homework, and working on math projects.

**Finding:** Most Minnesota fourth grade teachers and most fourth grade students report regular access to calculators during mathematics class. Only 11% of teachers and 19% of students report no access to calculators during math class.

**Finding:** For tests and exams, 82% of teachers report never or hardly ever having students use a calculator.

**Finding:** In most countries, homework is used to monitor student learning, but rarely or never contributes to a student's grade. In contrast, 84% of Minnesota students had homework used as part of their grade.

**Finding:** Most students do their homework at home, working alone.



### Findings Related to Teaching Environment:

**Finding:** Two thirds of Minnesota fourth grade teachers report meeting with other teachers to discuss and plan curriculum or teaching approaches at least once a week.

**Finding:** 77% of Minnesota fourth grade mathematics teachers report never having visited another teacher's class; almost that many have never had another teacher visit their class.

**Finding:** Factors that teachers report as limiting their effective teaching are: large class sizes, teaching students of differing abilities and with special needs, and disruptive students.

**Finding:** Minnesota fourth grade teachers teach an average of four hours of mathematics per week, slightly less than the U. S. average of 4.2 hours. Though common sense and research support the idea that time on task is related to achievement, there is not a clear pattern evident in the data from countries. Some of the issues that complicate the relationship include: the amount of time outside of class spent studying mathematics, and how effectively the time in class is used.

### Recommendations:

- In the curriculum and instructional planning process, efforts should be made to determine which topics will receive focused attention at each grade. This will reduce the repetition of previously taught topics, which causes teachers to give only brief attention to new topics each year. This effort is supported by instructional materials that provide greater focus on fewer topics each year.

- Some of the topics to which teachers report giving little attention are not recommended for this grade level, such as percentages, ratio and proportion. Others are not emphases of current state standards, such as sets and logic. However, a topic

such as three dimensional geometry, since it is very concrete, should receive increased emphasis in the primary and intermediate grades.

- Though calculators are widely used in Minnesota classrooms, there is room for more discussion, teacher preparation, and policymaking to ensure that they are being used effectively to help students learn mathematics. In light of national and state recommendations for calculator use on tests as well as state policy allowing use on state exams, teachers should find meaningful ways to incorporate calculators more frequently in testing situations.
- Opportunities for teachers to visit each other's classrooms need to be more widely available in order to provide observational feedback for improving instructional practices. Substantial research supports the importance of a peer coach or a critical friend for making thoughtful changes in the classroom.
- Since reducing class size can lead to improved learning when it is coupled with increased attention to each student, schools should continually investigate ways to support reduced class size and more effective ways to focus on individual student achievement.
- Teachers also recognize the challenges that accompany classrooms containing students with a wide range of abilities and needs. Ample opportunities need to be available for teachers to learn strategies and acquire materials to support successful achievement for all students.

# math Sample Items

(Figure 6)

**1**

## 4th Grade Sample Item: Fractions and Proportionality



Which number represents the shaded part of the figure?

- A. 28
- B. 0.5
- C. 0.2
- D. 0.02

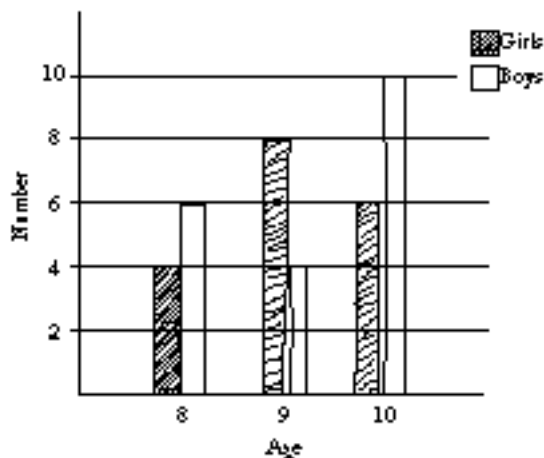
**2**

## 4th Grade Sample Item: Data Representation, Analysis, and Probability

This table shows the ages of the girls and boys in a club.

