# MINNESOTA TIMSS: The Rest of the Story

A SUMMARY OF RESULTS AS OF OCTOBER 2009

TRENDS IN INTERNATIONAL MATHEMATICS AND SCIENCE STUDY

## MINNESOTA SCIENCE AND MATH COMPARED INTERNATIONALLY IN TIMSS: REVIEWING THE CONTEXT

The 2007 TIMSS is referred to as the Trends in International Mathematics and Science Study. With over 60 participants and 425,000 students assessed, TIMSS 2007 is still the largest study of student math and science achievement in the world. Fourth and eighth grade students were the focus in 2007 and each participating country sampled approximately 4,000 students in 150 schools.

SciMath$^{MN}$ sponsored Minnesota's 1995 participation as a 'mini-nation' in TIMSS, and was selected to analyze the 2007 Minnesota TIMSS results, where Minnesota again participated as a mini-nation.

Mini-nation status allows Minnesota to participate as if it were a nation, establishing our ranking among the other participating nations and providing insight into our students' ability to compete on a global scale.

## WHERE WAS MINNESOTA MATHEMATICS IN 2007?

### MINNESOTA'S 2007 TIMSS MATHEMATICS PERFORMANCE

- The Minnesota 4th grade performance **gain** was among the largest of any of the 16 countries that participated in both the 1995 and 2007 TIMSS ($p < .05$).
- The Minnesota 4th grade **gain**, which was over a third of a standard deviation, was more than three times the gain indicated for the U.S. as a whole.
- At 8th grade, Minnesota's 2007 **gain** over 1995 was substantially less than the 4th grade gain – about one tenth of a standard deviation – which was not statistically significant ($p < .11$).
- A similar pattern of improvement from 1995 to 2007 for both the U.S. as a whole and Minnesota can be noted with the NAEP results.

## WHERE WAS MINNESOTA SCIENCE IN 2007?

### 2007 TIMSS SCIENCE PERFORMANCE:

- In contrast to the performance in mathematics, in science neither the U.S. nor Minnesota demonstrated significantly different performance in 2007 than in 1995.
- In 2007, Minnesota maintained its relatively high level of performance, being outperformed by very few countries at either 4th or 8th grade and significantly outperforming the U.S. at grade 8.

## WHAT HAS HAPPENED SINCE MINNESOTA PARTICIPATED LAST IN 1995? MORE THAN A DECADE OF ACTION

Minnesota has not stood idle in the twelve intervening years between these tests. A number of significant statewide educational changes have been implemented:

- State standards in mathematics and science were implemented in 1997 and have since been revised twice.
- Rigorous high stakes tests (Minnesota Comprehensive Assessments) have been in place since 1998 in mathematics (and 2008 for science).
- SciMath$^{MN}$ developed Frameworks for teaching mathematics and science (based on Minnesota state standards) that were widely distributed and used throughout Minnesota.
- Standards-based mathematics curriculum increased in use – especially in larger districts, thereby impacting the majority of students in the state.
- Increased classroom time has been allocated in many districts to the tested subjects – especially at the elementary level.
- Graduation requirements in both mathematics and science have significantly increased.
- Algebra will be required for all 8$^{th}$ grade students in the year 2011, and Algebra II will be required of the same cohort of students for graduation in 2015; graduates of 2015 must also complete either chemistry or physics. Many districts have already initiated the change process to prepare students for these requirements.
- SciMath$^{MN}$ shared Minnesota's participation in the 1995 TIMSS with many districts, which produced valuable lessons for the districts becoming resources for staff development and decision-making.

# MINNESOTA 2007 TIMSS REPORT
# MATHEMATICS - THE REST OF THE STORY

## TEACHING EMPHASIS

Preliminary results for Minnesota on the 2007 TIMSS assessment released in December 2008 and February 2009 indicated that 4th grade teachers in Minnesota are distributing their teaching time in closer alignment to teachers in high performing countries, which puts them in closer alignment with the Framework for the TIMSS Assessment. This Framework is also closely aligned with Minnesota's testing expectations as indicated in Test Specifications for the Minnesota Comprehensive Assessment – II. This latter has likely affected teacher practice and adjusted emphasis on strands since 1995 for most teachers.

For example at Grade 4, in 1995 teachers spent about 35% of their time on number, which should be the major focus of instruction at 4th grade, based on the TIMSS Framework, practice in high performing countries, and recommendations from multiple organizations and bodies of research. The TIMSS Framework specifies that about 50% of the content at 4th grade will be on number. By 2007, teachers reported spending about 55% of their time, on average, on number, much closer to the TIMSS expectations, and no doubt partly influenced by state testing expectations which specify 40% on number and 15% on patterns and functions, which at 4th grade is closely related to number.

Looking at other strands also gives better alignment. In 1995, Minnesota teachers reported spending about 20% of their time on geometry. This increased to 25% in 2007, closer to but still less than the 35% on the TIMSS assessment of the 30% on Minnesota assessments. The 1995 emphasis of only 5% on data increased to about 15% at the 4th grade in 2007, matching both the TIMSS distribution and Minnesota test requirements. In 1995 4th grade teachers reported spending about 40% of their time on "other", more than any other strand, whereas in 2007 this decreased to less than 5% of their time. This change alone is likely to have affected improved test results. (See Figure 1)

Figure 1b shows how the 2007 MN focus compares to the international focus. Compared to 1995, the variability in the reported percent teacher time devoted to Geometry and Data is greater in 2007. (Figure 1b)

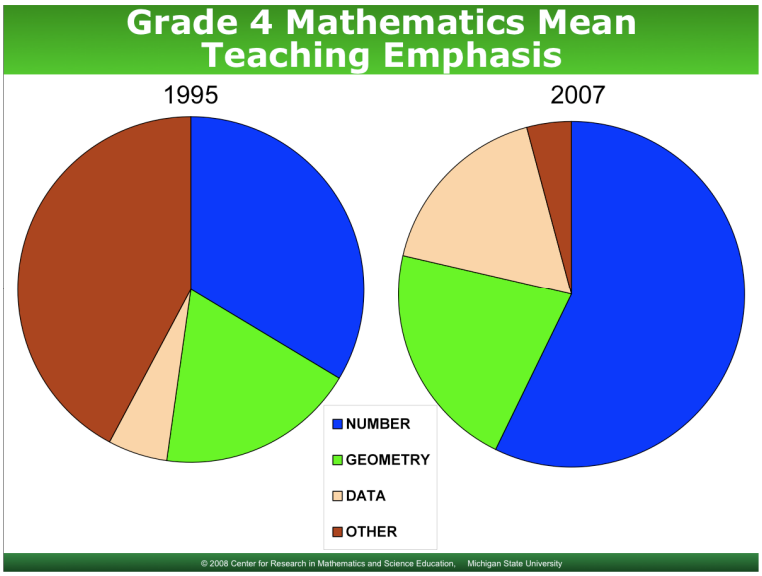



Figure 1

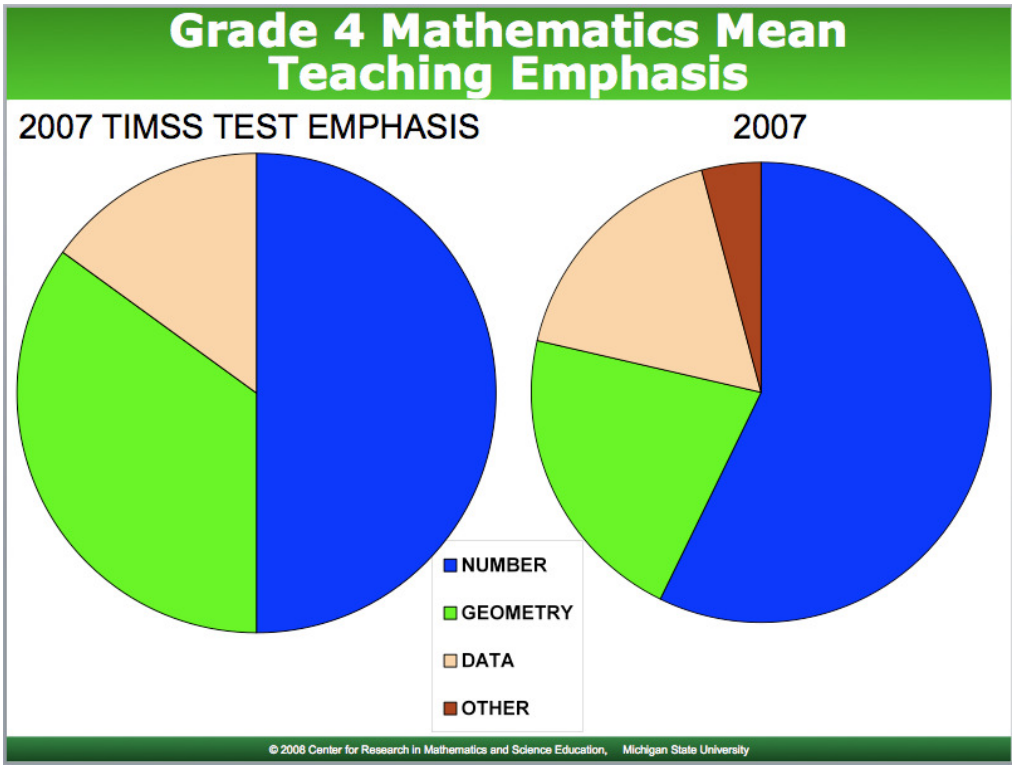
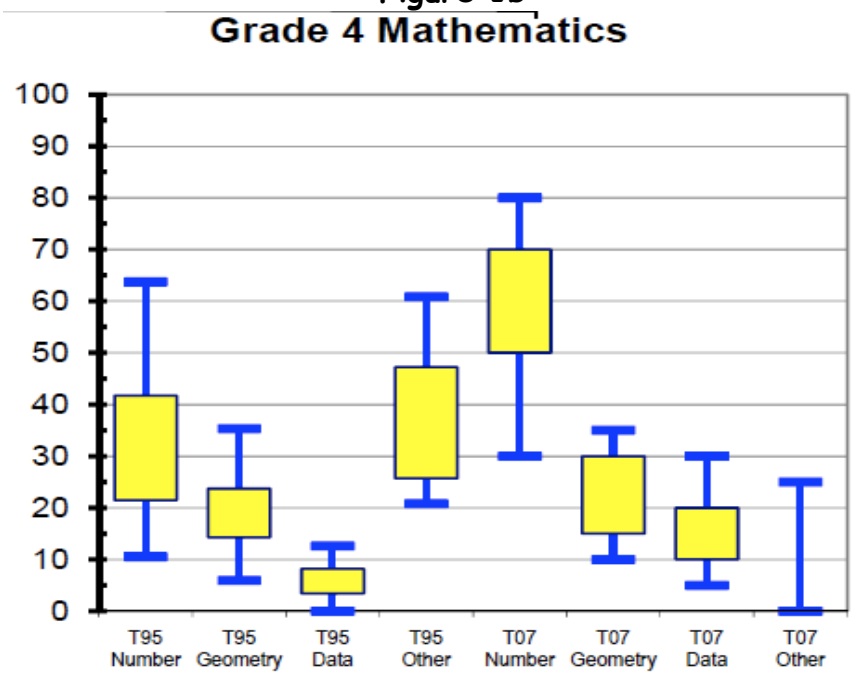



**Figure 1a**
**MINNESOTA TIMSS TEACHING TIME IN 1995 AND 2007**

**Figure 1b**



At the 8th Grade there is a similar story with regard to all strands, especially algebra, which is a major focus of instruction at this grade in the top performing countries, the TIMSS Content Framework, and Minnesota's 2007 standards (which were not in place at the time of the 2007 TIMSS assessment).

In 1995 8th grade Minnesota teachers reported spending about 10% of their time on algebra; this changed to nearly 50% in 2007. TIMSS Specifies 30%; Minnesota also specifies 30%. For the Number strand, in 1995 8th grade teachers reported spending about 40% on number; by 2007 this was reduced to 20%. TIMSS indicates 30% for Number at grade 8, while Minnesota specifies about 25%.

There was little change for the Geometry strand, with teachers reporting about 15% for both 1995 and 2007. TIMSS indicates 20% for Geometry at grade 8, while Minnesota specifies 30%.

For the Data strand, teachers moved from about 5% in 1995 to 15% in 2007, matching the Minnesota test specifications of 15%, but slightly less than the TIMSS Framework indicator of 20%.

Finally, as at 4th grade, the category of "Other", which represented about 30% of time in 1995, was less than 5% in 2007. (See Figure 2) Figure 2b shows how the 2007 math focus compared to the international focus. Compared to 1995, the variability in the reported percent of teacher time devoted to Geometry and Algebra is greater in 2007. (Figure 2b)

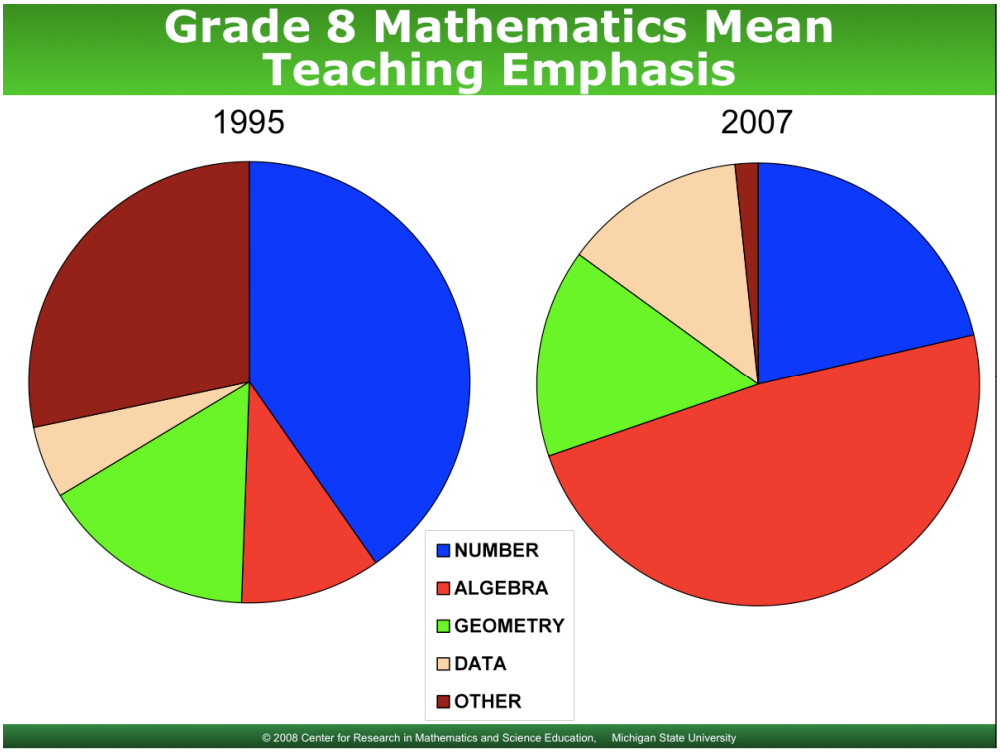



Figure 2

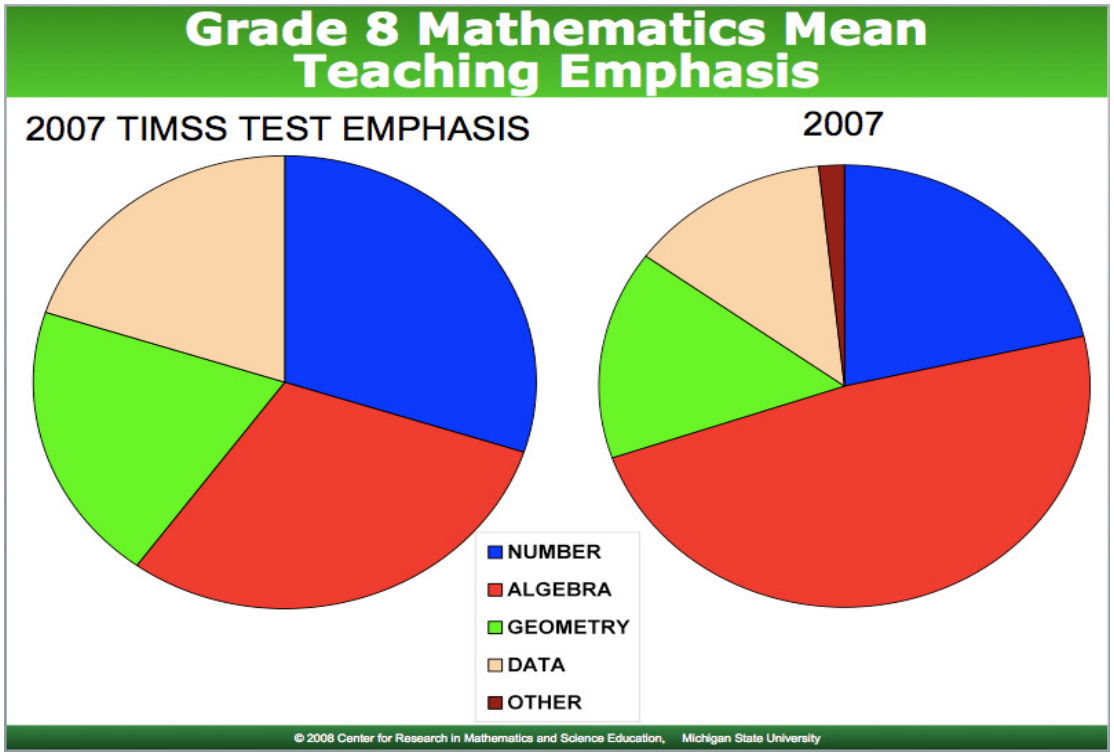



Figure 2a

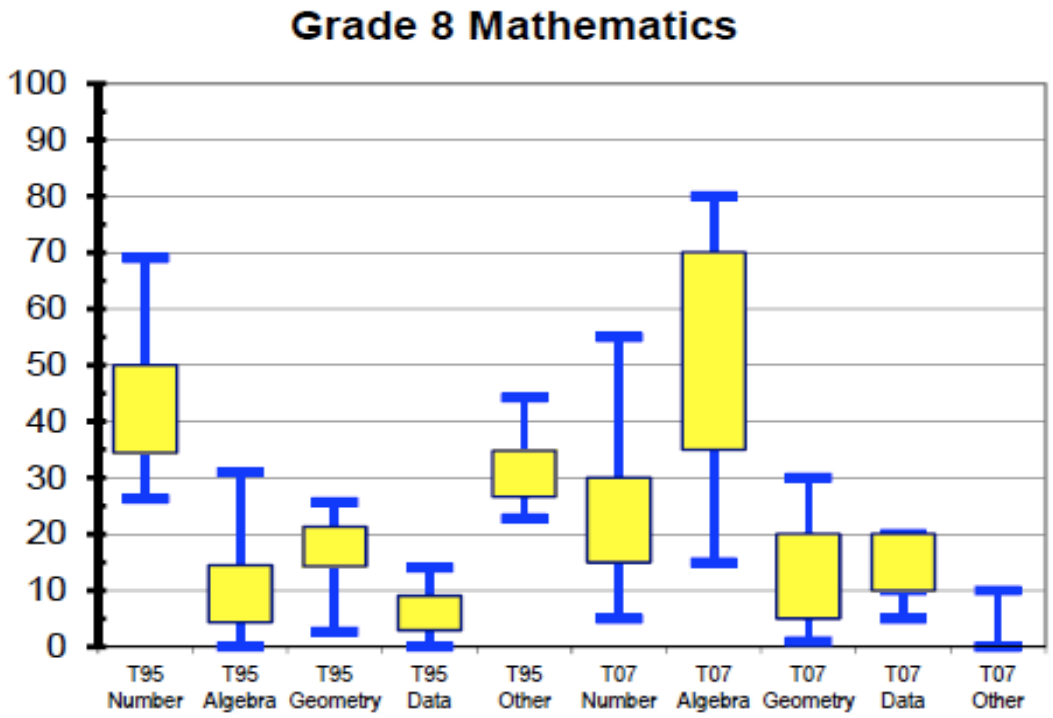



Figure 2b

- A major shift in the implemented curriculum is apparent in 8th grade. This is evident from the increase in reported percent teaching time devoted to Algebra. On average (Median), in 2007 MN teachers report spending more than 50% of teaching time on Algebra topics compared to less than 10% of teaching time on the same topics in 1995.

- The percentage of reported time on coverage of Data Representation also shows an increase-median percentage of approximately 15% in 2007 compared to approximately 5% in 1995.

- The reported percent time on Number, Geometry and "other" mathematics topics show a decrease in 2007 compared to 1995.

## Race/ minority status

There is some data on the performance of students in schools with different proportions of minority enrollment.

For 4th grade students, on the number strand, those in schools with 25% or less of minority enrollment performed the highest, on par with Japan, and above the overall Minnesota average. Students in schools with minority enrollment between 25 and 75% minority performed less well, slightly below the US average. Students in schools with more than 75% minority students performed least well, placing them between the Ukraine and Iran.