Age	Number of Girls	Number of Boys
8	4	6
9	8	4
10	6	10

Use the information in the table to complete the graph for ages 9 and 10.



**3**

## 4th Grade Sample Item: Patterns, Relations, and Functions

What do you have to do to each number in Column A to get the number next to it in Column B?

Column A	Column B
10	2
15	3
25	5
50	10

- A. Add 8 to the number in Column A.
- B. Subtract 8 from the number in Column A.
- C. Multiply the number in Column A by 5.
- D. Divide the number in Column A by 5.


### Average Percent Correct (TIMSS 4th Grade)

	International	U.S.
Item 1	40%	32%
Item 2	41%	55%
Item 3	39%	32%

# Science Sample Items (Figure 7)

**4th Grade Sample Item: Life Science** **1**

The pictures show different stages in a frog's growth.

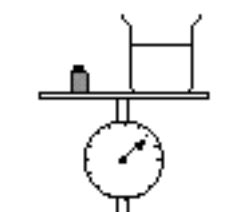


Write the letters in the boxes to show the pictures in the order of the frog's growth.

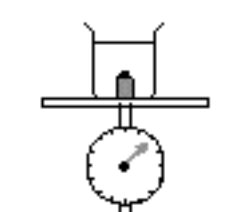
Young Z W Y X Old

**4th Grade Sample Item: Physical Science** **2**

Elizabeth puts a weight and a beaker of water on a scale, as shown in the first picture.



Then she moved the beaker and put the weight in it, as shown in the second picture.



What will the scale show now? Draw an arrow on the second picture to show your answer.

Average Percent Correct  
(TIMSS 4th Grade)

	International	U.S.
Item 1	83%	NA
Item 2	34%	NA
Item 3	70%	75%
Item 4	43%	58%

**3** **4th Grade Sample Item: Earth Science**

The Moon produces no light, and yet it is as bright as day. Why is this?

(A) The Moon reflects the light from the Sun.

B. The Moon rotates at a very high speed.

C. The Moon is covered with a thin layer of ice.

D. The Moon has many craters.

**4** **4th Grade Sample Item: Environmental Issues and the Nature of Science**

Your children can feel and smell an object inside a bag, but they can't see it. Which of the following is NOT an observation about the object?

A. "It is flat at one end and round at the other."

B. "It smells like peppermint."

C. "It has a bump on it."

(D) "I hope it is candy."

## summary of Contextual factors impacting science achievement in 4th grade

Minnesota has reason to be proud of its achievement in primary science. Our students were outperformed by only one country — Korea. This raises the question of why Minnesota did so well on this international test. The answer is that we don't fully understand our performance, although further investigation of the TIMSS data can give us clues. Some possible reasons are the natural curiosity of elementary-aged children, the variety of opportunities to learn science both in and out of the classroom, and a tradition of hands-on elementary science in Minnesota.

Children share many characteristics with scientists. Their natural curiosity leads them to explore dinosaurs and science fiction, and to investigate how the playground equipment works in their neighborhood. Through their play, they learn about the natural world and how it works. For kids, learning science is fun and they willingly admitted that on the TIMSS surveys.

The media recognizes the innate curiosity of children and produce a number of science television shows tailored for them. There are multiple shelves at the local library or bookstore full of science books for children. Teachers frequently use science to engage students in reading, math, and other subjects. In addition, environmental learning centers, museums, zoos, and other organizations around the state provide enrichment and engagement in science for thousands of students each year.

In contrast to traditional elementary mathematics instruction, Minnesota has a strong tradition of hands-on elementary science programs. Supported by the MN Department of Children, Families & Learning, the MN Science Teachers Association, the Service Cooperatives, and other organizations and business partners, many elementary teachers have had the opportunity to learn how to engage their students in science activities. While there is still much that can be done, informal and formal surveys of teachers suggest that this is a strong trend in Minnesota elementary science. It is important to note that while this emphasis on active science is necessary, it is not sufficient. The challenge is to move toward scientific inquiry and using hands-on science to promote understanding of science concepts.

The preliminary findings below provide some context for understanding the commendable performance of Minnesota fourth-graders in TIMSS. Further study of TIMSS and other contextual data will provide more information to help us improve science education for all the students in our state.

The Minnesota fourth grade science curriculum is 'hands-on' and includes both science content and science skills.

**Finding:** Over half of the teachers reported that they taught Nature of Science topics such as problem identification, observation and hypothesizing six or more lessons a year.

**Finding:** Only 6% of the teachers report that they do not teach measurement during fourth grade.

**Finding:** One in four teachers reports that they teach data analysis eleven lessons or more during the school year. 50% report teaching eleven or more lessons where students interpret provided data, and 43% report teaching eleven or more lessons where students interpret data they have collected.

**Finding:** Four in ten teachers report that they teach eleven or more lessons where students draw conclusions from data they have collected.

**Finding:** 80% of students report that they do an experiment in class most or some of the time.

**Finding:** More than 64% of the teachers report that they do not use a textbook in teaching science.

Minnesota fourth-graders enjoy learning science. Some attitudes about science decrease somewhat between fourth and eighth grade.

**Finding:** 81% of the fourth-graders agree or strongly agree that they like learning science. For eighth-graders, 72% agree or strongly agree.

**Finding:** Nearly 90% of fourth-graders indicate that to do well in science takes hard work and studying at home. This is about the same for eighth-graders.

**Finding:** 24% of fourth-graders report that science is boring. 41% of eighth-graders think science is boring.

**Finding:** 64% of fourth-graders think that science is an easy subject. 48% of eighth-graders think that science is an easy subject.

**Finding:** Surprisingly, fourth grade girls scored slightly better than fourth grade boys in science in Minnesota. This is noteworthy because in the U.S. in general, fourth grade boys outperformed the girls by a significant margin. By eighth grade, Minnesota boys outscored Minnesota girls by a large, though not statistically significant amount, while the gender gap for the U.S. in general is much smaller.

The teaching and learning of fourth grade science is not connected to students' lives.

**Finding:** 98% of the teachers report that they teach science mainly as a separate subject that is not integrated with other subjects.

**Finding:** Of those who teach science as a separate subject, 69% teach science less than 30 minutes per day.

**Finding:** 34% report that they will not teach designing or making things, the use of technology in science or interactions among science, technology and society during the school year. Of the teachers who do teach these concepts, it is the focus of five or fewer lessons for 69% of the teachers.

**Finding:** 36% report that they will not teach about the history of science and technology during the school year. Of the teachers who do teach this, three out of four report that they will spend less than five lessons on it.

**Finding:** One in five students report that they never use things from every day life in solving science problems.

Minnesota educators indicate that there are some limitations to teaching science.

**Finding:** Only about one in five teachers indicate that they are not limited by a shortage of instructional equipment for student use.

**Finding:** About one half of the teachers report that they are limited by inadequate physical facilities.

**Finding:** 42% of the teachers report that they are limited quite a lot or a great deal by high student/teacher ratios.

Conclusions:

Once again, Minnesota teachers and students can celebrate the strong showing of fourth-graders in TIMSS. Our students enjoy learning science and are successful at learning science. We must continue our endeavor of equity and excellence in Minnesota science education.

- All Minnesota students should study science every day, from the first day of Kindergarten until they graduate from high school. The Minnesota Graduation Standards provide guidance for a well-rounded education for every student. Learning science must be an integral part of every student's education.