Teachers in schools with more than 75% minority enrollment spend about the same proportion of their teaching time on number as most teachers in Minnesota; nevertheless their students perform less well. (Figure 3)

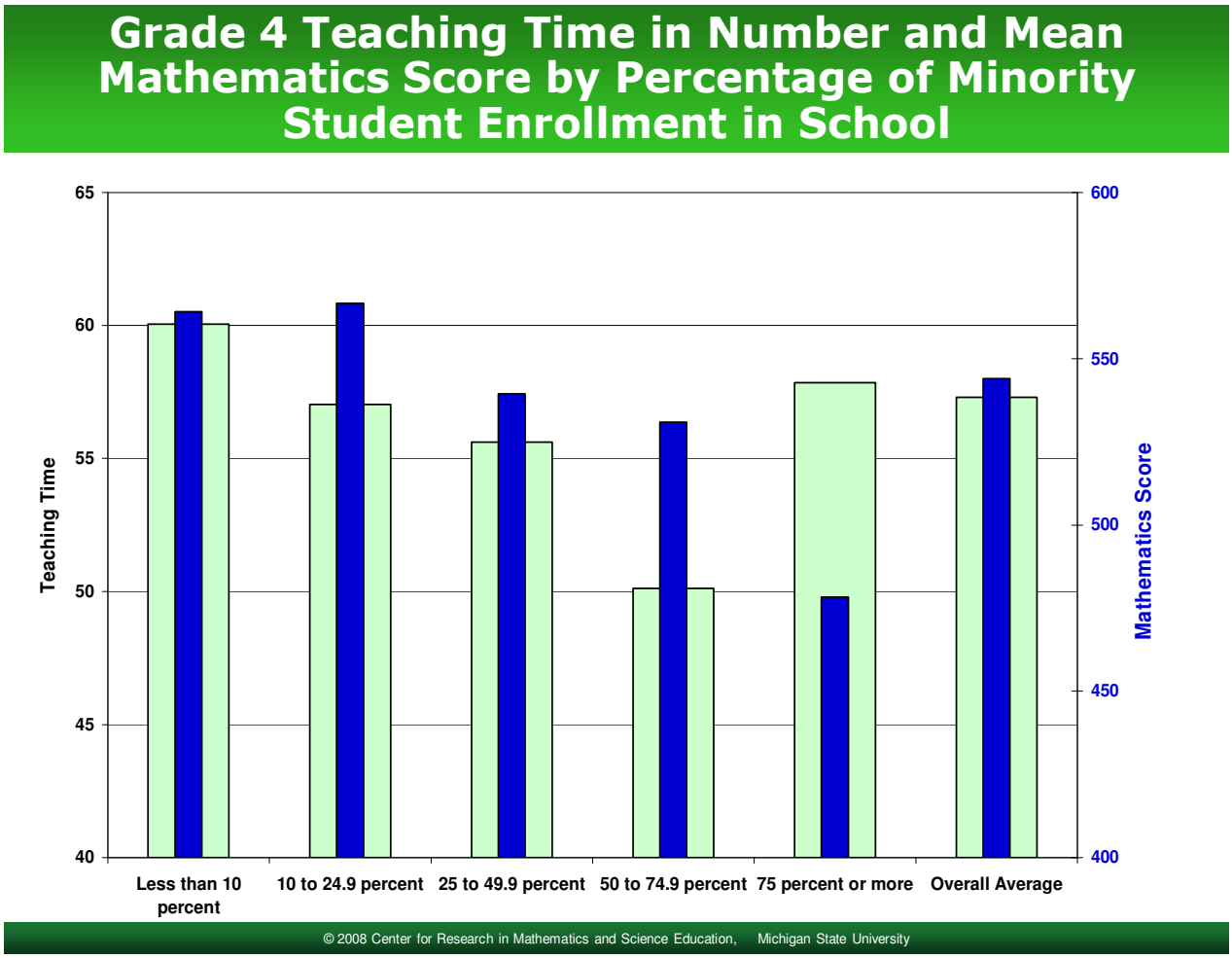



Figure 3

At the 8th grade, a similar result occurs on the algebra strand. Students in schools with less than 25% minority enrollment score better than the Minnesota average, those in schools with between 25 and 75% minority enrollment score at approximately the Minnesota average, and those in schools with more than 75% minority enrollment are considerably below the others, again at about the achievement level of the Ukraine, though above Iran.

8th grade teachers in schools with more than 75% minority enrollment report spending about 35% of their time on algebra, less than the 47% of the average 8th grade Minnesota teacher. (Figure 4)

## Grade 8 Teaching Time in Algebra and Mean Mathematics Score by Percentage of Minority Student Enrollment in School

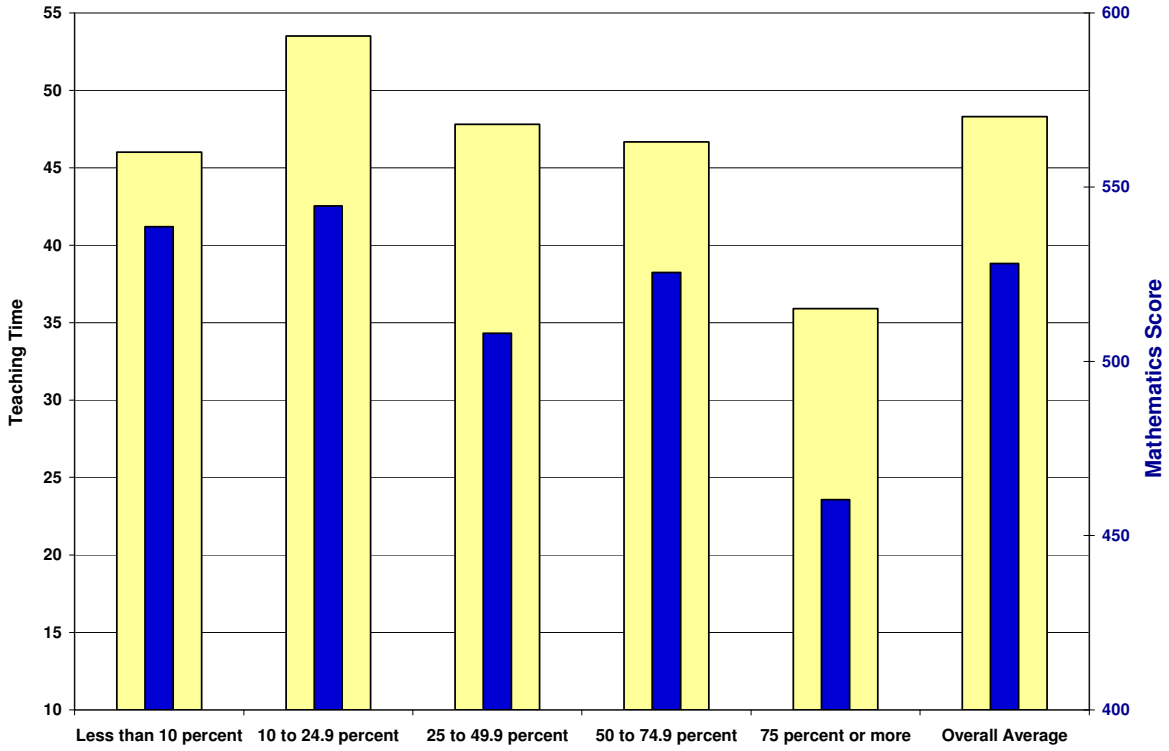





Figure 4

## SOCIO-ECONOMIC STATUS

When students are disaggregated by Socio-Economic Status (SES), qualification for Free or Reduced price Lunch (FRL) is used as a marker, since qualification is based on poverty guidelines.

Looking at 4th grade student overall scores, Minnesota students in schools where less than 25% of the students qualify for FRL perform the highest, above the overall average. Students in schools with between 25 and 50% FRL perform at about the Minnesota average, while students in schools with between 50 and 75% FRL perform below the state average.

Schools where more than 75% of students qualify for FRL perform well below the Minnesota average. In all cases, Minnesota students perform above the US average for the group. (Figure 5)

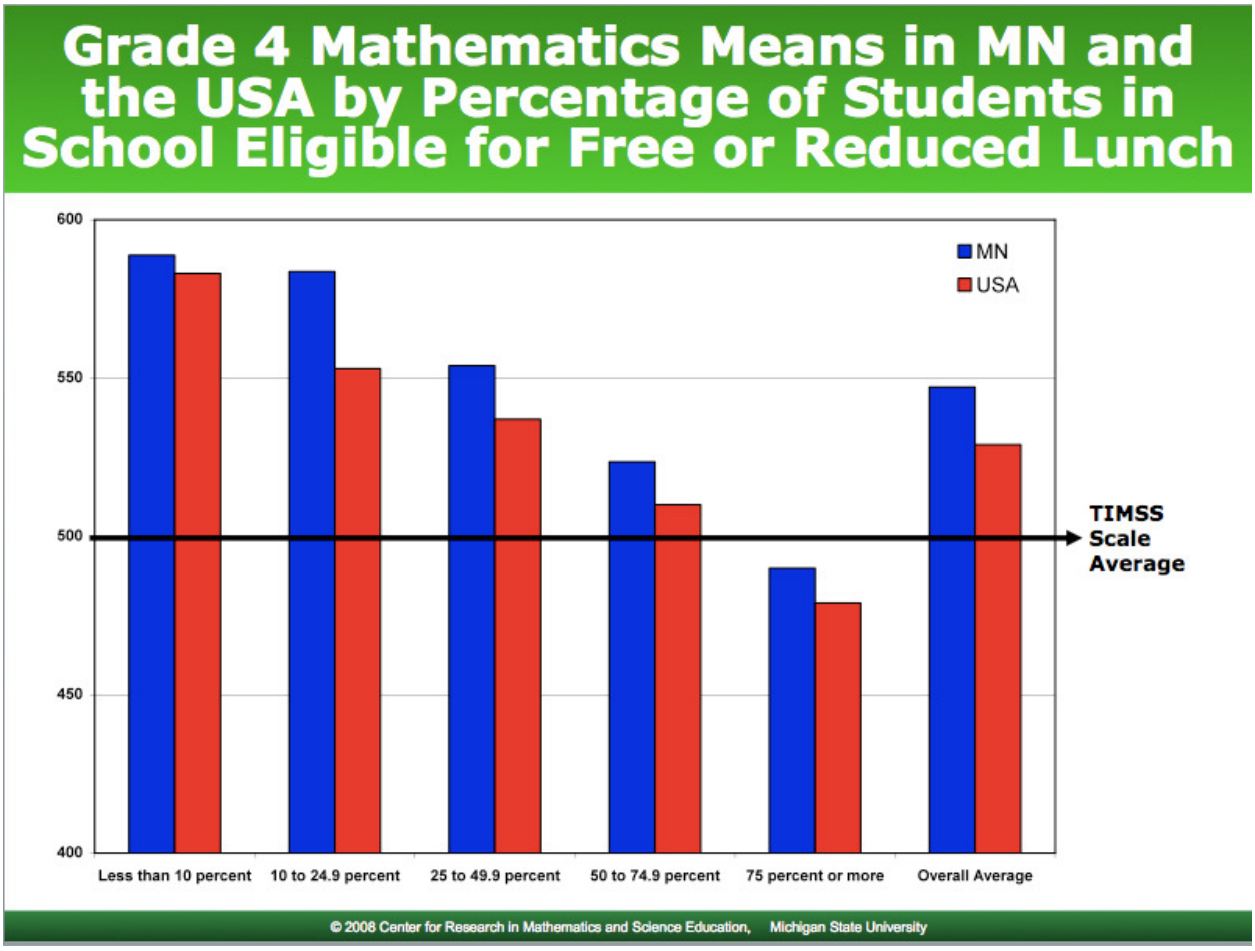



Figure 5

At the 8th grade, the pattern is somewhat different. Students in schools with less than 10% FRL perform just slightly above the Minnesota average, and below the US average. For those in schools with 10-25% FRL, Minnesota students perform above their peers in more affluent schools, above the Minnesota average, and nearly as well as the US average.

Students in schools with between 25 and 75% FRL perform at approximately the Minnesota average and above the US average. Students in high poverty schools, those with more than 75% FRL, perform well below the Minnesota average, and below the US average for students in similar schools. (Figure 6)

For 4th grade, a similar pattern is evidenced when looking at the number strand. There is a steady decrease in performance on TIMSS as the proportion of students eligible for FRL increases. (Figure 7)

At the 8th grade, the results for the algebra strand exhibit a different pattern. The Minnesota average is about 525, and students in schools with less than 75% FRL all hover around that score, ranging from about 515 to about 540. However, students in schools with more than 75% FRL average about 450 in algebra, putting them far behind their peers. Their teachers also report spending less time on algebra than their counterparts in other schools. (Figure 8)

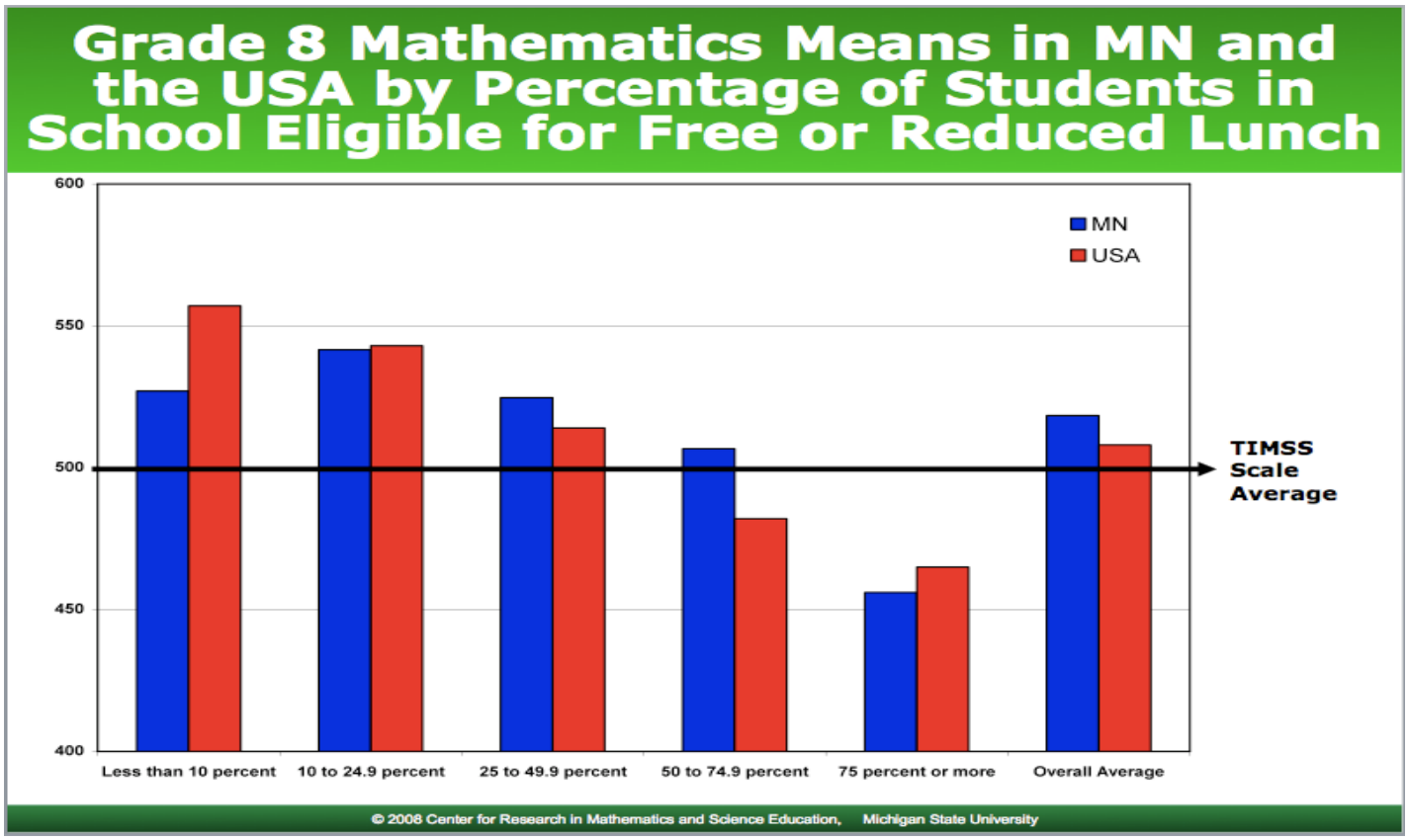



Figure 6

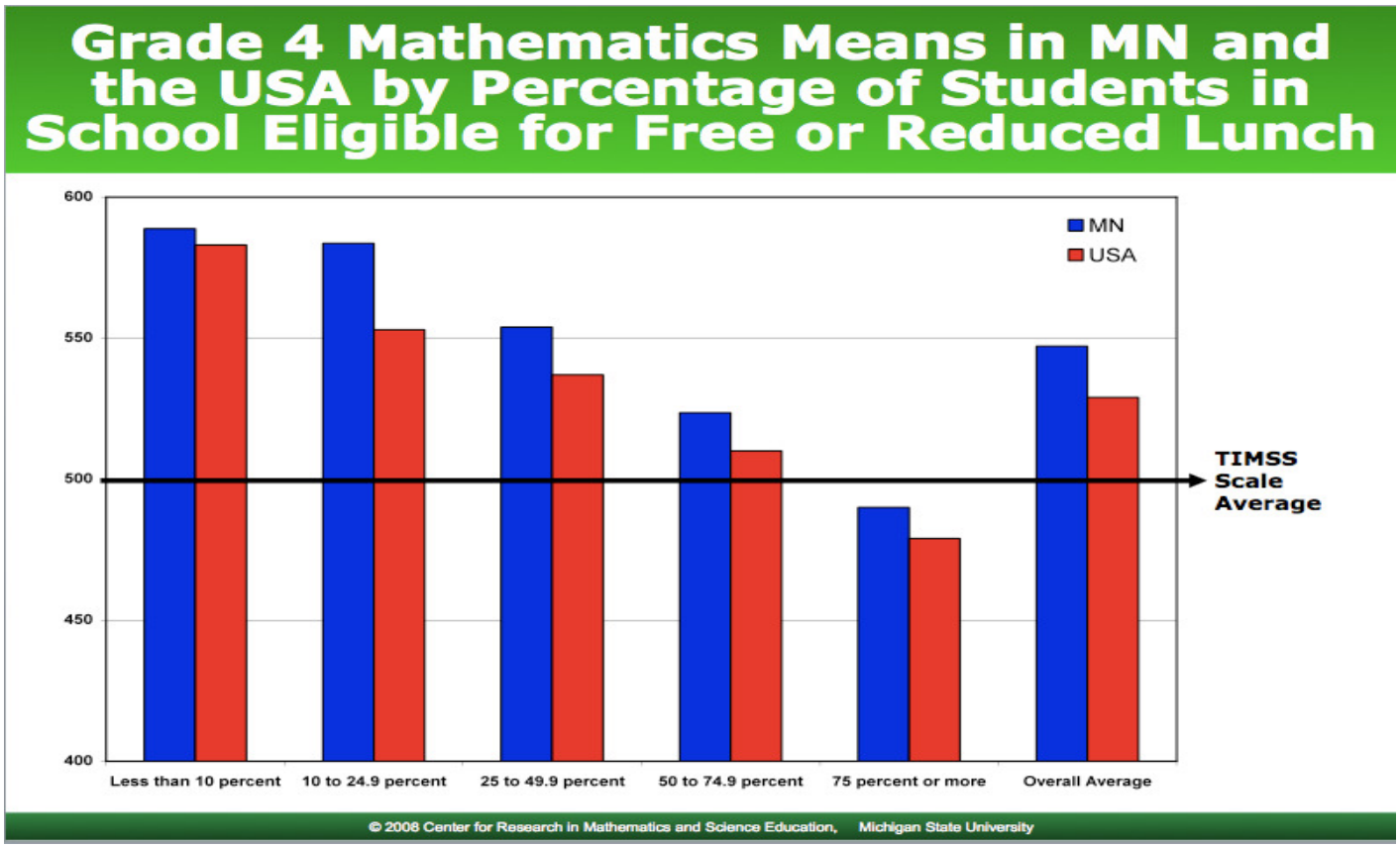



Figure 7

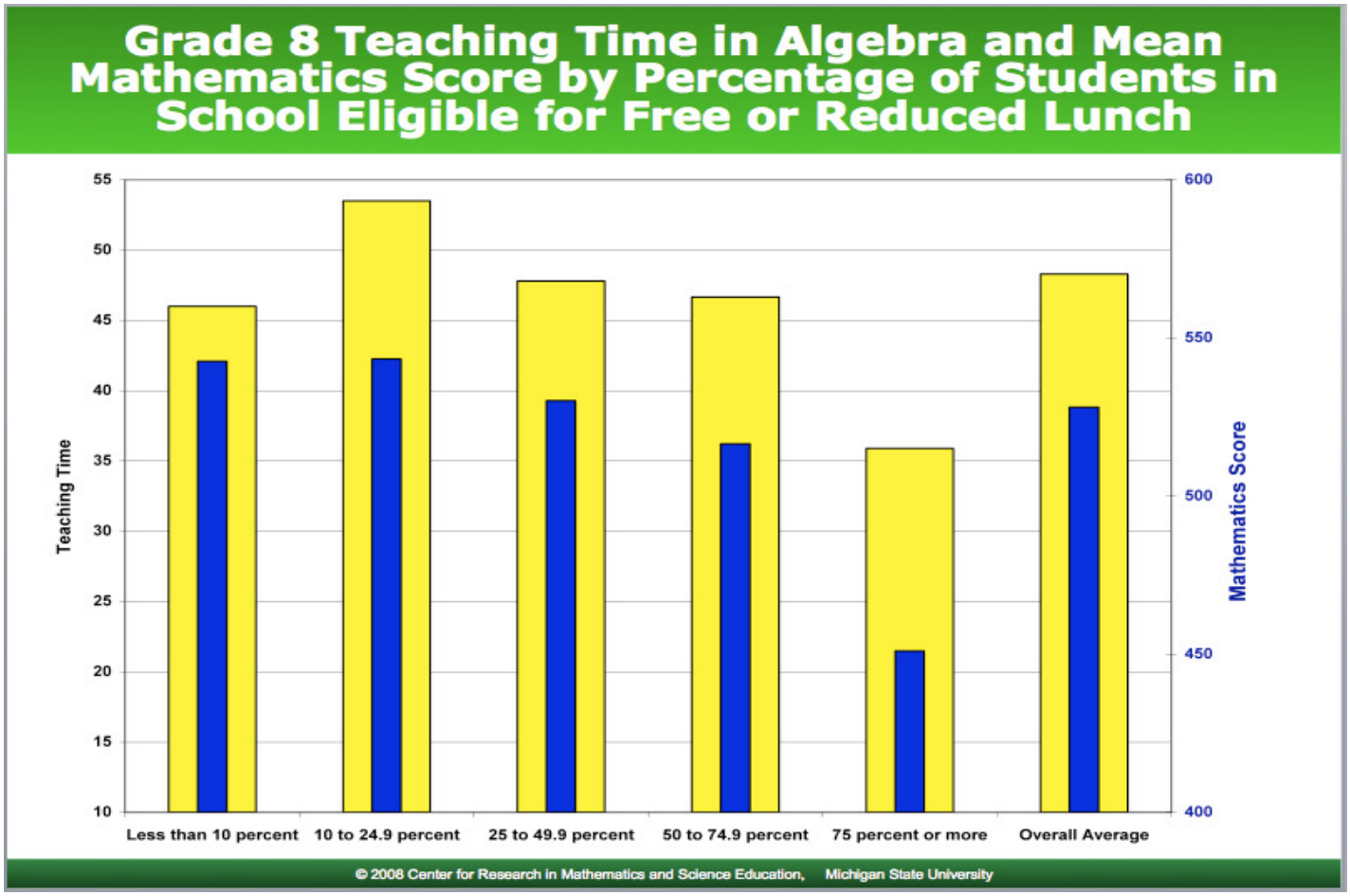



Figure 8

Looking at substrand data for 4th grade over SES gives a picture similar to other data for 4th grade. There is a decline in performance as the percent of students eligible for FRL increases, For Whole Number Operations, scores range from about 63% correct for students in schools with less than 25% FRL to about 40% for schools with more than 75% FRL. (Figure 9).