- All Minnesota students should be provided with opportunities to learn rigorous science content and participate in scientific inquiry. Inquiry is the heart of science. It is important to realize that although students are participating in hands-on science, it does not mean they are experiencing meaningful learning or are engaged in scientific inquiry. TIMSS tells us that if we have a focused and coherent program, with few topics, students will learn. The same is true for scientific inquiry. If students are given opportunities to engage in and reflect on natural events through the process of scientific inquiry (exploring, questioning, experimenting, organizing, and communicating), they will learn to do science. They just need the opportunities.

- All Minnesota teachers of science, K-12, must be confident in teaching inquiry-based science and must have the resources necessary to provide science education that is essential for each student. This requires professional development throughout a teacher's career. On-going professional development in science education must be valued and supported by teachers and the education community.

## preliminary synthesis of findings for grades 4 and 8

Over the next twelve months, SciMath<sup>MN</sup> will conduct a more detailed review of the results from Minnesota's participation in the TIMSS assessments at grades 4 and 8 (and 12 as well) and prepare a synthesis report, tentatively scheduled for release in the spring of 1999. But some preliminary conclusions are already apparent from the analysis completed for the reports on achievement at grades 8 and 4. Chief among the findings about elementary and middle school science and mathematics in Minnesota are the following:

- The time devoted to mathematics and science instruction may make a difference in achievement, but generally speaking the content of what is taught and the access that students have (or do not have) to that content are relatively more important than the amount of time devoted to instruction, in determining the relative degree of student learning.
  - Mathematics education in Minnesota (and in the U.S. up through the eighth grade) is characterized by relatively less emphasis on new (and more rigorous) material, along with more repetition of basic material, as compared to instructional practices in the majority of the TIMSS countries.
  - Seatwork, review, and homework characterize mathematics instruction in Minnesota (and U.S.) classrooms, again as compared to instructional practices (integrating seatwork with group discussions) in many of the high-performing TIMSS countries. However, science instruction in Minnesota (as the U.S.) includes a markedly different pattern by including a significant amount of class discussion and student engagement in lab work, which may help explain the relatively stronger performance of Minnesota (and U.S.) students in science as compared to mathematics on the TIMSS assessments.
  - The traditional education delivery system for mathematics and science in Minnesota, with its lack of statewide standards and with differential access to content (especially in mathematics), guarantees wide variation in performance from district to district and diminishes the capacity for statewide improvement of student achievement.
- The TIMSS data show that generally speaking, current practice in Minnesota elementary and middle school mathematics and science classrooms differs significantly from the model of curriculum and instruction envisioned in the newly adopted statewide Minnesota Graduation Standards program. Moving from policy change to change in actual teaching practice will necessitate significant additional professional development for teachers.

As the U.S. Department of Education observed about the international results, "*TIMSS is not an answer book, but a mirror through which we can see our own education system in international perspective.*" Careful study of the unique data available in the Minnesota TIMSS results will assist educators, parents, the business community, and policy-makers in implementing the Minnesota Graduation Standards and achieving the vision of mathematics and scientific literacy for all students.

**Note:** For more information on the TIMSS fourth grade results for the U.S. as a whole, see "Pursuing Excellence: A Study of U.S. Fourth-Grade Mathematics and Science Achievement in International Context." U.S. Department of Education. National Center for Education Statistics, NCES 97-255, Washington, DC: U.S. Government Printing Office, 1997.

For information on Minnesota's eighth grade TIMSS results, see "Minnesota TIMSS Report: A Preliminary Summary of Results," SciMath<sup>MN</sup>, March 1997. Available from SciMathMN, 638 Capitol Square, 550 Cedar Street, St. Paul, MN 55101. Also available via SciMath<sup>MN</sup>'s website: <http://www.scimathmn.org>

## Recommendations for change in policy and practice

Based on Minnesota's performance in the Third International Mathematics and Science Study (TIMSS), SciMath<sup>MN</sup> recommends the following actions for improving science and mathematics education in Minnesota:

### RECOMMENDATIONS FOR IMPROVEMENTS IN WHAT WE TEACH:

- Use the national mathematics and science education standards to guide further development of the Minnesota Graduation Standards (in mathematics and science), and the Minnesota K-12 Mathematics and Science Curriculum Frameworks to assist districts in focusing their curriculum and instruction.
- Include algebra and geometry in the Minnesota basic standards test to meet international standards for eighth grade mathematics content.

### RECOMMENDATIONS FOR IMPROVEMENTS IN HOW WE TEACH:

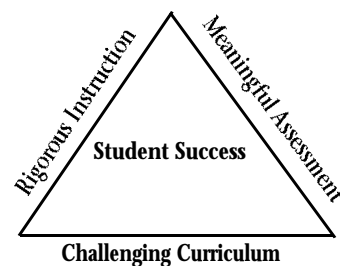
- Emphasize tighter focus in district curricula and greater rigor, as well as real-world applications, in teaching the Minnesota high standards and the use of assessment packages.
- Fund, plan and implement a coordinated and coherent statewide professional development program to orient teacher training around implementing the standards.
- Align teacher licensure and teacher education programs to support effective implementation of the Minnesota Graduation Standards and their call for inquiry-based teaching and learning.

### RECOMMENDATIONS FOR IMPROVEMENTS IN HOW WE MEASURE:

- Align statewide testing with the Gradation Standards and include more demanding items (such as open-ended questions or student-constructed response problems) on the statewide tests.
- Analyze curriculum, instruction, and assessment practices to insure that all students, particularly those who have been underserved in mathematics and science education previously, receive adequate opportunity to learn.
- Provide funding and incentives for local alignment with statewide standards and assessment. Create and implement a statewide continuous improvement plan.

**Figure 8**

**TIMSS shows  
the most important factors  
in improving student achievement  
are a focus on what we teach,  
how we teach it,  
and how we measure it.**



## for further information about timss...

### For U.S. TIMSS Information:

- National Library of Education 1-800-424-1616
- National Center for Educational Statistics 1-202-219-1333
- NCES U.S. TIMSS Internet site <http://www.nces.ed.gov/timss>
- Boston College U.S. TIMSS Internet site <http://www.csteep.bc.edu/timss>
- Michigan State University U.S. TIMSS Internet site <http://ustimss.msu.edu>
- TIMSS-Forum Homepage <http://www.rbs.org/eisenhower/resources/timss/forum.html>

### For Minnesota TIMSS Information:

- Call SciMath<sup>MN</sup> at 612-296-4058
- E-mail [scimath-mn@informns.k12.mn.us](mailto:scimath-mn@informns.k12.mn.us)
- Visit the SciMath<sup>MN</sup> Internet site at [www.scimathmn.org](http://www.scimathmn.org)

## Timeline of Additional Minnesota TIMSS Reports:

### Fall 1998

- Minnesota 12th Grade TIMSS Results
- Minnesota TIMSS Performance Assessment Results

### Spring 1999

- SciMath<sup>MN</sup>'s synthesis report on Minnesota TIMSS results at grades 4,8, and 12



## about scimath<sup>mn</sup>...

Founded in 1993, SciMath<sup>MN</sup> is a partnership among business, education and state government pursuing statewide improvement in the teaching and learning of K-12 mathematics and science based on the national mathematics and science education standards. SciMath<sup>MN</sup>'s vision is to increase the educational achievement and participation of all Minnesota students in science and mathematics to help them meet the complex challenges of their future.

To contact SciMath<sup>MN</sup>, call or write to us at 638 Capitol Square, 550 Cedar Street, St. Paul, MN 55101; Phone 612-296-4058; Fax 612-297-7340; E-mail [scimath-mn@informns.k12.mn.us](mailto:scimath-mn@informns.k12.mn.us); Internet [www.scimathmn.org](http://www.scimathmn.org)

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