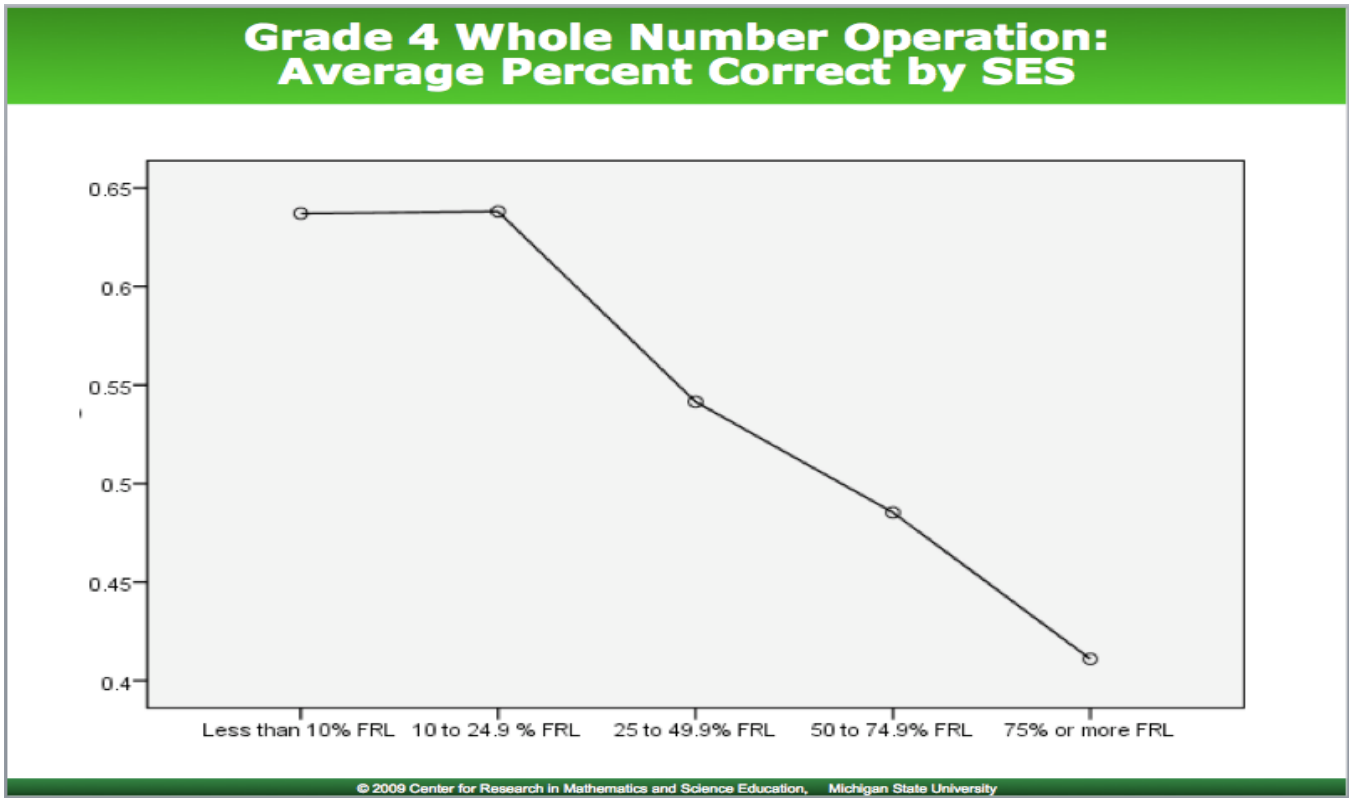



Figure 9

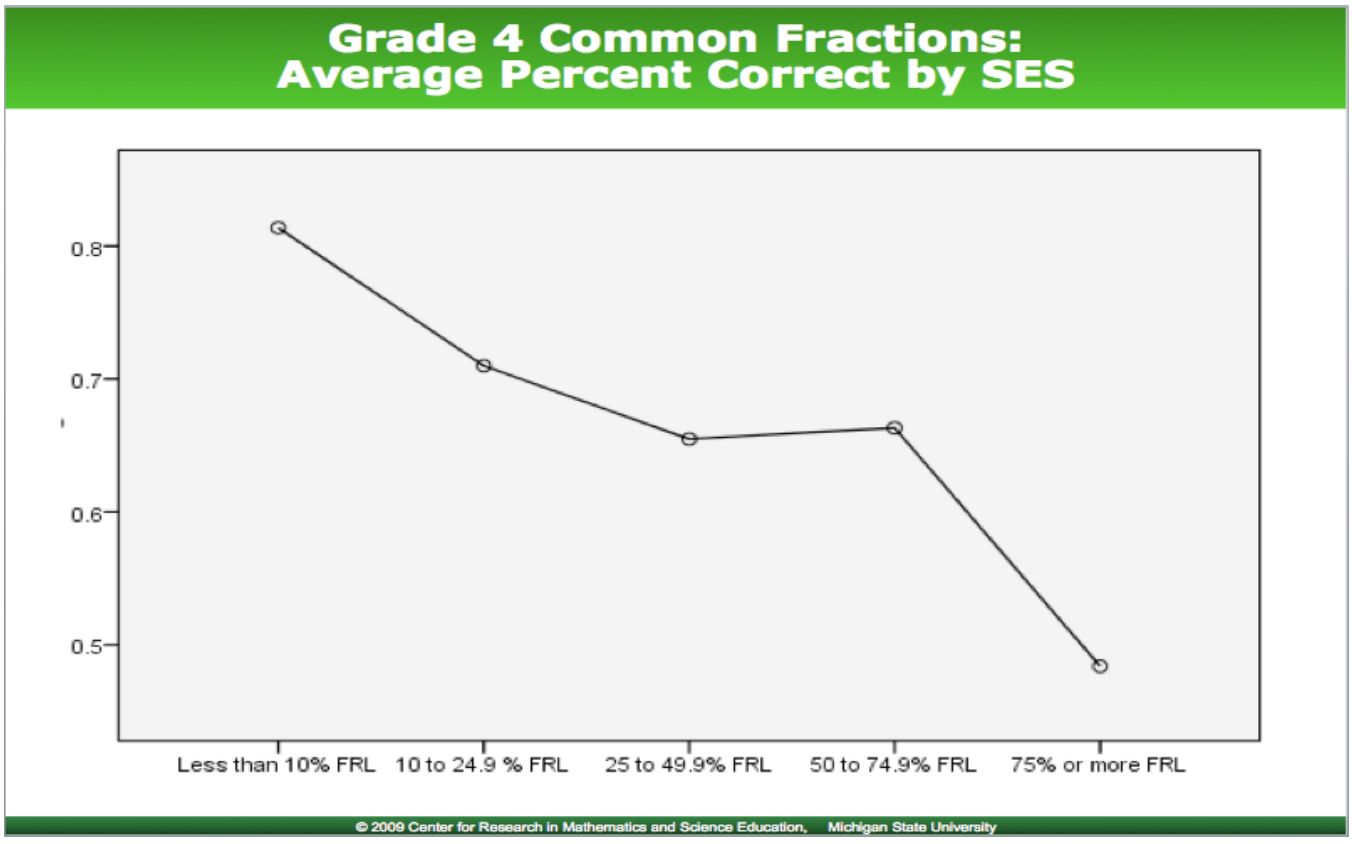



Figure 10

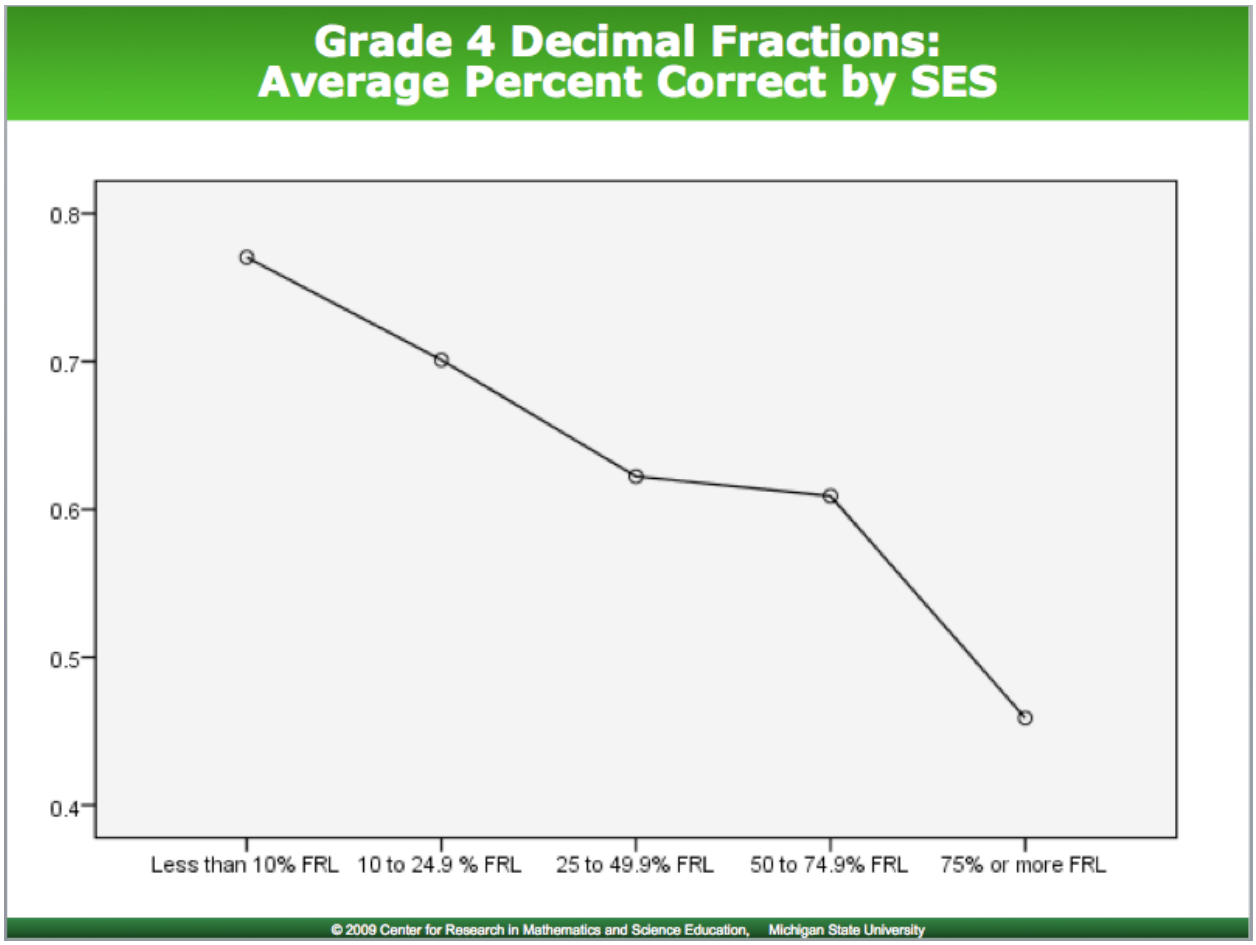



Figure 11

For the Common Fraction substrand at grade 4, students in schools with less than 10% FRL answered more than 80% of the items correctly, while students in schools with more than 75% FRL answered less than 50% correctly. (Figure 10)

On Decimal Fractions, correct responses ranged from almost 80% correct for students in schools with less than 10% FRL to less than 50% for schools with more than 75% FRL. (Figure 11)

On the Measurement Units substrand at grade 4, there is a similar decrease, with students in schools with less than 10% FRL answering about 70% of items correctly, while students in schools with more than 75% FRL answer less than 40% correctly. (Figure 12)

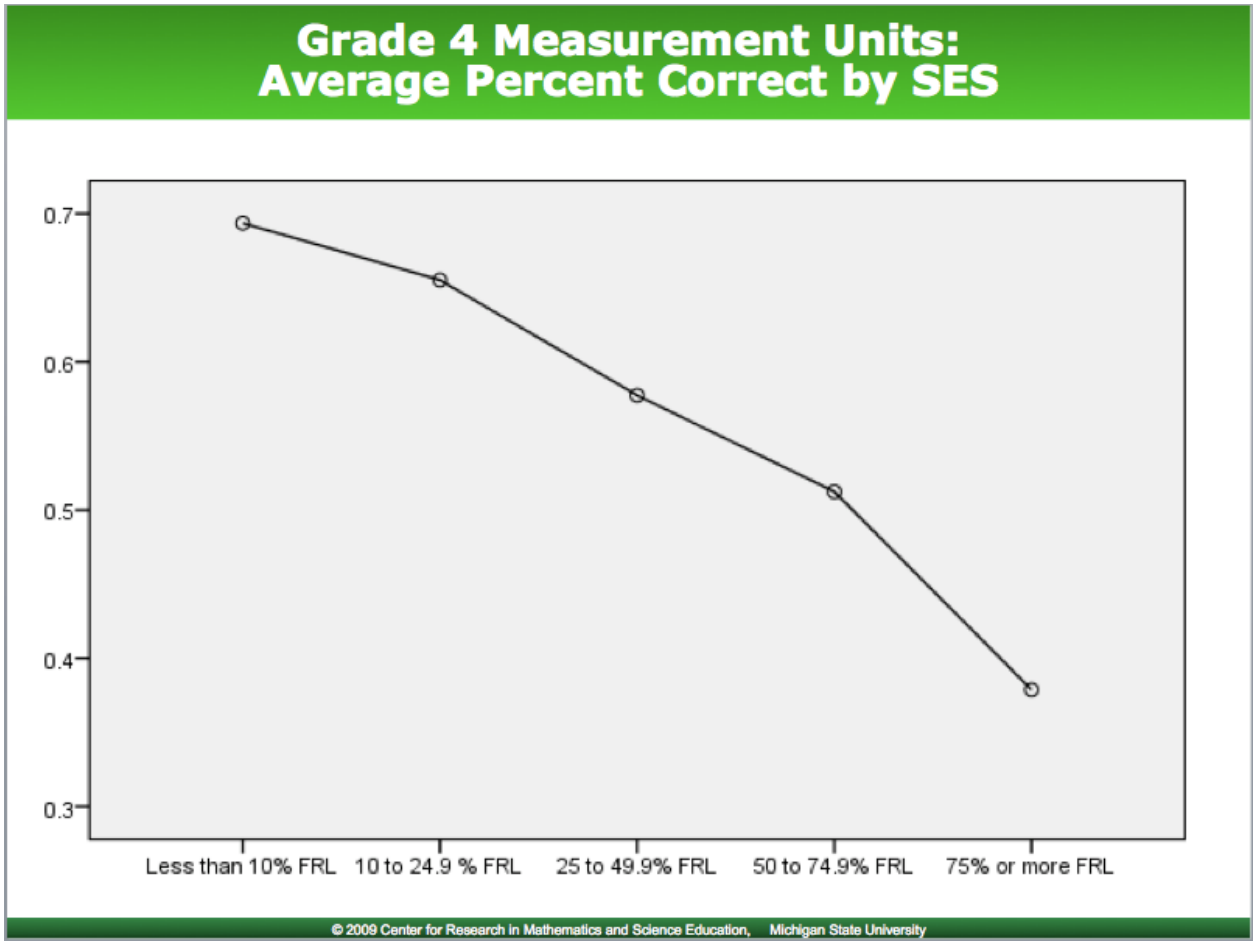



Figure 12

When we consider total instructional time at grade 4, the picture that emerges is somewhat different. Teachers in schools with more than 75% FRL spend the largest amount of time on mathematics, a total of about 225 hours per year, or 75-90 minutes per day.

On the other hand, teachers in schools with less than 10% FRL, and those in schools with between 50 and 75% FRL spend slightly more than one hour per day on mathematics. Teachers in schools with between 10 and 50% FRL report spending about 45 minutes per day on mathematics instruction. (Figure 13)

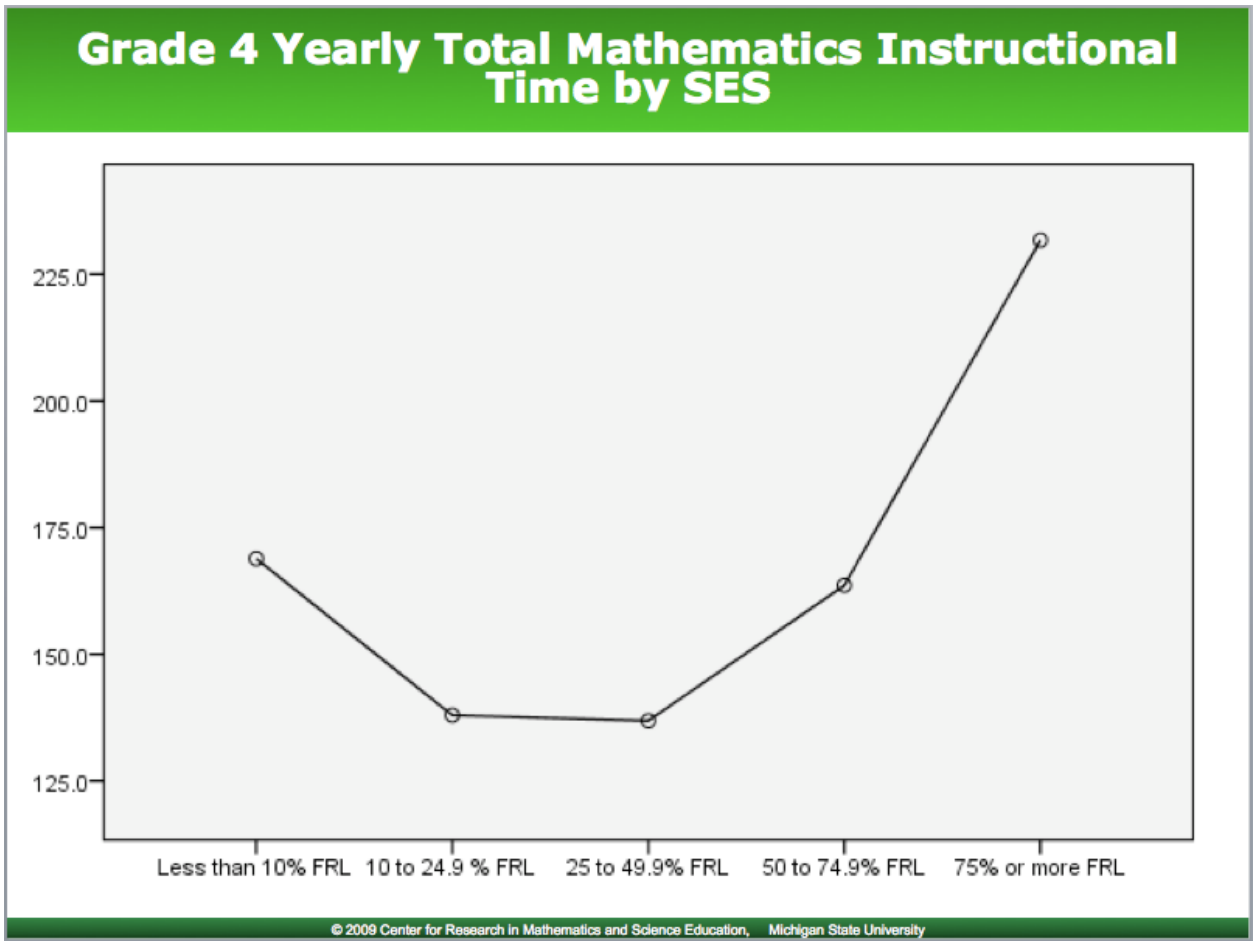

Grade 4 Yearly Total Mathematics Instructional Time by SES
225.0
200.0
175.0
150.0
125.0
Less than 10% FRL
10 to 24.9 % FRL
25 to 49.9% FRL
50 to 74.9% FRL
75% or more FRL
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Figure 13

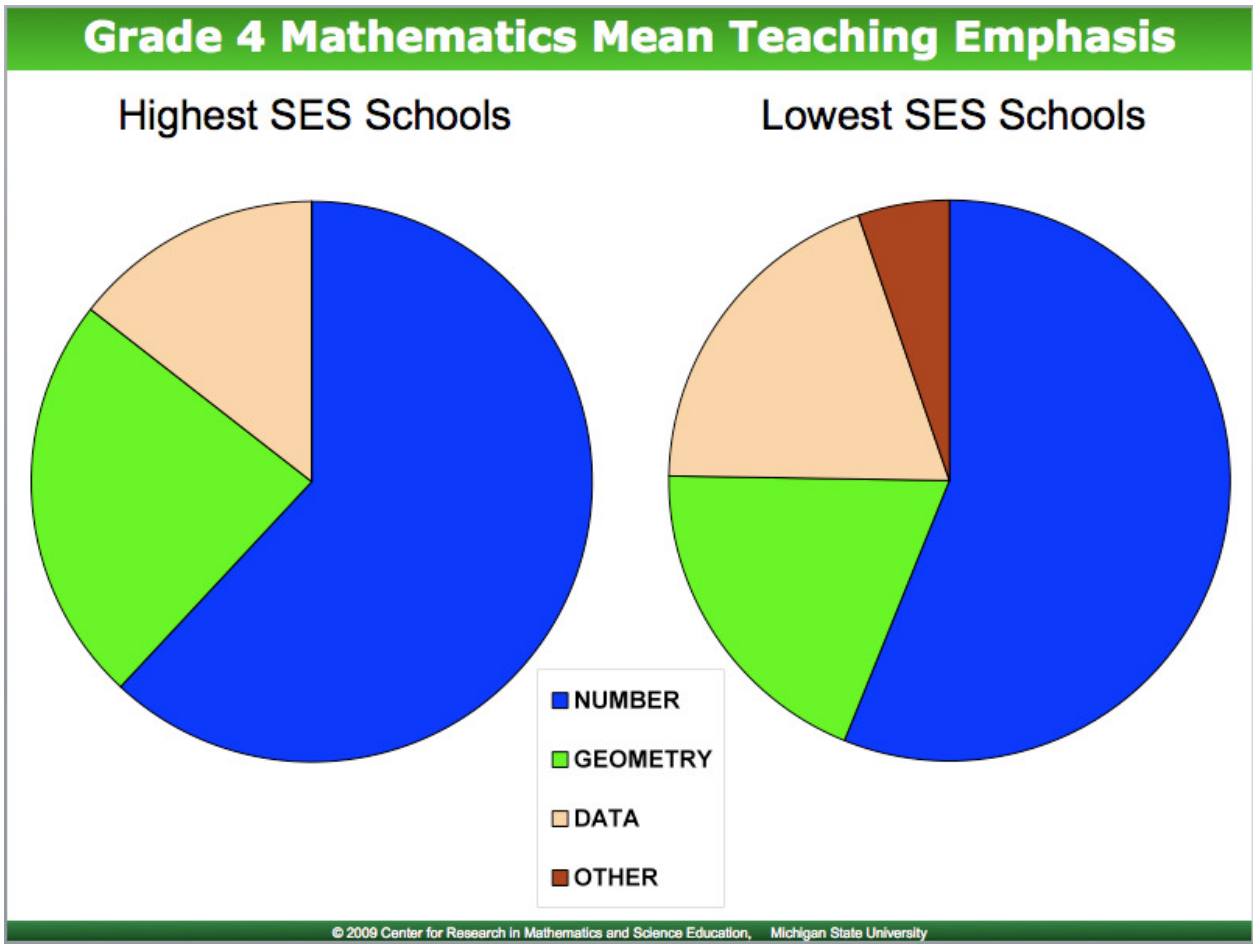


Figure 14

At 4th grade there are also differences in teacher emphasis across SES. Teachers in the highest SES schools spend more time on number and geometry than teachers in the lowest SES schools. Teachers in the highest SES schools spend no time on the "other" category; teachers in the lowest SES schools spend about 5% of their time on "other". (Figure 14)

The variation between them is the difference between 62% for the highest SES schools on number, and 56% for the lowest. This amounts to a difference of more than 2 weeks of instruction. For geometry, the differences are about 5%, so the high SES schools have about 2 weeks more of geometry instruction. The amount of time the low SES schools spend on "other" also translates into about 2 weeks. (Figure 15)

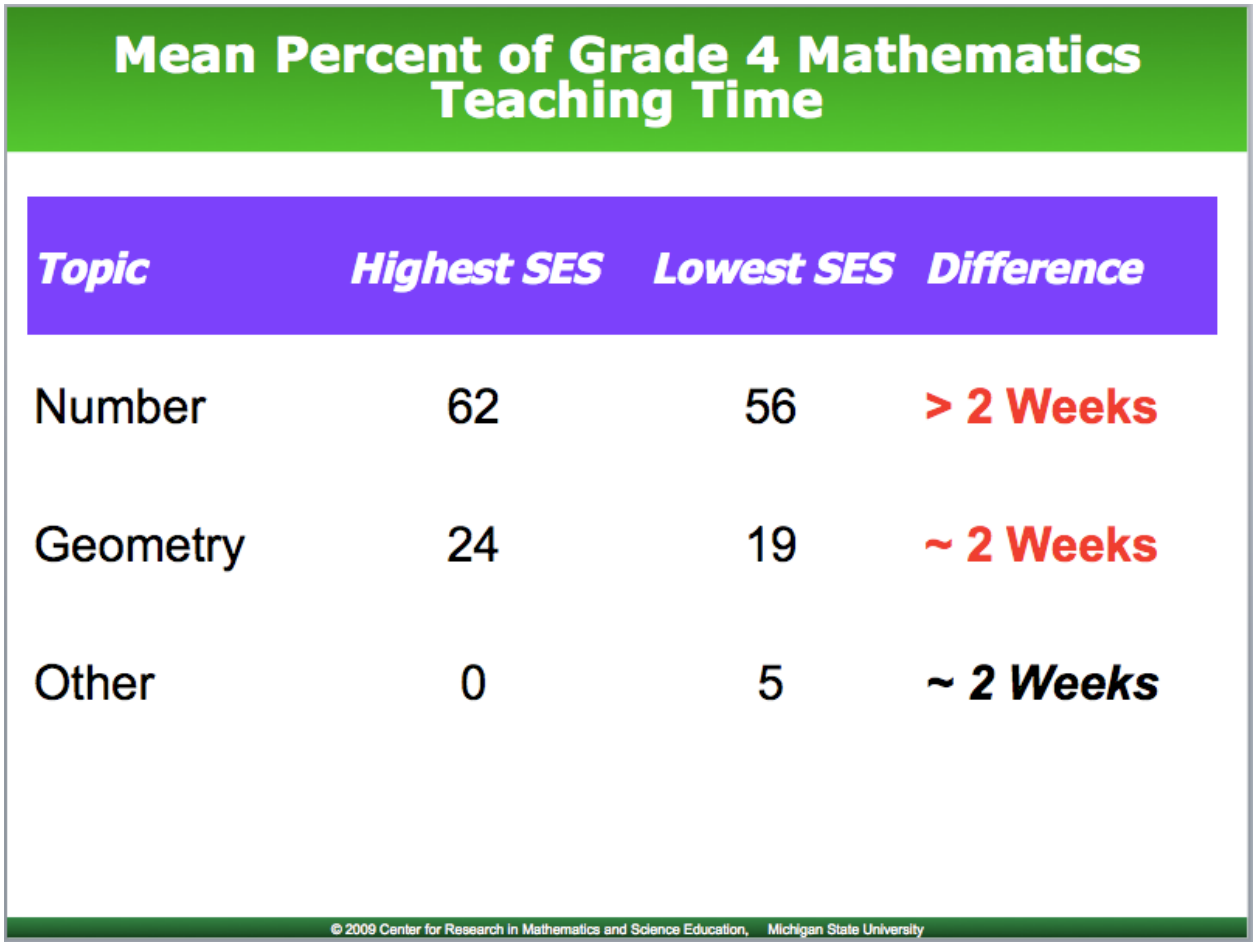


Figure 15

At the 8th grade level, the data on substrands gives a picture similar to that at 4th grade, but is often more dramatic. For example, on the Common Fractions substrand, there is a 5% decline between the scores of students in schools with less than 10% FRL and schools in the 50 to 75% FRL range. However, the drop from scores of students in the 50 to 75% FRL is about 20%. (Figure 16)

For Congruence and Similarity, the decline from 1 to 75% is 4%, while the drop from 50 to 75% to more than 75% FRL is about 12%. (Figure 17)

For Proportion Concepts, there is a 2% drop from the schools with less than 10% FRL to those between 50 and 75%, but from the latter to students in schools with more than 75% FRL there is a 20% drop. (Figure 18)

For Proportion Problems, there is a 16% drop from the schools with less than 10% FRL to those between 50 and 75%, but from the latter to students in schools with more than 75% FRL there is a 22% drop. (Figure 19)

For Functions, the drop from schools with less than 10% FRL to those with between 50 and 75% FRL is about 7 points, while the drop from there to students in schools with more than 75% FRL is about 19%. (Figure 20)

And for Equations, the corresponding numbers are 6% and 20%. (Figure 21)

In other words, students in schools with less than 75% FRL do not perform much differently from each other, though there is slight drop in achievement for students as the percentage of poor students increases. However, students in schools with more than 75% FRL perform substantially below those in schools with less than 75% FRL.

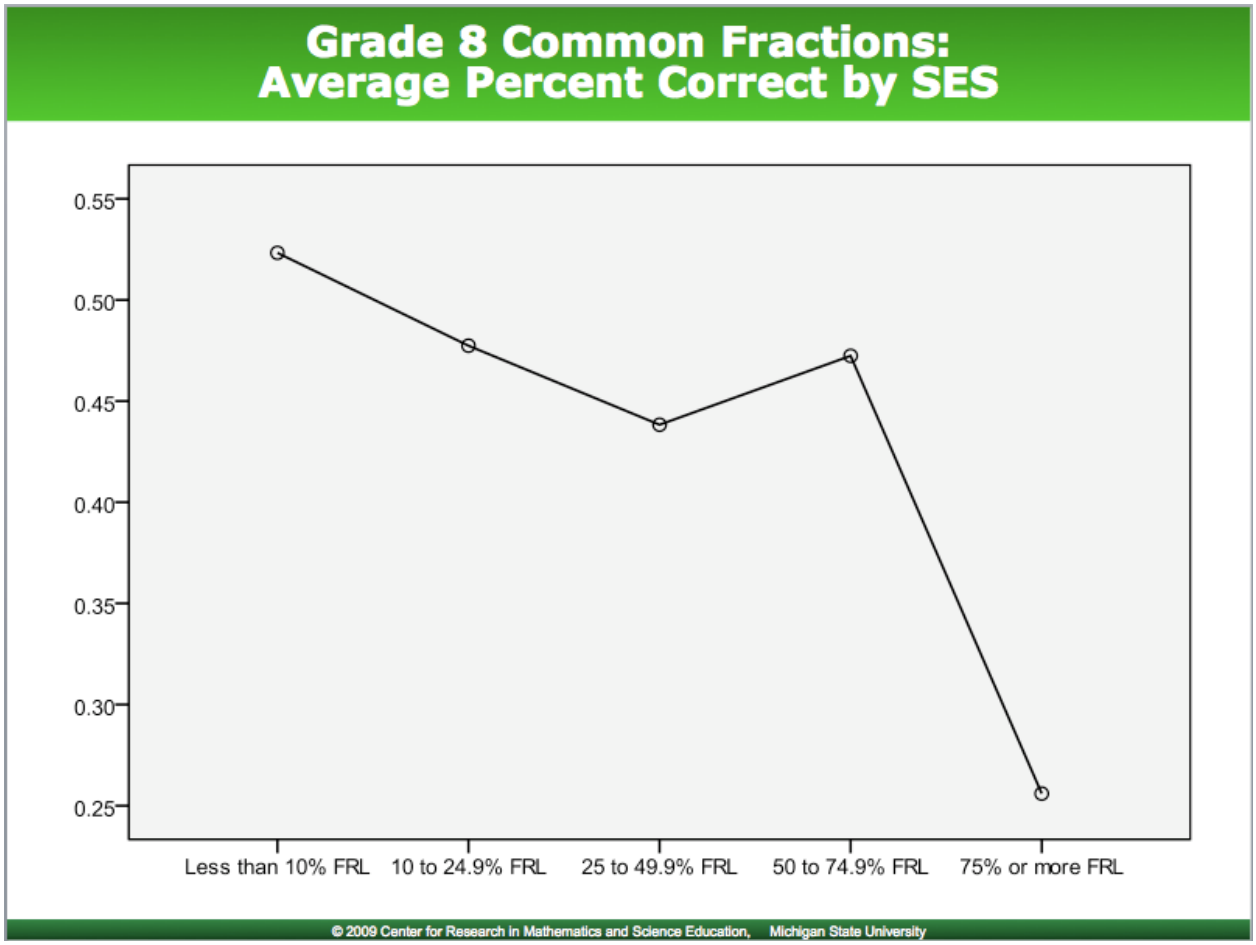


Figure 16

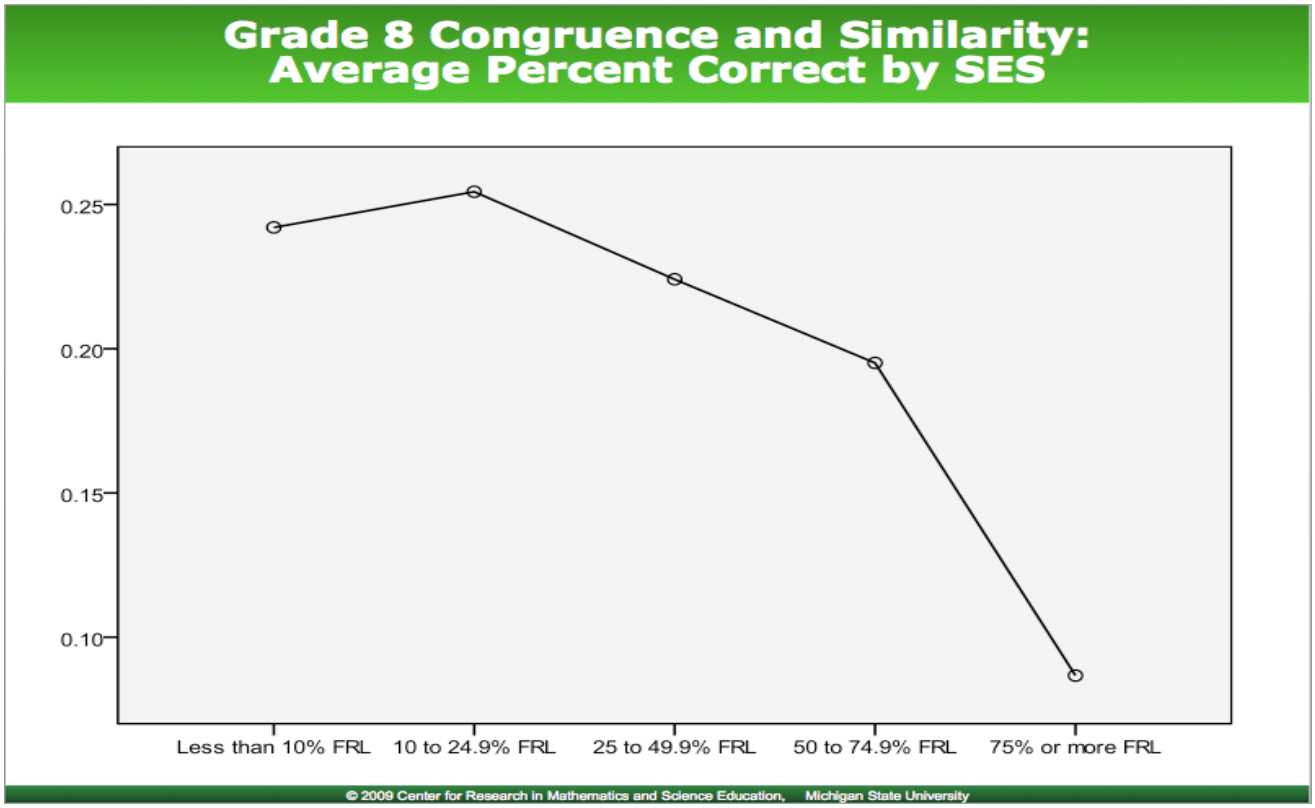


Figure 17

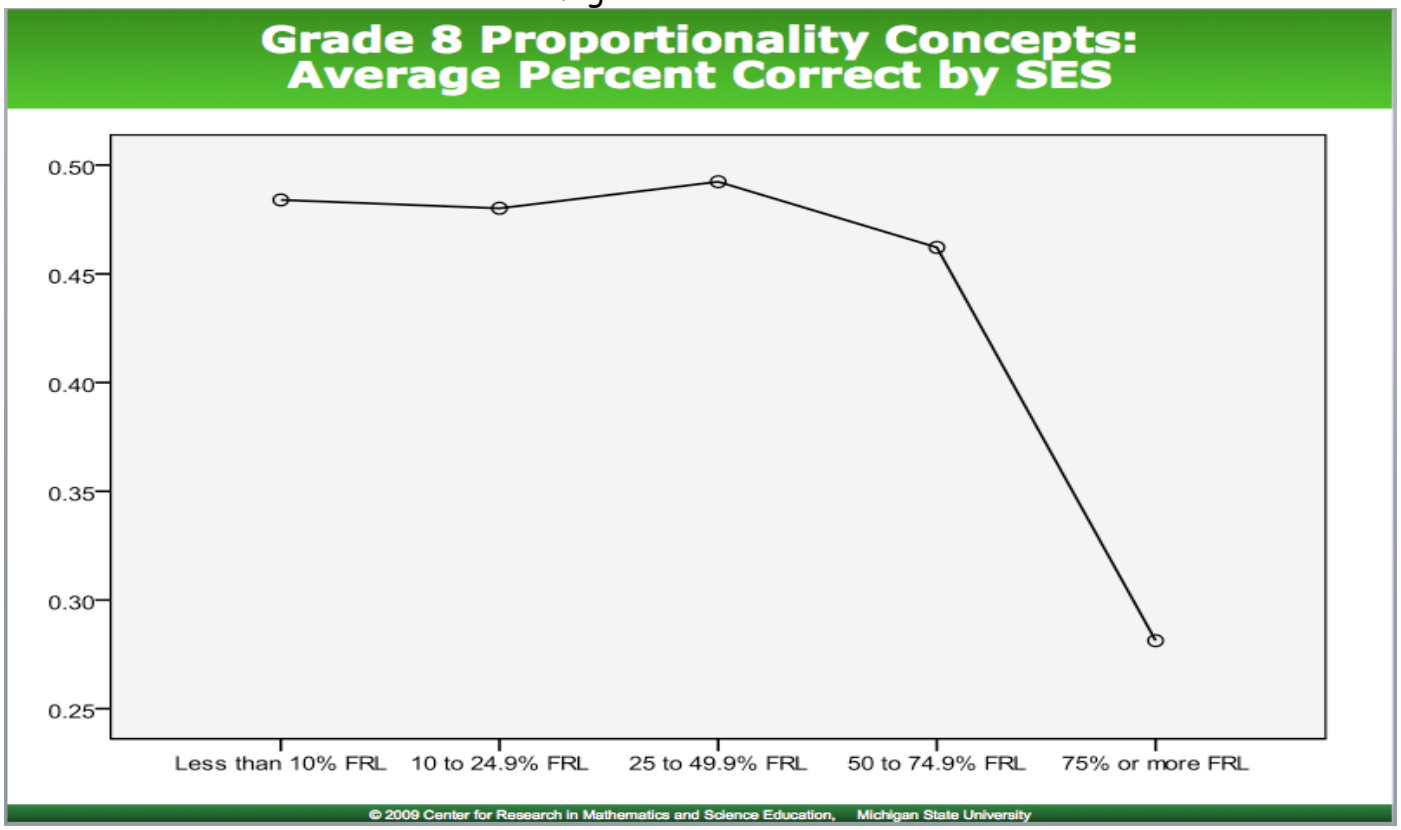


Figure 18

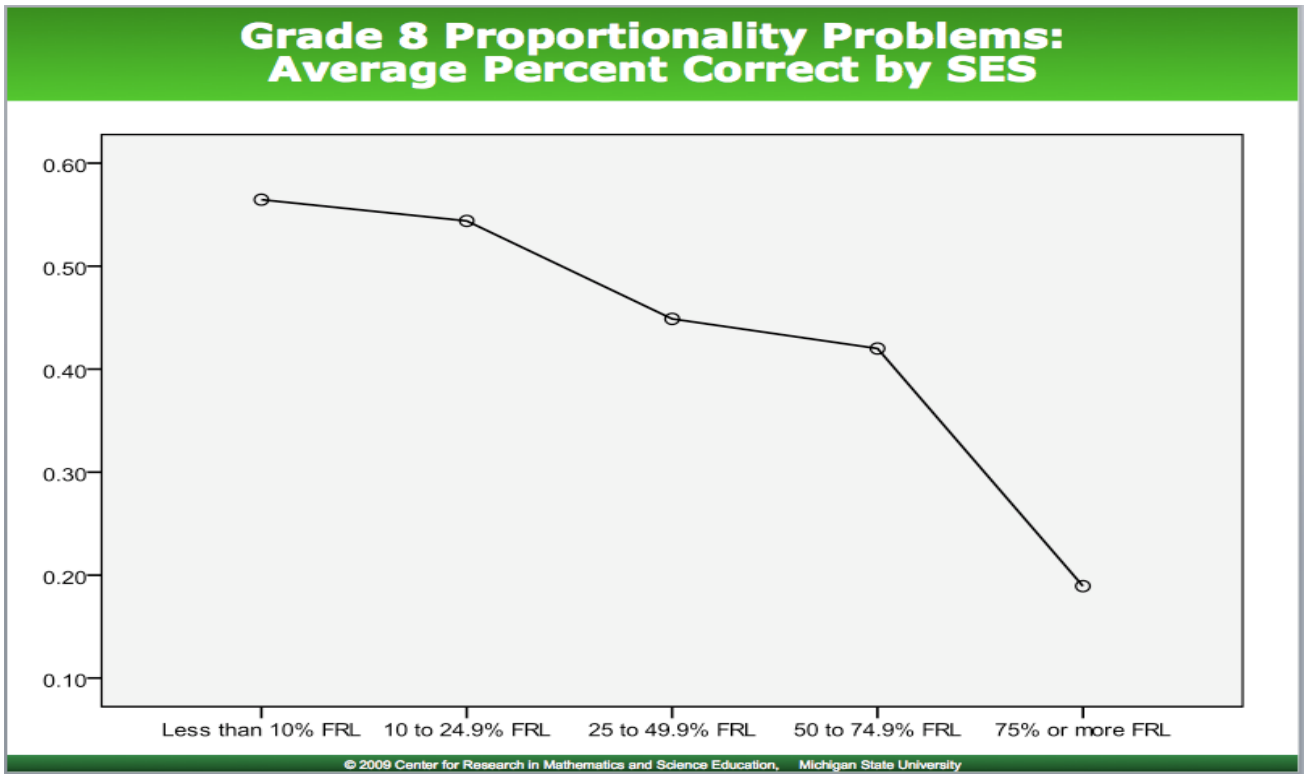


Figure 19

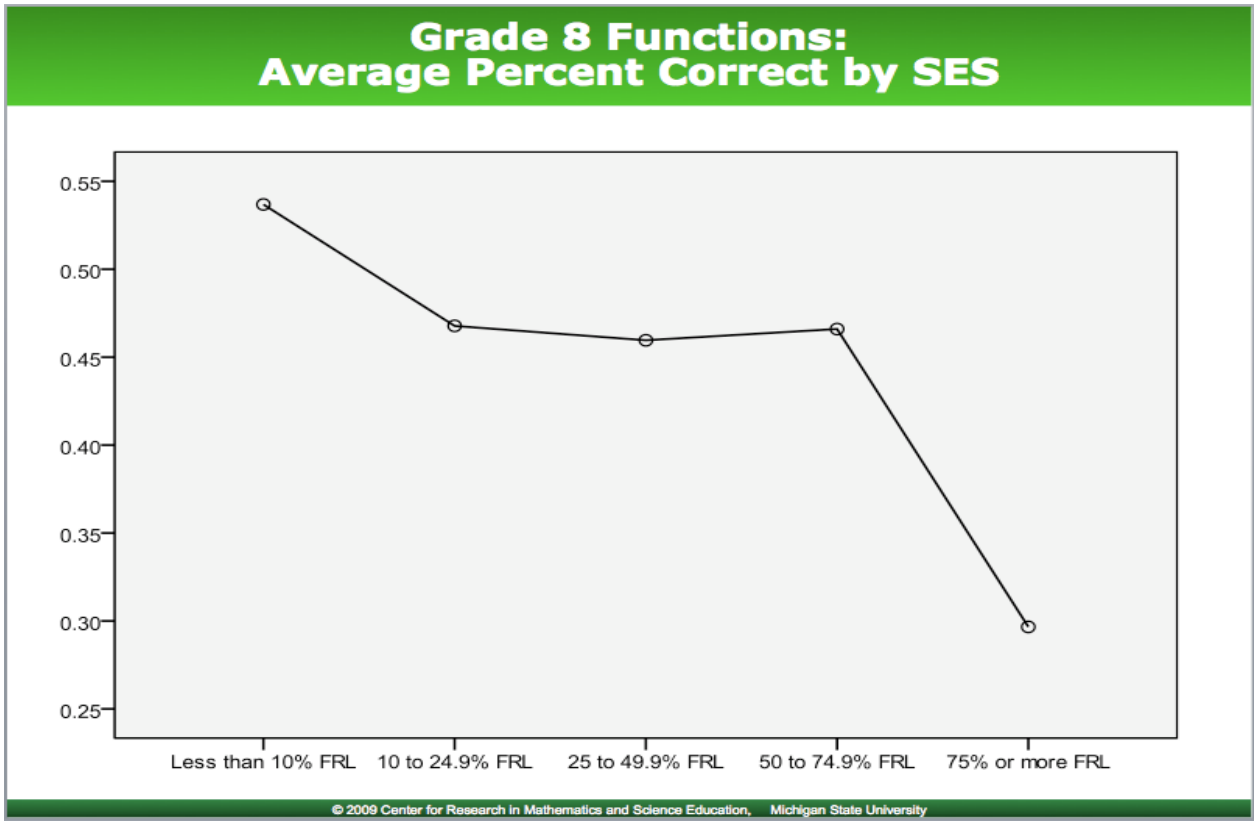


Figure 20

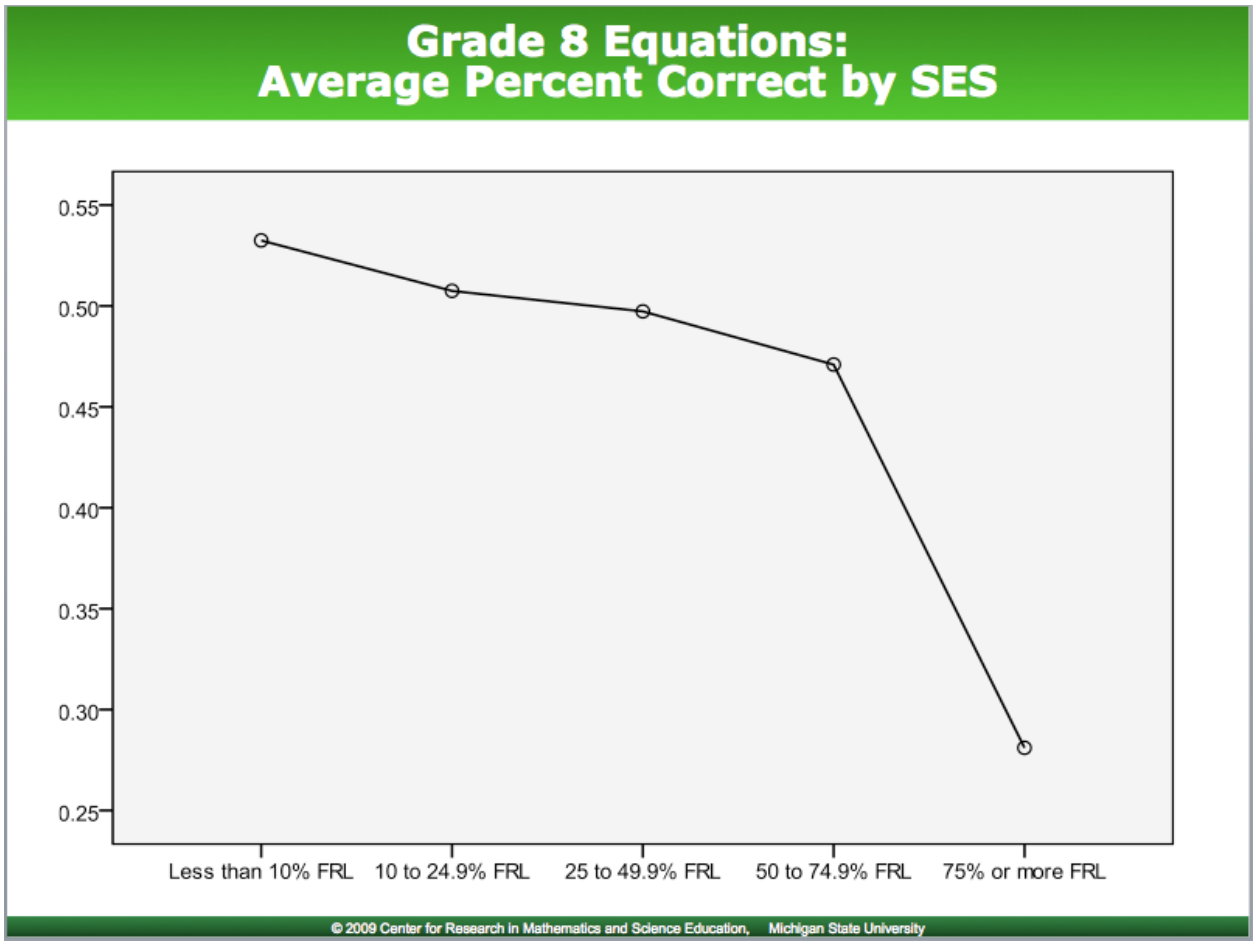


Figure 21

Looking at total time in mathematics across SES groups at grade 8, we see a direct relationship between the percent of students in poverty and time spent on mathematics. That is, the lower the proportion of low SES students in a school, the less time they spend on mathematics.

Students in schools with less than 10% FRL spend about 50 minutes per day in mathematics, the least amount of time for any group. Students in other schools vary between an average of 50 and 60 minutes, with the most time occurring at schools with between 50 and 75% FRL. (Figure 22)

There are also discrepancies in teacher emphasis at Grade 8. Looking at the key strands of Algebra, Geometry and Number, we find that students in the highest SES schools spend about 4 weeks more per year in Algebra, 2 weeks more on Geometry, and 6 weeks less on Number. (Figure 23, 24)

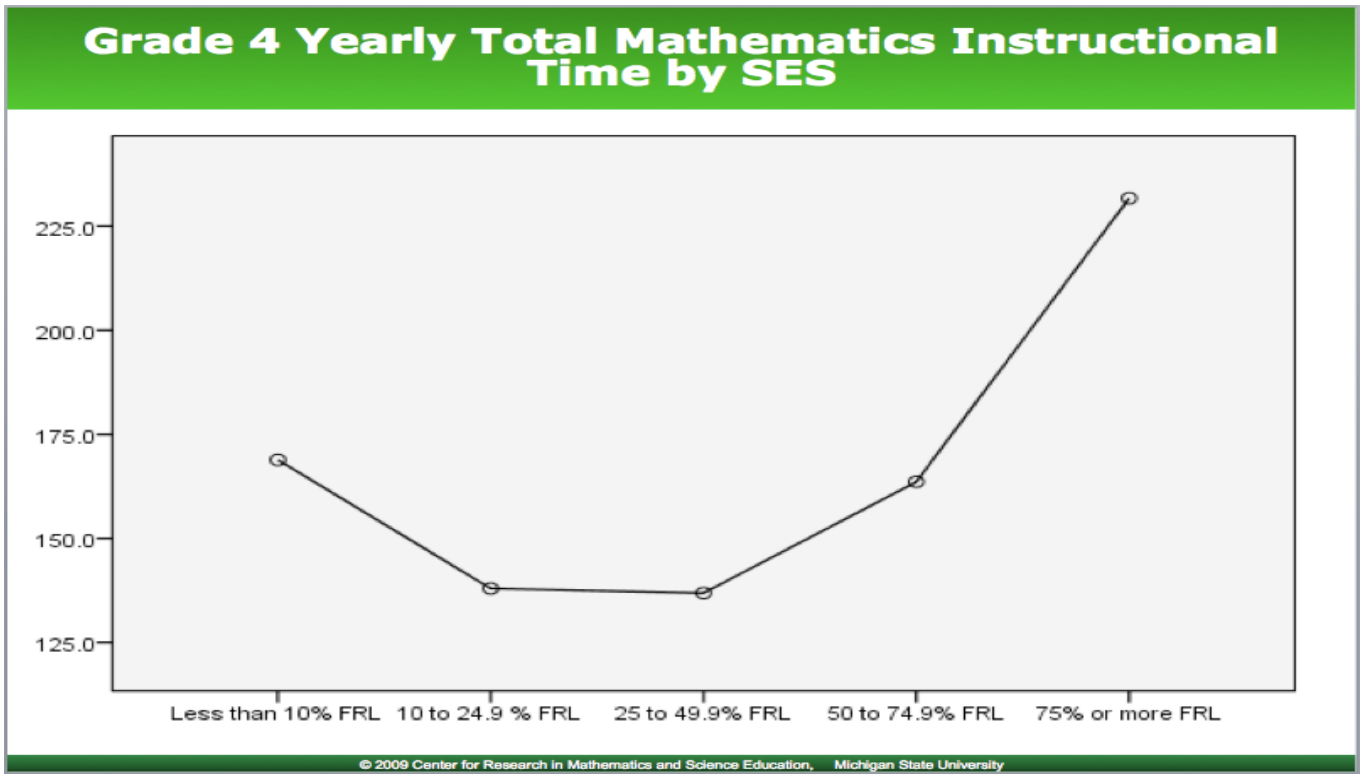


Figure 22

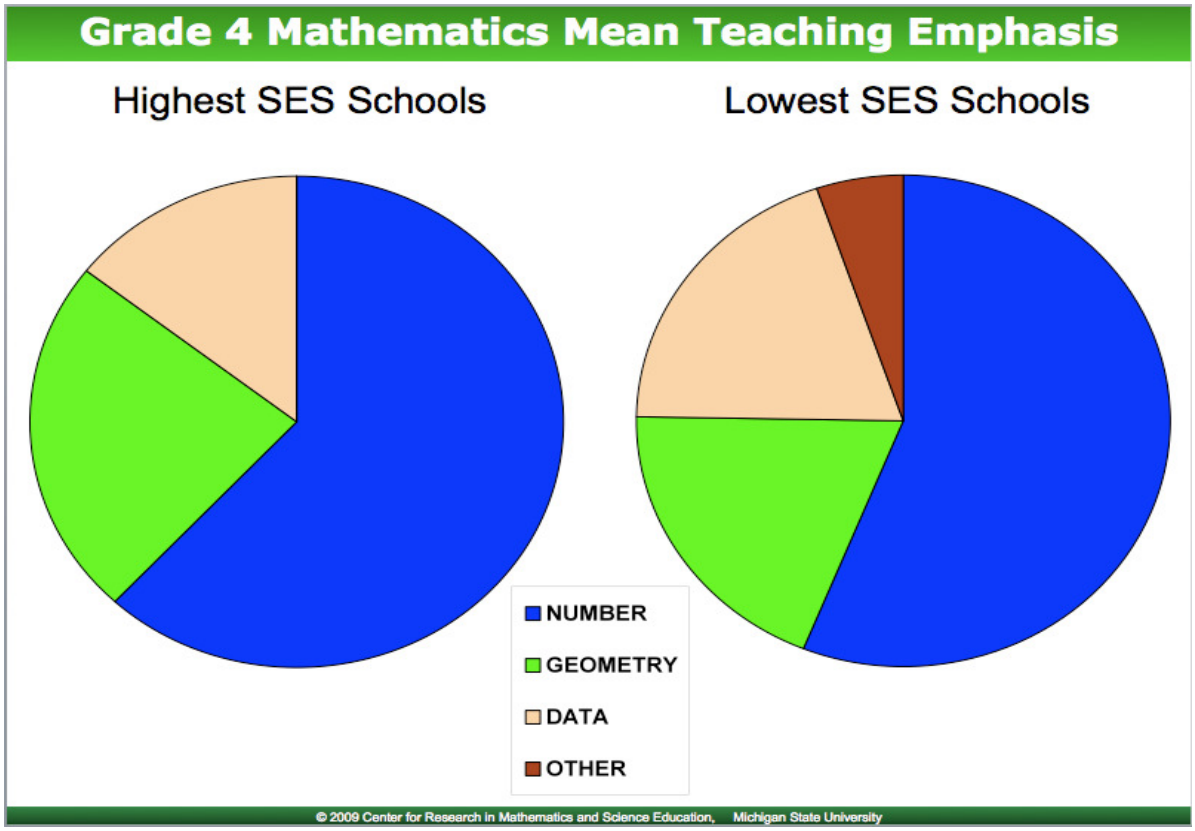


Figure 23

## Mean Percent of Grade 4 Mathematics Teaching Time

| *Topic* | *Highest SES* | *Lowest SES* | *Difference* |
|---|---|---|---|
| Number | 62 | 56 | > 2 Weeks |
| Geometry | 24 | 19 | ~ 2 Weeks |
| Other | 0 | 5 | ~ 2 Weeks |

Figure 24

### NATIONAL ASSESSMENT OF EDUCATIONAL PROGRESS (NAEP) AND TIMSS

Minnesota students continue to perform well on NAEP compared to students in most other states, scoring in the top tier of states for both 4th and 8th grades. For the 2009 NAEP administration for mathematics, at grade 4, about 42% of Minnesota students are proficient, and about 11% are advanced.

At grade 8, about 37% are proficient while about 13% are advanced. On NAEP, as on TIMSS 2007, Massachusetts's students outperform Minnesota students at both grades 4 and 8. (Figures 25, 26)

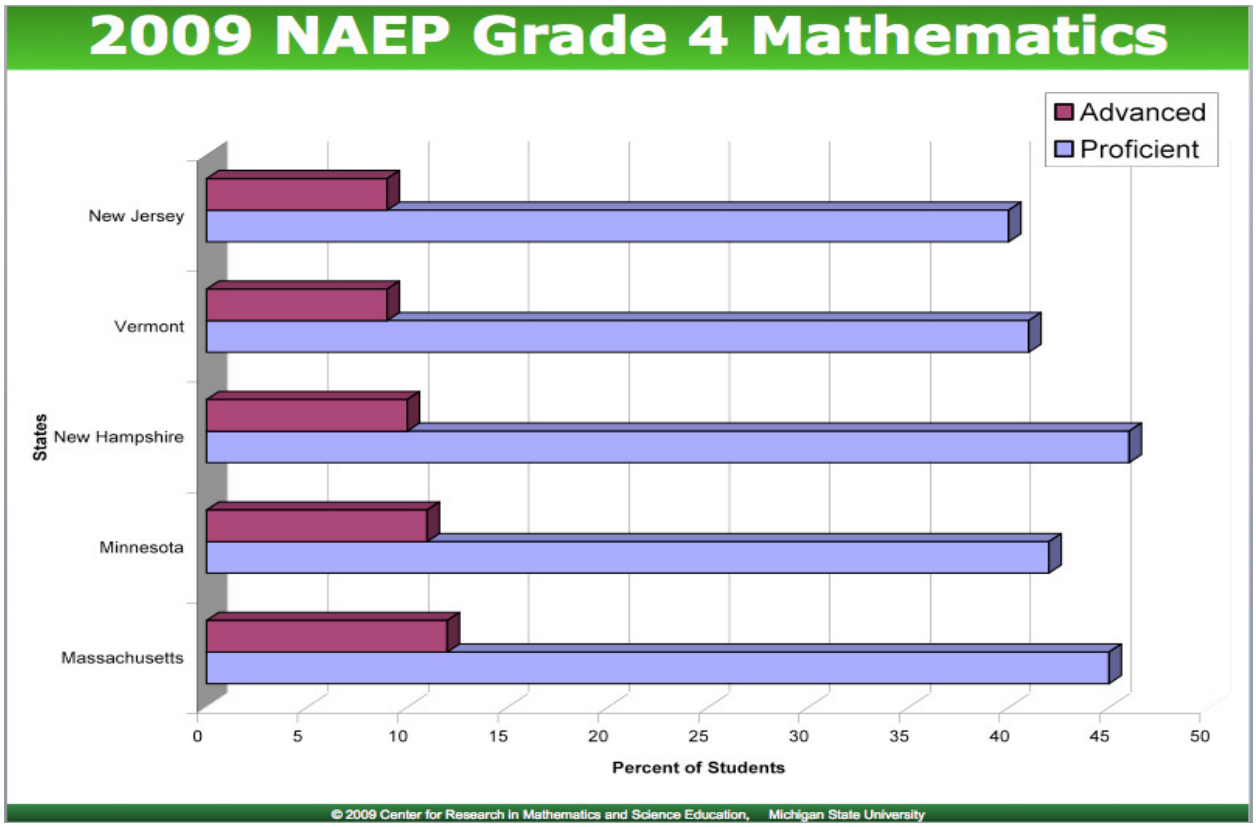


Figure 25

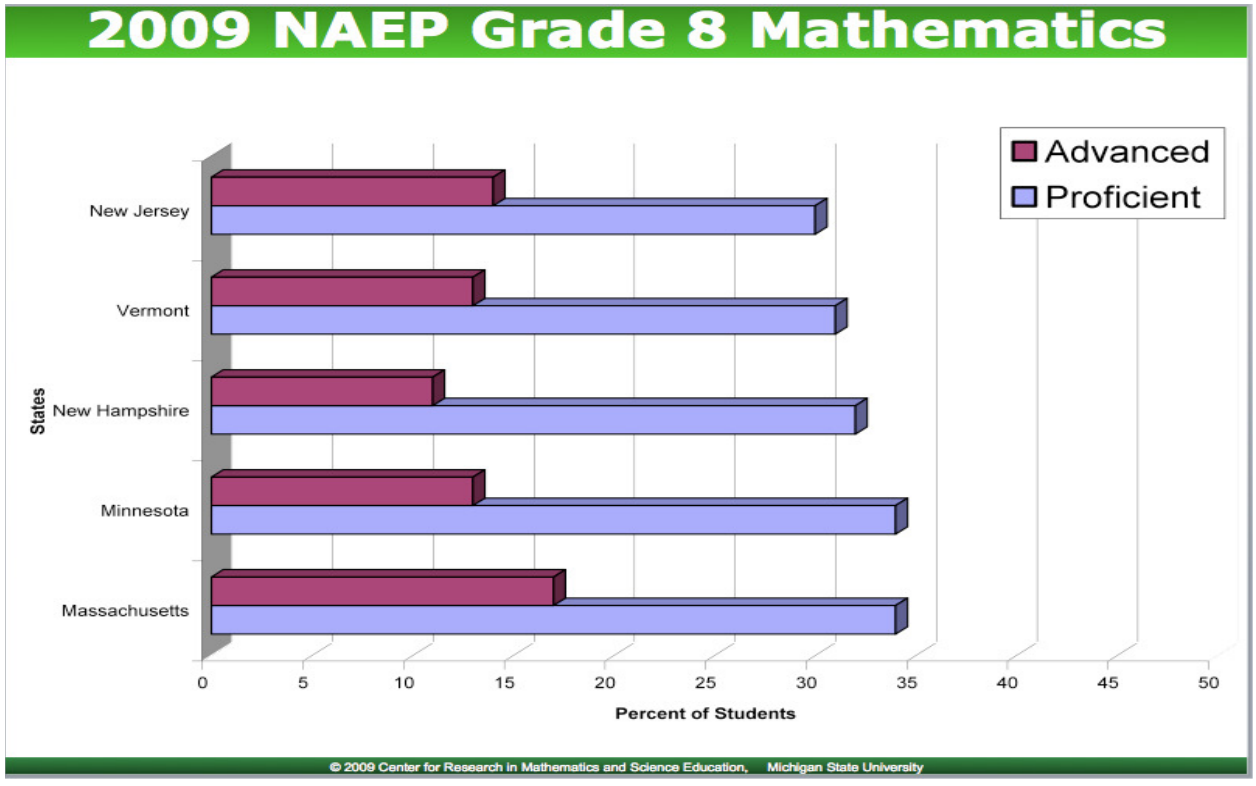


Figure 26

## CONTENT - SUB STRANDS

TIMSS test items were coded into broad categories of mathematics topics. For 4th grade there were 14 categories for mathematics and for 8th grade there were 21 categories the same categories were used in the 1995 analysis.

Student performance for Minnesota and the other countries/benchmarking participants was calculated for each of the categories and statistical tests were conducted to determine Minnesota students' performance relative to the students in other participating countries. The countries included in the comparisons are ones that participated in both 1995 and 2007.

Displays were constructed for categories that contained four or more items. Student performance is represented in terms of percentage of items correct in each category. At grade 4, Minnesota students only scored significantly lower than students in three countries-Hong Kong, Singapore and Japan. Minnesota students scored significantly lower than students in:

- Hong Kong on all twelve broad mathematics categories displayed.
- Singapore on ten broad mathematics categories.
- Japan on four broad mathematics categories

Minnesota students scored significantly higher than the US students in six broad categories of mathematics-Common and Decimal Fractions; Measurement Units; Perimeter, Area and Volume; Geometry: Positions and Shapes; and Symmetry, Congruence and Similarity. Although Minnesota students scored higher than the US students in the other six broad categories, the differences were not statistically significant. (Figure 27 - Display 1)

At grade 8 Minnesota students scored significantly lower than students in seven countries or benchmark participants-Hong Kong, Singapore, Rep. of Korea, Japan, England, the Russian Federation and Quebec. Minnesota students scored significantly lower than students in:

- Rep. of Korea on fifteen broad mathematics categories.
- Singapore on fourteen broad mathematics categories.
- Hong Kong on twelve broad mathematics categories.
- Japan on nine broad mathematics categories.

Minnesota students scored significantly higher than the US students in eight broad categories of mathematics-Decimal Fractions and Percents, Relations of Fractions, 2-D and 3-D Geometry, Perimeter, Area and Volume, Data Representation and Uncertainty-Probability.

Although Minnesota students scored higher than the US students in all other broad categories, the differences were not statistically significant. (Figure 28 - Display 3, two parts)

## Display 1: Grade 4 Mathematics Topics

| Meaning of Whole Numbers | |
|---|---|
| HONG KONG SAR | 80 |
| JAPAN | 77 |
| SINGAPORE | 74 |
| NETHERLANDS | 71 |
| MINNESOTA, US | 70 |
| ENGLAND | 69 |
| LATVIA | 68 |
| QUEBEC, CANADA | 67 |
| HUNGARY | 66 |
| UNITED STATES | 66 |
| AUSTRIA | 64 |
| ALBERTA, CANADA | 62 |
| AUSTRALIA | 62 |
| ONTARIO, CANADA | 62 |
| SCOTLAND | 60 |
| CZECH REPUBLIC | 60 |
| ITALY | 59 |
| NEW ZEALAND | 57 |
| SLOVENIA | 56 |
| International Average | 56 |
| NORWAY | 53 |
| IRAN, ISLAMIC REP. OF | 39 |
| KUWAIT | 37 |

| Whole Number Operations | |
|---|---|
| HONG KONG SAR | 75 |
| SINGAPORE | 74 |
| JAPAN | 60 |
| LATVIA | 60 |
| MINNESOTA, US | 56 |
| NETHERLANDS | 55 |
| HUNGARY | 53 |
| ENGLAND | 52 |
| UNITED STATES | 51 |
| AUSTRIA | 48 |
| QUEBEC, CANADA | 48 |
| CZECH REPUBLIC | 47 |
| SLOVENIA | 47 |
| ITALY | 47 |
| International Average | 44 |
| AUSTRALIA | 43 |
| ONTARIO, CANADA | 42 |
| ALBERTA, CANADA | 42 |
| SCOTLAND | 40 |
| NEW ZEALAND | 38 |
| NORWAY | 36 |
| IRAN, ISLAMIC REP. OF | 27 |
| KUWAIT | 17 |

| Common Fractions | |
|---|---|
| SINGAPORE | 76 |
| HONG KONG SAR | 75 |
| MINNESOTA, US | 68 |
| ENGLAND | 62 |
| NETHERLANDS | 60 |
| JAPAN | 60 |
| UNITED STATES | 59 |
| QUEBEC, CANADA | 57 |
| AUSTRALIA | 55 |
| LATVIA | 52 |
| NEW ZEALAND | 50 |
| ONTARIO, CANADA | 50 |
| ALBERTA, CANADA | 49 |
| SCOTLAND | 49 |
| ITALY | 47 |
| HUNGARY | 44 |
| International Average | 42 |
| SLOVENIA | 41 |
| AUSTRIA | 39 |
| NORWAY | 38 |
| CZECH REPUBLIC | 27 |
| IRAN, ISLAMIC REP. OF | 24 |
| KUWAIT | 19 |

| Decimal Fractions | |
|---|---|
| SINGAPORE | 83 |
| HONG KONG SAR | 73 |
| MINNESOTA, US | 65 |
| ENGLAND | 57 |
| UNITED STATES | 57 |
| JAPAN | 56 |
| NETHERLANDS | 53 |
| ITALY | 50 |
| LATVIA | 49 |
| QUEBEC, CANADA | 44 |
| AUSTRALIA | 43 |
| NEW ZEALAND | 40 |
| International Average | 38 |
| ONTARIO, CANADA | 35 |
| ALBERTA, CANADA | 34 |
| AUSTRIA | 34 |
| HUNGARY | 34 |
| SCOTLAND | 33 |
| NORWAY | 29 |
| SLOVENIA | 25 |
| CZECH REPUBLIC | 20 |
| IRAN, ISLAMIC REP. OF | 16 |
| KUWAIT | 13 |

| Measurement Units | |
|---|---|
| HONG KONG SAR | 74 |
| SINGAPORE | 69 |
| JAPAN | 68 |
| NETHERLANDS | 67 |
| LATVIA | 66 |
| ENGLAND | 62 |
| MINNESOTA, US | 59 |
| CZECH REPUBLIC | 57 |
| HUNGARY | 57 |
| AUSTRIA | 57 |
| AUSTRALIA | 54 |
| SLOVENIA | 51 |
| SCOTLAND | 50 |
| UNITED STATES | 49 |
| NEW ZEALAND | 49 |
| ALBERTA, CANADA | 49 |
| QUEBEC, CANADA | 49 |
| ONTARIO, CANADA | 49 |
| International Average | 46 |
| ITALY | 45 |
| NORWAY | 44 |
| IRAN, ISLAMIC REP. OF | 23 |
| KUWAIT | 14 |

| Perimeter, Area & Volume | |
|---|---|
| HONG KONG SAR | 78 |
| SINGAPORE | 73 |
| JAPAN | 65 |
| MINNESOTA, US | 63 |
| LATVIA | 62 |
| NETHERLANDS | 61 |
| AUSTRALIA | 55 |
| ENGLAND | 54 |
| AUSTRIA | 53 |
| QUEBEC, CANADA | 53 |
| UNITED STATES | 52 |
| ONTARIO, CANADA | 50 |
| HUNGARY | 48 |
| ALBERTA, CANADA | 47 |
| International Average | 46 |
| ITALY | 44 |
| CZECH REPUBLIC | 43 |
| SLOVENIA | 42 |
| NORWAY | 40 |
| SCOTLAND | 40 |
| NEW ZEALAND | 38 |
| IRAN, ISLAMIC REP. OF | 30 |
| KUWAIT | 21 |

| Geometry: Position & Shapes | |
|---|---|
| HONG KONG SAR | 78 |
| SINGAPORE | 71 |
| JAPAN | 70 |
| MINNESOTA, US | 67 |
| ENGLAND | 64 |
| AUSTRALIA | 61 |
| LATVIA | 61 |
| QUEBEC, CANADA | 61 |
| ONTARIO, CANADA | 60 |
| UNITED STATES | 59 |
| NETHERLANDS | 57 |
| SLOVENIA | 57 |
| AUSTRIA | 56 |
| HUNGARY | 55 |
| ALBERTA, CANADA | 55 |
| ITALY | 54 |
| SCOTLAND | 52 |
| NEW ZEALAND | 51 |
| CZECH REPUBLIC | 50 |
| NORWAY | 49 |
| International Average | 49 |
| IRAN, ISLAMIC REP. OF | 37 |
| KUWAIT | 20 |

| Symmetry, Congruence & Similarity | |
|---|---|
| HONG KONG SAR | 83 |
| SINGAPORE | 81 |
| ENGLAND | 73 |
| MINNESOTA, US | 72 |
| ONTARIO, CANADA | 67 |
| JAPAN | 65 |
| AUSTRALIA | 65 |
| UNITED STATES | 64 |
| SLOVENIA | 62 |
| SCOTLAND | 61 |
| ITALY | 60 |
| NEW ZEALAND | 59 |
| HUNGARY | 58 |
| NETHERLANDS | 57 |
| ALBERTA, CANADA | 57 |
| LATVIA | 56 |
| QUEBEC, CANADA | 56 |
| AUSTRIA | 52 |
| International Average | 49 |
| CZECH REPUBLIC | 48 |
| NORWAY | 47 |
| IRAN, ISLAMIC REP. OF | 37 |
| KUWAIT | 18 |

| Proportionality | |
|---|---|
| HONG KONG SAR | 75 |
| SINGAPORE | 69 |
| JAPAN | 64 |
| LATVIA | 59 |
| NETHERLANDS | 57 |
| MINNESOTA, US | 56 |
| ENGLAND | 55 |
| ONTARIO, CANADA | 54 |
| UNITED STATES | 52 |
| AUSTRALIA | 52 |
| ALBERTA, CANADA | 48 |
| QUEBEC, CANADA | 47 |
| HUNGARY | 46 |
| SLOVENIA | 45 |
| ITALY | 44 |
| NEW ZEALAND | 44 |
| SCOTLAND | 42 |
| International Average | 42 |
| CZECH REPUBLIC | 40 |
| AUSTRIA | 39 |
| NORWAY | 37 |
| IRAN, ISLAMIC REP. OF | 27 |
| KUWAIT | 14 |

| Patterns, Relations, & Functions | |
|---|---|
| SINGAPORE | 71 |
| HONG KONG SAR | 71 |
| JAPAN | 65 |
| MINNESOTA, US | 62 |
| ENGLAND | 59 |
| LATVIA | 59 |
| UNITED STATES | 57 |
| NETHERLANDS | 56 |
| HUNGARY | 55 |
| ONTARIO, CANADA | 53 |
| ITALY | 52 |
| AUSTRALIA | 51 |
| ALBERTA, CANADA | 51 |
| QUEBEC, CANADA | 51 |
| NEW ZEALAND | 48 |
| AUSTRIA | 48 |
| SLOVENIA | 47 |
| SCOTLAND | 46 |
| CZECH REPUBLIC | 46 |
| International Average | 46 |
| NORWAY | 42 |
| IRAN, ISLAMIC REP. OF | 26 |
| KUWAIT | 17 |

| Equations & Formulas | |
|---|---|
| HONG KONG SAR | 73 |
| SINGAPORE | 69 |
| JAPAN | 68 |
| MINNESOTA, US | 62 |
| HUNGARY | 59 |
| UNITED STATES | 58 |
| LATVIA | 57 |
| ENGLAND | 56 |
| ITALY | 53 |
| NETHERLANDS | 51 |
| AUSTRALIA | 48 |
| QUEBEC, CANADA | 47 |
| ONTARIO, CANADA | 46 |
| ALBERTA, CANADA | 46 |
| CZECH REPUBLIC | 46 |
| International Average | 46 |
| SLOVENIA | 45 |
| AUSTRIA | 45 |
| SCOTLAND | 44 |
| NEW ZEALAND | 44 |
| NORWAY | 39 |
| IRAN, ISLAMIC REP. OF | 32 |
| KUWAIT | 21 |

| Data Representation, Probability & Statistics | |
|---|---|
| HONG KONG SAR | 85 |
| SINGAPORE | 83 |
| JAPAN | 82 |
| MINNESOTA, US | 77 |
| ENGLAND | 75 |
| UNITED STATES | 74 |
| ONTARIO, CANADA | 74 |
| NETHERLANDS | 73 |
| ALBERTA, CANADA | 72 |
| LATVIA | 71 |
| AUSTRALIA | 70 |
| QUEBEC, CANADA | 69 |
| SCOTLAND | 66 |
| SLOVENIA | 65 |
| NEW ZEALAND | 65 |
| AUSTRIA | 63 |
| ITALY | 62 |
| HUNGARY | 61 |
| CZECH REPUBLIC | 58 |
| NORWAY | 57 |
| International Average | 56 |
| IRAN, ISLAMIC REP. OF | 34 |
| KUWAIT | 22 |

Significantly higher than MN

Not Statistically Different from MN

Significantly lower than MN

## Display 3: Grade 8 Mathematics Topics

| Whole Numbers | |
|---|---|
| SINGAPORE | 72 |
| KOREA, REP. OF | 71 |
| HONG KONG SAR | 68 |
| JAPAN | 66 |
| **MINNESOTA, US** | **88** |
| ONTARIO, CANADA | 62 |
| QUEBEC, CANADA | 60 |
| **UNITED STATES** | **58** |
| ENGLAND | 58 |
| CZECH REPUBLIC | 57 |
| HUNGARY | 57 |
| AUSTRALIA | 56 |
| SLOVENIA | 55 |
| SWEDEN | 55 |
| RUSSIAN FEDERATION | 54 |
| SCOTLAND | 53 |
| NORWAY | 51 |
| LITHUANIA | 51 |
| ITALY | 50 |
| THAILAND | 43 |
| ISRAEL | 43 |
| BULGARIA | 42 |
| CYPRUS | 42 |
| International Average | 41 |
| ROMANIA | 38 |
| IRAN, ISLAMIC REP. OF | 29 |
| COLOMBIA | 27 |
| KUWAIT | 20 |

| Common Fractions | |
|---|---|
| SINGAPORE | 72 |
| KOREA, REP. OF | 68 |
| HONG KONG SAR | 64 |
| JAPAN | 60 |
| QUEBEC, CANADA | 49 |
| RUSSIAN FEDERATION | 46 |
| HUNGARY | 46 |
| ONTARIO, CANADA | 45 |
| **MINNESOTA, US** | **46** |
| CZECH REPUBLIC | 44 |
| ITALY | 43 |
| SWEDEN | 42 |
| ENGLAND | 42 |
| LITHUANIA | 42 |
| SLOVENIA | 40 |
| AUSTRALIA | 40 |
| **UNITED STATES** | **40** |
| CYPRUS | 37 |
| ISRAEL | 37 |
| SCOTLAND | 36 |
| NORWAY | 36 |
| International Average | 35 |
| ROMANIA | 35 |
| BULGARIA | 34 |
| THAILAND | 31 |
| IRAN, ISLAMIC REP. OF | 27 |
| COLOMBIA | 19 |
| KUWAIT | 19 |

| Decimal Fractions & Percents | |
|---|---|
| SINGAPORE | 78 |
| KOREA, REP. OF | 72 |
| HONG KONG SAR | 71 |
| JAPAN | 69 |
| QUEBEC, CANADA | 69 |
| **MINNESOTA, US** | **67** |
| SWEDEN | 65 |
| ONTARIO, CANADA | 64 |
| ENGLAND | 62 |
| LITHUANIA | 62 |
| HUNGARY | 62 |
| CZECH REPUBLIC | 62 |
| **UNITED STATES** | **60** |
| AUSTRALIA | 58 |
| RUSSIAN FEDERATION | 57 |
| SCOTLAND | 57 |
| NORWAY | 57 |
| SLOVENIA | 57 |
| ITALY | 52 |
| ISRAEL | 48 |
| BULGARIA | 48 |
| CYPRUS | 47 |
| International Average | 46 |
| ROMANIA | 45 |
| THAILAND | 40 |
| IRAN, ISLAMIC REP. OF | 30 |
| COLOMBIA | 24 |
| KUWAIT | 21 |

| Relations of Fractions | |
|---|---|
| KOREA, REP. OF | 79 |
| SINGAPORE | 79 |
| HONG KONG SAR | 74 |
| JAPAN | 67 |
| **MINNESOTA, US** | **64** |
| QUEBEC, CANADA | 59 |
| ONTARIO, CANADA | 57 |
| **UNITED STATES** | **56** |
| RUSSIAN FEDERATION | 55 |
| HUNGARY | 54 |
| SWEDEN | 53 |
| LITHUANIA | 52 |
| CZECH REPUBLIC | 51 |
| AUSTRALIA | 50 |
| ENGLAND | 48 |
| SLOVENIA | 48 |
| NORWAY | 46 |
| ISRAEL | 46 |
| BULGARIA | 46 |
| International Average | 44 |
| SCOTLAND | 43 |
| ITALY | 43 |
| CYPRUS | 42 |
| ROMANIA | 42 |
| THAILAND | 36 |
| IRAN, ISLAMIC REP. OF | 31 |
| KUWAIT | 25 |
| COLOMBIA | 19 |

| Estimating Quantity & Size | |
|---|---|
| KOREA, REP. OF | 67 |
| **MINNESOTA, US** | **66** |
| JAPAN | 64 |
| SINGAPORE | 63 |
| **UNITED STATES** | **60** |
| HUNGARY | 60 |
| SLOVENIA | 60 |
| ENGLAND | 59 |
| ONTARIO, CANADA | 59 |
| HONG KONG SAR | 58 |
| AUSTRALIA | 57 |
| QUEBEC, CANADA | 57 |
| SWEDEN | 54 |
| SCOTLAND | 54 |
| CZECH REPUBLIC | 54 |
| ITALY | 51 |
| LITHUANIA | 51 |
| RUSSIAN FEDERATION | 51 |
| NORWAY | 51 |
| CYPRUS | 41 |
| International Average | 40 |
| THAILAND | 40 |
| BULGARIA | 40 |
| ROMANIA | 40 |
| ISRAEL | 39 |
| COLOMBIA | 35 |
| KUWAIT | 25 |
| IRAN, ISLAMIC REP. OF | 24 |

| Rounding | |
|---|---|
| SINGAPORE | 63 |
| HONG KONG SAR | 62 |
| KOREA, REP. OF | 55 |
| **MINNESOTA, US** | **50** |
| JAPAN | 49 |
| **UNITED STATES** | **48** |
| QUEBEC, CANADA | 42 |
| ONTARIO, CANADA | 42 |
| HUNGARY | 40 |
| SWEDEN | 40 |
| ENGLAND | 39 |
| LITHUANIA | 38 |
| CZECH REPUBLIC | 38 |
| RUSSIAN FEDERATION | 37 |
| NORWAY | 35 |
| AUSTRALIA | 35 |
| SLOVENIA | 34 |
| BULGARIA | 33 |
| SCOTLAND | 31 |
| International Average | 29 |
| ITALY | 28 |
| ISRAEL | 28 |
| THAILAND | 28 |
| ROMANIA | 27 |
| CYPRUS | 27 |
| IRAN, ISLAMIC REP. OF | 15 |
| COLOMBIA | 9 |
| KUWAIT | 9 |

Significantly higher than MN
Not Statistically Different from MN
Significantly lower than MN

| Measurement Units | |
|---|---|
| SINGAPORE | 73 |
| KOREA, REP. OF | 69 |
| HONG KONG SAR | 67 |
| JAPAN | 67 |
| QUEBEC, CANADA | 58 |
| ENGLAND | 57 |
| **MINNESOTA, US** | **67** |
| SLOVENIA | 53 |
| CZECH REPUBLIC | 53 |
| HUNGARY | 53 |
| SWEDEN | 53 |
| SCOTLAND | 52 |
| UNITED STATES | 51 |
| ONTARIO, CANADA | 51 |
| AUSTRALIA | 49 |
| RUSSIAN FEDERATION | 49 |
| LITHUANIA | 48 |
| NORWAY | 45 |
| CYPRUS | 40 |
| ITALY | 40 |
| THAILAND | 40 |
| International Average | 38 |
| ISRAEL | 38 |
| BULGARIA | 37 |
| ROMANIA | 34 |
| COLOMBIA | 25 |
| IRAN, ISLAMIC REP. OF | 24 |
| KUWAIT | 22 |

| Perimeter, Area & Volume | |
|---|---|
| SINGAPORE | 70 |
| HONG KONG SAR | 66 |
| KOREA, REP. OF | 64 |
| JAPAN | 60 |
| QUEBEC, CANADA | 48 |
| **MINNESOTA, US** | **48** |
| LITHUANIA | 47 |
| ONTARIO, CANADA | 46 |
| ENGLAND | 45 |
| HUNGARY | 44 |
| RUSSIAN FEDERATION | 44 |
| ITALY | 43 |
| ROMANIA | 42 |
| CZECH REPUBLIC | 41 |
| UNITED STATES | 40 |
| SLOVENIA | 39 |
| AUSTRALIA | 38 |
| SWEDEN | 38 |
| CYPRUS | 37 |
| BULGARIA | 37 |
| SCOTLAND | 35 |
| International Average | 35 |
| NORWAY | 33 |
| ISRAEL | 32 |
| THAILAND | 29 |
| IRAN, ISLAMIC REP. OF | 25 |
| KUWAIT | 19 |
| COLOMBIA | 18 |

| 2-D Geometry | |
|---|---|
| KOREA, REP. OF | 74 |
| JAPAN | 72 |
| HONG KONG SAR | 67 |
| SINGAPORE | 66 |
| QUEBEC, CANADA | 52 |
| SLOVENIA | 49 |
| ENGLAND | 48 |
| HUNGARY | 48 |
| RUSSIAN FEDERATION | 48 |
| **MINNESOTA, US** | **46** |
| CZECH REPUBLIC | 45 |
| ONTARIO, CANADA | 44 |
| LITHUANIA | 43 |
| BULGARIA | 43 |
| SCOTLAND | 41 |
| AUSTRALIA | 40 |
| UNITED STATES | 39 |
| SWEDEN | 39 |
| ITALY | 39 |
| ISRAEL | 38 |
| ROMANIA | 37 |
| THAILAND | 37 |
| CYPRUS | 37 |
| NORWAY | 36 |
| IRAN, ISLAMIC REP. OF | 32 |
| KUWAIT | 27 |
| COLOMBIA | 20 |
| International Average | 39 |

| Polygons & Circles | |
|---|---|
| KOREA, REP. OF | 68 |
| SINGAPORE | 68 |
| HONG KONG SAR | 66 |
| JAPAN | 65 |
| RUSSIAN FEDERATION | 48 |
| QUEBEC, CANADA | 48 |
| HUNGARY | 47 |
| ENGLAND | 45 |
| LITHUANIA | 44 |
| ITALY | 43 |
| CZECH REPUBLIC | 42 |
| SLOVENIA | 42 |
| ONTARIO, CANADA | 42 |
| **MINNESOTA, US** | **42** |
| ROMANIA | 41 |
| BULGARIA | 40 |
| SWEDEN | 40 |
| CYPRUS | 39 |
| International Average | 38 |
| SCOTLAND | 37 |
| ISRAEL | 37 |
| AUSTRALIA | 37 |
| UNITED STATES | 37 |
| THAILAND | 36 |
| NORWAY | 35 |
| IRAN, ISLAMIC REP. OF | 30 |
| KUWAIT | 23 |
| COLOMBIA | 20 |

| 3-D Geometry & Transformations | |
|---|---|
| JAPAN | 73 |
| KOREA, REP. OF | 72 |
| SINGAPORE | 71 |
| HONG KONG SAR | 71 |
| ENGLAND | 65 |
| ONTARIO, CANADA | 63 |
| QUEBEC, CANADA | 61 |
| HUNGARY | 60 |
| LITHUANIA | 60 |
| AUSTRALIA | 59 |
| **MINNESOTA, US** | **58** |
| SCOTLAND | 58 |
| CZECH REPUBLIC | 55 |
| SLOVENIA | 55 |
| UNITED STATES | 53 |
| RUSSIAN FEDERATION | 53 |
| ITALY | 49 |
| SWEDEN | 47 |
| NORWAY | 46 |
| BULGARIA | 42 |
| International Average | 42 |
| CYPRUS | 40 |
| ROMANIA | 40 |
| THAILAND | 39 |
| ISRAEL | 35 |
| IRAN, ISLAMIC REP. OF | 33 |
| KUWAIT | 27 |
| COLOMBIA | 26 |

| Proportionality Concepts | |
|---|---|
| SINGAPORE | 80 |
| KOREA, REP. OF | 76 |
| HONG KONG SAR | 65 |
| JAPAN | 62 |
| RUSSIAN FEDERATION | 48 |
| ONTARIO, CANADA | 47 |
| **MINNESOTA, US** | **47** |
| ENGLAND | 46 |
| QUEBEC, CANADA | 46 |
| HUNGARY | 45 |
| CZECH REPUBLIC | 44 |
| UNITED STATES | 44 |
| BULGARIA | 42 |
| AUSTRALIA | 41 |
| SCOTLAND | 40 |
| CYPRUS | 39 |
| LITHUANIA | 38 |
| International Average | 37 |
| THAILAND | 37 |
| ITALY | 36 |
| ROMANIA | 36 |
| SLOVENIA | 33 |
| ISRAEL | 33 |
| NORWAY | 31 |
| IRAN, ISLAMIC REP. OF | 28 |
| KUWAIT | 28 |
| SWEDEN | 25 |
| COLOMBIA | 20 |

## Display 3: Grade 8 Mathematics Topics

| Proportionality Problems | |
|---|---|
| KOREA, REP. OF | 69 |
| SINGAPORE | 69 |
| HONG KONG SAR | 63 |
| JAPAN | 54 |
| QUEBEC, CANADA | 50 |
| ENGLAND | 49 |
| **MINNESOTA, US** | **48** |
| RUSSIAN FEDERATION | 44 |
| ONTARIO, CANADA | 42 |
| HUNGARY | 42 |
| LITHUANIA | 42 |
| SWEDEN | 41 |
| **UNITED STATES** | **41** |
| AUSTRALIA | 41 |
| SLOVENIA | 40 |
| ROMANIA | 39 |
| SCOTLAND | 38 |
| CZECH REPUBLIC | 38 |
| CYPRUS | 38 |
| ISRAEL | 36 |
| BULGARIA | 35 |
| International Average | 34 |
| NORWAY | 32 |
| THAILAND | 30 |
| ITALY | 30 |
| IRAN, ISLAMIC REP. OF | 24 |
| COLOMBIA | 20 |
| KUWAIT | 16 |

| Patterns, Relations, & Functions | |
|---|---|
| KOREA, REP. OF | 66 |
| SINGAPORE | 64 |
| JAPAN | 62 |
| HONG KONG SAR | 57 |
| **MINNESOTA, US** | **48** |
| QUEBEC, CANADA | 46 |
| HUNGARY | 45 |
| ENGLAND | 45 |
| ONTARIO, CANADA | 44 |
| SLOVENIA | 41 |
| RUSSIAN FEDERATION | 41 |
| **UNITED STATES** | **41** |
| AUSTRALIA | 41 |
| SCOTLAND | 39 |
| CZECH REPUBLIC | 39 |
| LITHUANIA | 36 |
| BULGARIA | 35 |
| SWEDEN | 35 |
| ITALY | 34 |
| ROMANIA | 34 |
| ISRAEL | 34 |
| CYPRUS | 33 |
| International Average | 32 |
| NORWAY | 32 |
| THAILAND | 30 |
| IRAN, ISLAMIC REP. OF | 24 |
| COLOMBIA | 20 |
| KUWAIT | 14 |

| Equations & Formulas | |
|---|---|
| KOREA, REP. OF | 70 |
| SINGAPORE | 68 |
| HONG KONG SAR | 65 |
| JAPAN | 61 |
| RUSSIAN FEDERATION | 51 |
| **MINNESOTA, US** | **48** |
| QUEBEC, CANADA | 46 |
| HUNGARY | 46 |
| UNITED STATES | 44 |
| ROMANIA | 43 |
| ENGLAND | 42 |
| LITHUANIA | 42 |
| BULGARIA | 42 |
| SLOVENIA | 41 |
| ONTARIO, CANADA | 41 |
| CZECH REPUBLIC | 39 |
| ISRAEL | 39 |
| CYPRUS | 38 |
| ITALY | 36 |
| AUSTRALIA | 36 |
| International Average | 36 |
| SCOTLAND | 35 |
| SWEDEN | 33 |
| THAILAND | 29 |
| NORWAY | 26 |
| IRAN, ISLAMIC REP. OF | 25 |
| COLOMBIA | 20 |
| KUWAIT | 18 |

| Data Representation & Analysis | |
|---|---|
| KOREA, REP. OF | 72 |
| SINGAPORE | 72 |
| JAPAN | 71 |
| **MINNESOTA, US** | **67** |
| HONG KONG SAR | 66 |
| ENGLAND | 62 |
| ONTARIO, CANADA | 62 |
| QUEBEC, CANADA | 60 |
| **UNITED STATES** | **58** |
| HUNGARY | 58 |
| SWEDEN | 58 |
| LITHUANIA | 57 |
| AUSTRALIA | 56 |
| SLOVENIA | 55 |
| SCOTLAND | 54 |
| CZECH REPUBLIC | 54 |
| NORWAY | 52 |
| RUSSIAN FEDERATION | 48 |
| ITALY | 48 |
| ISRAEL | 44 |
| CYPRUS | 41 |
| International Average | 41 |
| THAILAND | 40 |
| BULGARIA | 37 |
| ROMANIA | 35 |
| IRAN, ISLAMIC REP. OF | 28 |
| COLOMBIA | 28 |
| KUWAIT | 22 |

| Uncertainty & Probability | |
|---|---|
| KOREA, REP. OF | 87 |
| JAPAN | 76 |
| **MINNESOTA, US** | **76** |
| SINGAPORE | 72 |
| ENGLAND | 72 |
| ONTARIO, CANADA | 71 |
| QUEBEC, CANADA | 71 |
| HONG KONG SAR | 69 |
| AUSTRALIA | 67 |
| **UNITED STATES** | **67** |
| LITHUANIA | 66 |
| SWEDEN | 62 |
| SCOTLAND | 60 |
| NORWAY | 58 |
| HUNGARY | 58 |
| CZECH REPUBLIC | 57 |
| SLOVENIA | 57 |
| ITALY | 57 |
| RUSSIAN FEDERATION | 55 |
| CYPRUS | 52 |
| ISRAEL | 51 |
| International Average | 47 |
| BULGARIA | 46 |
| ROMANIA | 43 |
| THAILAND | 42 |
| IRAN, ISLAMIC REP. OF | 39 |
| COLOMBIA | 32 |
| KUWAIT | 26 |

## Content – Curriculum, Standards and Textbooks

What are the characteristics of a coherent and focused curriculum? Can these characteristics be identified or measured? We believe that a coherent curriculum introduces and develops topics in a logical sequence.

Different topics 'fit' together as part of an integrated, systematic whole, both within a grade level and from grade to grade. Simple concepts are first introduced within simple topics. Topics are developed fully by gradually moving to more complex concepts. Once a topic has been fully developed, it is excluded from the curriculum and other, more complex topics are introduced.

A focused curriculum is one that intends a carefully selected and relatively small number of topics, especially in the early grades. The idea is that less is more, in that if fewer topics are included in the curriculum, the few can be addressed in greater depth. The concepts related to them can be developed completely so that students fully understand them. Such an approach facilitates the process of building a strong foundation in mathematics while advancing on to new and more complex topics in succeeding years of study.

One model of a coherent curriculum for mathematics is depicted in the display that follows. It is a matrix that depicts a composite of mathematics content areas of the top achieving countries (TAC) intended for grades one through eight according to results from the Third International Mathematics and Science Study (TIMSS), completed in 1995.

Thirty-two topics are identified in rows that are listed in the left column. The remaining columns identify the first eight grades. Our matrix has 256 cells (8 x 32). There are 99 shaded cells that identify the grades in which topics are included in the mathematics curricula in more than half of the TAC (four out of six countries).

Thus the shaded cells, representing topic-grade combinations, can be referred to as "coherence cells". The display lists topics in somewhat the same sequence suggested by results from the TAC curricular studies. The sequence of the major topics can be thought of as in a hierarchical structure that concurrently establishes a logical sequence for introducing these topics across the grades. (Figure 29)

By overlaying the curriculum intended according to the Minnesota standards on the appropriate silhouetted region, our model of a coherent and focused curriculum, we have a sense for the extent of agreement with our models. Whether examining the mathematics or science matrix, the cells within the matrix fall into three groups:

1) Cells that match the shaded area, displaying agreement with the ideal scenario of coherence as defined by our model.
2) Cells that are located in the grid in grades before those defined by the shaded region – these cells indicate topics that are covered earlier than that suggested by the ideal scenario of our model.
3) Cells that are located in the grid in grades after those defined by the shaded region – these cells indicate that topics are introduced or covered beyond the time that is recommended by our model.

## Mathematics Topics Intended at Each Grade in the state of Minnesota

| Topic | Grade 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|---|---|---|---|---|---|---|---|---|
| Whole Number: Meaning | ● | ● | ● | ● | | | | |
| Whole Number: Operations | ● | ● | ● | ● | ● | | | |
| Measurement Units | ● | ● | ● | ● | ● | ● | ● | ● |
| Common Fractions | ● | ● | ● | ● | ● | ● | ● | |
| Equations & Formulas | | | ● | ● | ● | ● | ● | ● |
| Data Representation & Analysis | ● | ● | ● | ● | ● | ● | ● | ● |
| 2-D Geometry: Basics | | | ● | ● | ● | ● | ● | |
| 2-D Geometry: Polygons & Circles | ● | ● | ● | ● | ● | ● | ● | ● |
| Measurement: Perimeter, Area & Volume | | | ● | ● | ● | ● | ● | ● |
| Rounding & Significant Figures | | | | ● | ● | ● | | |
| Estimating Computations | | ● | | ● | ● | ● | ● | ● |
| Whole Numbers: Properties of Operations | | ● | ● | ● | | ● | ● | ● |
| Estimating Quantity & Size | | | | | | | | |
| Decimal Fractions | | ● | ● | ● | ● | ● | | |
| Relation of Common & Decimal Fractions | | | | | | | ● | |
| Properties of Common & Decimal Fractions | | | | | | | | |
| Percentages | | | | | ● | ● | ● | ● |
| Proportionality Concepts | | | | | | | | |
| Proportionality Problems | | | | | | | ● | ● |
| 2-D Geometry: Coordinate Geometry | | | | | | ● | ● | ● |
| Geometry: Transformations | ● | ● | ● | | ● | ● | ● | ● |
| Negative Numbers, Integers, & Their Properties | | | | | ● | ● | | |
| Number Theory | ● | ● | | | | ● | | |
| Exponents, Roots & Radicals | | | | | | | ● | ● |
| Exponents & Orders of Magnitude | | | | | | | ● | ● |
| Measurement: Estimation & Errors | ● | ● | | | | | | |
| Constructions Using Straightedge & Compass | | | | | | ● | | |
| 3-D Geometry | ● | ● | ● | ● | ● | ● | ● | ● |
| Geometry: Congruence & Similarity | | | | ● | | | | |
| Rational Numbers & Their Properties | | | | | | ● | ● | ● |
| Patterns, Relations & Functions | | ● | ● | ● | ● | | ● | ● |
| Proportionality: Slope & Trigonometry | | | | | | | ● | |

Figure 29

Observations for mathematics follow: Across the first four grades, Minnesota intended to cover most of the same topics that were intended by the TAC. All topics that were intended by the TAC were intended in the Minnesota standards in grades one through three. Only two topics were not intended in fourth grade that were intended by the TAC: Estimating Quantity and Size; Relation of Common and Decimal Fractions.

The matrix identifies thirty-nine cases across grades one through seven where Minnesota intended to cover topics earlier than the grade first suggested by the coherence model. Several topics were intended not only earlier but also in two or more grades prior to what the coherence model suggests. The topics most frequently covered early were: Common and Decimal Fractions; Data Representation & Analysis; 2-D Geometry, Polygons & Circles; Whole Numbers, Properties of Operations; Transformations; 3-D Geometry; and Patterns, Relations & Functions.

The number of topics intended to be covered early in grades one through three is of particular concern. When teachers must dedicate classroom time teaching topics before their time as suggested by the coherence model they have less time to develop the concepts related to the topics that are considered more essential at the early grades: Whole Numbers, Meaning and Operations; and Measurement Units.

This is particularly extreme in grade two. Out of the thirty-two topics that are considered in the matrix, Minnesota intended to cover eleven more topics than the three suggested by the TAC composite.

Moving across the matrix to the higher grades, there are several topics in each of grades five through eight that were intended by the TAC but not the Minnesota standards. These topics fall into the three categories: those that are not covered in any of the eight grades (three topics); those that are covered in earlier grades; and topics that were intended in grades later than suggested by the model.

One of the topics never intended, Estimating Quantity & Size, was mentioned above as part of the discussion related to grade four. The other two topics that were not intended in grades one through eight are: Properties of Common & Decimal Fractions; and Proportionality Concepts.

Other topics of particular concern that were not intended according to the suggested model are: Relation of Common & /Decimal Fractions; Proportionality Problems; Coordinate Geometry; Proportionality, Slope & Trigonometry. These topics are important to laying a foundation for more complex content that will be introduced in later high school courses.

Taken together these gaps in intended topic coverage are noteworthy because concepts associated with these topics must be developed fully in grades five through eight to ensure that students have the foundation that they need to understand even more complex content related to algebra, geometry, trigonometry and beyond.

Figures 29a and 29b show how the mathematics topic focus in MN compares to the rest of the US in 2007 and how it has changed from 1995.

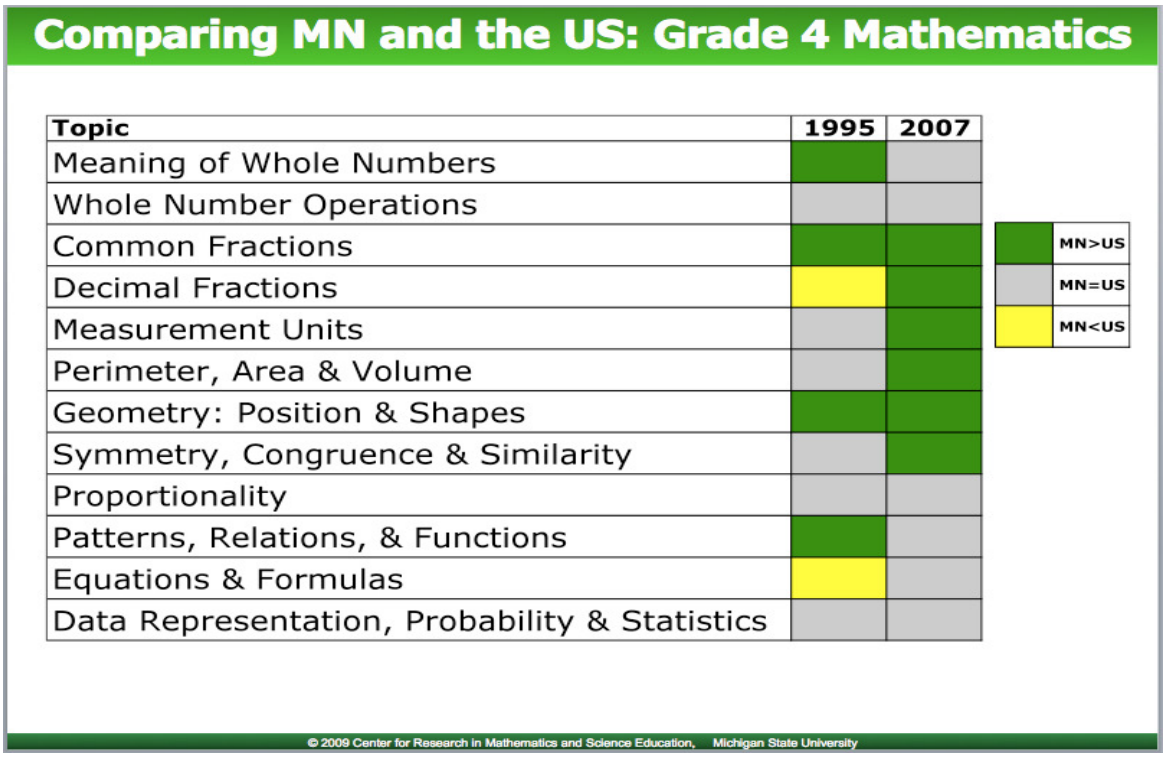


Figure 29a

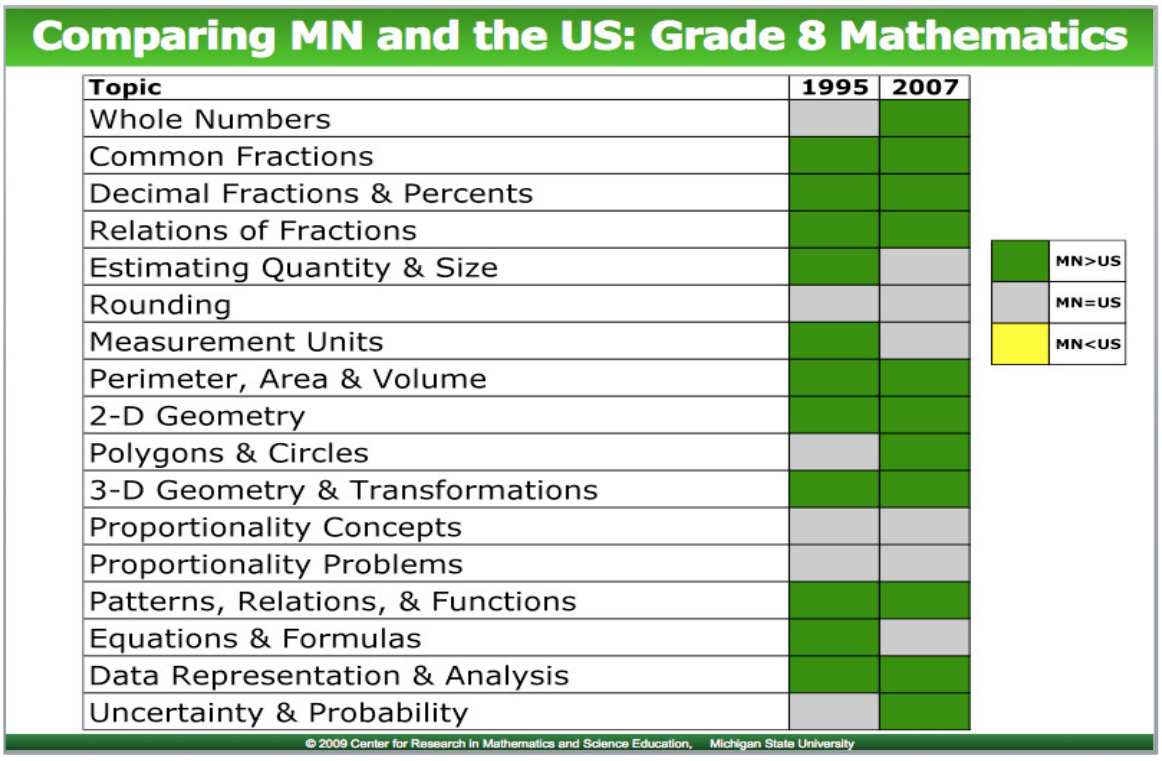


Figure 29b

# MINNESOTA STUDENTS' PERFORMANCE IN BROAD AREAS OF SCIENCE: 2007 INTERNATIONAL COMPARISONS

TIMSS test items were coded into15 broad categories for Grade 4 science and 17 categories for grade 8 science, the same categories used in the 1995 analysis.

## GRADE 4 SCIENCE

- Only students in Singapore scored significantly higher overall than Minnesota students.
- Singapore scored higher on seven of the broad science categories displayed.
- Japan on three broad science categories-Human Biology and Health; Energy and Physical Processes; and Physical and Chemical Changes.
- Netherlands on one broad science category-Human Biology and Health.
- MN students maintained their relatively high level of performance in science at a time when the requirements of No Child Left Behind led elementary schools to heavily emphasize reading and math instruction
- MN students scored significantly higher than the U.S. students in one area of science - Forces and motion.
- Although MN students scored higher than the US students in all but one other broad category, the differences were not statistically significant. (Figures 30 and 31)

**Display 2: Grade 4 Science Topics**

| Earth Features | | Earth Processes | | Earth in the Universe | | Plants & Animals | | Organs & Tissues | |
|---|---|---|---|---|---|---|---|---|---|
| MINNESOTA, US | 70 | ALBERTA, CANADA | 70 | LATVIA | 66 | SINGAPORE | 70 | HUNGARY | 63 |
| HONG KONG SAR | 66 | JAPAN | 70 | ENGLAND | 66 | ITALY | 63 | ITALY | 63 |
| UNITED STATES | 64 | MINNESOTA, US | 67 | SINGAPORE | 66 | MINNESOTA, US | 62 | NETHERLANDS | 62 |
| SINGAPORE | 64 | ONTARIO, CANADA | 66 | HONG KONG SAR | 63 | ALBERTA, CANADA | 61 | AUSTRIA | 61 |
| ALBERTA, CANADA | 64 | ENGLAND | 65 | MINNESOTA, US | 62 | UNITED STATES | 61 | SLOVENIA | 60 |
| ENGLAND | 63 | UNITED STATES | 65 | UNITED STATES | 61 | ENGLAND | 60 | SINGAPORE | 60 |
| JAPAN | 63 | ITALY | 64 | ALBERTA, CANADA | 60 | ONTARIO, CANADA | 60 | MINNESOTA, US | 60 |
| AUSTRIA | 62 | HONG KONG SAR | 64 | AUSTRALIA | 60 | LATVIA | 60 | LATVIA | 60 |
| AUSTRALIA | 60 | AUSTRIA | 64 | ONTARIO, CANADA | 58 | HUNGARY | 60 | ENGLAND | 59 |
| ONTARIO, CANADA | 60 | AUSTRALIA | 64 | AUSTRIA | 58 | HONG KONG SAR | 59 | ONTARIO, CANADA | 58 |
| NETHERLANDS | 60 | NETHERLANDS | 63 | SLOVENIA | 56 | AUSTRALIA | 59 | UNITED STATES | 58 |
| LATVIA | 60 | QUEBEC, CANADA | 61 | HUNGARY | 56 | NETHERLANDS | 58 | HONG KONG SAR | 58 |
| ITALY | 59 | HUNGARY | 60 | NETHERLANDS | 55 | CZECH REPUBLIC | 57 | ALBERTA, CANADA | 58 |
| HUNGARY | 58 | SINGAPORE | 60 | NORWAY | 55 | AUSTRIA | 57 | CZECH REPUBLIC | 56 |
| SCOTLAND | 57 | CZECH REPUBLIC | 60 | NEW ZEALAND | 55 | JAPAN | 56 | QUEBEC, CANADA | 54 |
| NEW ZEALAND | 57 | NEW ZEALAND | 59 | QUEBEC, CANADA | 55 | QUEBEC, CANADA | 55 | AUSTRALIA | 53 |
| SLOVENIA | 56 | LATVIA | 58 | ITALY | 54 | NEW ZEALAND | 54 | JAPAN | 53 |
| NORWAY | 54 | SCOTLAND | 58 | SCOTLAND | 54 | SLOVENIA | 54 | SCOTLAND | 51 |
| QUEBEC, CANADA | 53 | SLOVENIA | 57 | JAPAN | 54 | SCOTLAND | 54 | NEW ZEALAND | 50 |
| International Average | 51 | International Average | 51 | CZECH REPUBLIC | 53 | International Average | 50 | NORWAY | 50 |
| CZECH REPUBLIC | 50 | NORWAY | 51 | International Average | 50 | NORWAY | 50 | International Average | 49 |
| IRAN, ISLAMIC REP. OF | 37 | IRAN, ISLAMIC REP. OF | 34 | IRAN, ISLAMIC REP. OF | 40 | IRAN, ISLAMIC REP. OF | 42 | IRAN, ISLAMIC REP. OF | 37 |
| KUWAIT | 30 | KUWAIT | 32 | KUWAIT | 27 | KUWAIT | 33 | KUWAIT | 28 |
| TUNISIA | 20 | TUNISIA | 27 | TUNISIA | 23 | TUNISIA | 26 | TUNISIA | 24 |

| Life Processes & Function | | Life Cycles & Genetics | | Interactions of Living Things | | Human Biology and Health | | Matter | |
|---|---|---|---|---|---|---|---|---|---|
| SINGAPORE | 82 | SINGAPORE | 62 | ITALY | 71 | JAPAN | 65 | SINGAPORE | 72 |
| HONG KONG SAR | 63 | AUSTRIA | 58 | AUSTRIA | 70 | SINGAPORE | 64 | HONG KONG SAR | 67 |
| ONTARIO, CANADA | 60 | CZECH REPUBLIC | 56 | SINGAPORE | 69 | NETHERLANDS | 63 | JAPAN | 65 |
| ITALY | 59 | HUNGARY | 56 | NETHERLANDS | 69 | HONG KONG SAR | 61 | LATVIA | 64 |
| UNITED STATES | 58 | MINNESOTA, US | 55 | MINNESOTA, US | 68 | ITALY | 61 | MINNESOTA, US | 61 |
| ALBERTA, CANADA | 57 | ITALY | 55 | HUNGARY | 68 | HUNGARY | 60 | ITALY | 61 |
| ENGLAND | 56 | LATVIA | 54 | LATVIA | 66 | QUEBEC, CANADA | 60 | AUSTRIA | 59 |
| MINNESOTA, US | 55 | ALBERTA, CANADA | 53 | ALBERTA, CANADA | 66 | LATVIA | 59 | ENGLAND | 59 |
| JAPAN | 55 | AUSTRALIA | 53 | JAPAN | 66 | ALBERTA, CANADA | 58 | HUNGARY | 59 |
| LATVIA | 50 | JAPAN | 52 | AUSTRALIA | 65 | ONTARIO, CANADA | 58 | UNITED STATES | 59 |
| NETHERLANDS | 49 | ONTARIO, CANADA | 52 | HONG KONG SAR | 65 | MINNESOTA, US | 57 | SLOVENIA | 58 |
| AUSTRALIA | 48 | ENGLAND | 52 | CZECH REPUBLIC | 65 | ENGLAND | 57 | CZECH REPUBLIC | 58 |
| HUNGARY | 48 | UNITED STATES | 52 | UNITED STATES | 65 | AUSTRIA | 55 | QUEBEC, CANADA | 57 |
| SLOVENIA | 47 | SLOVENIA | 51 | ONTARIO, CANADA | 64 | UNITED STATES | 55 | ALBERTA, CANADA | 57 |
| CZECH REPUBLIC | 47 | NETHERLANDS | 50 | ENGLAND | 64 | AUSTRALIA | 54 | ONTARIO, CANADA | 56 |
| IRAN, ISLAMIC REP. OF | 47 | HONG KONG SAR | 49 | SLOVENIA | 64 | CZECH REPUBLIC | 54 | AUSTRALIA | 55 |
| International Average | 45 | NEW ZEALAND | 48 | QUEBEC, CANADA | 62 | SLOVENIA | 53 | NETHERLANDS | 52 |
| AUSTRIA | 44 | QUEBEC, CANADA | 48 | NEW ZEALAND | 59 | NEW ZEALAND | 53 | SCOTLAND | 52 |
| SCOTLAND | 44 | SCOTLAND | 44 | NORWAY | 57 | NORWAY | 51 | International Average | 50 |
| NEW ZEALAND | 44 | International Average | 43 | SCOTLAND | 57 | SCOTLAND | 49 | NEW ZEALAND | 50 |
| QUEBEC, CANADA | 43 | NORWAY | 42 | International Average | 55 | International Average | 48 | NORWAY | 48 |
| NORWAY | 35 | IRAN, ISLAMIC REP. OF | 34 | IRAN, ISLAMIC REP. OF | 47 | IRAN, ISLAMIC REP. OF | 40 | IRAN, ISLAMIC REP. OF | 38 |
| KUWAIT | 33 | KUWAIT | 20 | TUNISIA | 31 | TUNISIA | 25 | KUWAIT | 31 |
| TUNISIA | 23 | TUNISIA | 18 | KUWAIT | 29 | KUWAIT | 24 | TUNISIA | 29 |

Figure 30

| Grade 4 Science Topics | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Energy and Physical Processes | | Physical & Chemical Changes | | Forces and Motion | | Environmental & Resource Issues | | Scientific Processes | |
| SINGAPORE | 73 | SINGAPORE | 69 | HONG KONG SAR | 71 | ALBERTA, CANADA | 67 | SINGAPORE | 70 |
| JAPAN | 67 | JAPAN | 65 | SINGAPORE | 70 | MINNESOTA, US | 63 | HONG KONG SAR | 70 |
| HONG KONG SAR | 61 | HONG KONG SAR | 61 | MINNESOTA, US | 67 | QUEBEC, CANADA | 62 | ENGLAND | 69 |
| MINNESOTA, US | 58 | LATVIA | 60 | ONTARIO, CANADA | 64 | SINGAPORE | 62 | MINNESOTA, US | 67 |
| LATVIA | 58 | HUNGARY | 58 | ALBERTA, CANADA | 63 | HONG KONG SAR | 61 | LATVIA | 67 |
| ENGLAND | 56 | MINNESOTA, US | 57 | AUSTRIA | 63 | ONTARIO, CANADA | 61 | UNITED STATES | 67 |
| ALBERTA, CANADA | 56 | ENGLAND | 57 | AUSTRALIA | 62 | JAPAN | 59 | AUSTRALIA | 67 |
| UNITED STATES | 55 | SLOVENIA | 56 | LATVIA | 62 | AUSTRALIA | 58 | JAPAN | 65 |
| ONTARIO, CANADA | 54 | CZECH REPUBLIC | 55 | ENGLAND | 62 | ITALY | 58 | ALBERTA, CANADA | 64 |
| HUNGARY | 54 | ITALY | 55 | UNITED STATES | 61 | ENGLAND | 58 | NETHERLANDS | 63 |
| NETHERLANDS | 54 | ALBERTA, CANADA | 55 | JAPAN | 61 | UNITED STATES | 57 | HUNGARY | 62 |
| SLOVENIA | 54 | UNITED STATES | 55 | ITALY | 61 | NETHERLANDS | 57 | ITALY | 61 |
| ITALY | 53 | ONTARIO, CANADA | 53 | NETHERLANDS | 60 | HUNGARY | 57 | QUEBEC, CANADA | 61 |
| AUSTRIA | 53 | AUSTRIA | 51 | NEW ZEALAND | 60 | AUSTRIA | 55 | ONTARIO, CANADA | 61 |
| AUSTRALIA | 53 | AUSTRALIA | 51 | HUNGARY | 58 | LATVIA | 55 | SCOTLAND | 61 |
| CZECH REPUBLIC | 50 | QUEBEC, CANADA | 50 | SCOTLAND | 56 | SCOTLAND | 52 | NEW ZEALAND | 60 |
| NEW ZEALAND | 49 | NETHERLANDS | 49 | International Average | 54 | SLOVENIA | 52 | AUSTRIA | 60 |
| QUEBEC, CANADA | 48 | International Average | 46 | SLOVENIA | 54 | CZECH REPUBLIC | 51 | SLOVENIA | 58 |
| SCOTLAND | 48 | NEW ZEALAND | 45 | CZECH REPUBLIC | 54 | NEW ZEALAND | 51 | CZECH REPUBLIC | 57 |
| International Average | 47 | SCOTLAND | 44 | NORWAY | 53 | International Average | 45 | International Average | 56 |
| NORWAY | 42 | NORWAY | 40 | QUEBEC, CANADA | 52 | IRAN, ISLAMIC REP. OF | 42 | NORWAY | 54 |
| IRAN, ISLAMIC REP. OF | 38 | IRAN, ISLAMIC REP. OF | 35 | IRAN, ISLAMIC REP. OF | 45 | NORWAY | 41 | IRAN, ISLAMIC REP. OF | 45 |
| TUNISIA | 28 | KUWAIT | 26 | KUWAIT | 42 | KUWAIT | 22 | KUWAIT | 37 |
| KUWAIT | 26 | TUNISIA | 25 | TUNISIA | 39 | TUNISIA | 19 | TUNISIA | 35 |

| |
|---|
| Significantly higher than MN |
| Not Statistically Different from MN |
| Significantly lower than MN |

Figure 31

## Grade 8 Science

- Minnesota students scored significantly lower than students in five countries: China, Korea, Singapore, Hong Kong and Japan.

- Minnesota students scored significantly better than students from the other 44 participating countries.

- On specific categories of science, Minnesota students scored significantly lower than students in six other countries.

- Singapore and Japan scored higher on eight of the broad science categories displayed.

- Rep. of Korea scored higher on six of the broad science categories displayed.

- The Czech Republic scored higher on five of the broad science categories-Properties and Classification of Matter; Structure of Matter; Energy and Physical Processes; Physical Changes; and Forces and Motion.

- Hungary scored higher on four of the broad science categories- Properties and Classification of Matter; Structure of Matter; Energy and Physical Processes; and Physical Changes.

- The Russian Federation Scored higher on three of the broad science categories-Properties and Classification of Matter; Structure of Matter; and Physical Changes.

- Hong Kong scored higher on two of the broad science categories-Life Cycles and Genetics and Energy and Physical Processes.

- MN students scored significantly higher than the U.S. students in seven areas of science-Earth Features and Processes; Diversity and Structure of Living Things; Interaction of Living Things; Human Biology and Health; Environmental and Resource Issues and Scientific Processes.

- Although MN students scored higher than the US students in all but one of the other broad categories, the differences were not statistically significant.

  (Figures 32 and 33)

## Display 4: Grade 8 Science Topics

| Earth Features | | Earth Processes | | Earth in the Universe | | Diversity & Structure of Living Things | | Life Processes & Functions | | Life Cycles & Genetics | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **MINNESOTA, US** | **61** | CZECH REPUBLIC | 60 | SLOVENIA | 63 | SINGAPORE | 61 | SINGAPORE | 68 | KOREA, REP. OF | 65 |
| SLOVENIA | 60 | HONG KONG SAR | 60 | CZECH REPUBLIC | 61 | KOREA, REP. OF | 60 | KOREA, REP. OF | 63 | JAPAN | 60 |
| HUNGARY | 59 | JAPAN | 59 | KOREA, REP. OF | 60 | **MINNESOTA, US** | **59** | JAPAN | 62 | HONG KONG SAR | 60 |
| CZECH REPUBLIC | 59 | **MINNESOTA, US** | **58** | **MINNESOTA, US** | **60** | JAPAN | 57 | HONG KONG SAR | 59 | SINGAPORE | 57 |
| JAPAN | 58 | SLOVENIA | 58 | **UNITED STATES** | **58** | HUNGARY | 56 | ENGLAND | 58 | RUSSIAN FEDERATION | 52 |
| RUSSIAN FEDERATION | 57 | RUSSIAN FEDERATION | 57 | SWEDEN | 57 | CZECH REPUBLIC | 56 | **MINNESOTA, US** | **56** | HUNGARY | 51 |
| KOREA, REP. OF | 57 | ONTARIO, CANADA | 56 | NORWAY | 57 | ONTARIO, CANADA | 55 | SLOVENIA | 52 | QUEBEC, CANADA | 49 |
| SWEDEN | 56 | SINGAPORE | 56 | SINGAPORE | 57 | SLOVENIA | 55 | RUSSIAN FEDERATION | 52 | **MINNESOTA, US** | **49** |
| NORWAY | 54 | QUEBEC, CANADA | 53 | ENGLAND | 56 | LITHUANIA | 55 | **UNITED STATES** | **52** | LITHUANIA | 49 |
| ONTARIO, CANADA | 53 | **UNITED STATES** | **53** | RUSSIAN FEDERATION | 55 | ENGLAND | 55 | ONTARIO, CANADA | 51 | **UNITED STATES** | **47** |
| SINGAPORE | 53 | LITHUANIA | 53 | BULGARIA | 55 | **UNITED STATES** | **54** | LITHUANIA | 50 | ENGLAND | 47 |
| LITHUANIA | 52 | AUSTRALIA | 52 | ITALY | 55 | RUSSIAN FEDERATION | 53 | CZECH REPUBLIC | 47 | CZECH REPUBLIC | 46 |
| **UNITED STATES** | **61** | ENGLAND | 52 | LITHUANIA | 55 | HONG KONG SAR | 51 | SWEDEN | 47 | AUSTRALIA | 44 |
| AUSTRALIA | 51 | ITALY | 51 | AUSTRALIA | 53 | AUSTRALIA | 50 | AUSTRALIA | 47 | SLOVENIA | 43 |
| ITALY | 50 | SWEDEN | 51 | HONG KONG SAR | 51 | SWEDEN | 48 | SCOTLAND | 47 | BULGARIA | 43 |
| HONG KONG SAR | 50 | KOREA, REP. OF | 50 | QUEBEC, CANADA | 50 | QUEBEC, CANADA | 48 | ITALY | 45 | ITALY | 42 |
| ENGLAND | 50 | HUNGARY | 50 | ONTARIO, CANADA | 50 | ITALY | 47 | QUEBEC, CANADA | 44 | SWEDEN | 41 |
| QUEBEC, CANADA | 49 | NORWAY | 47 | HUNGARY | 49 | THAILAND | 44 | HUNGARY | 43 | ONTARIO, CANADA | 41 |
| SCOTLAND | 46 | THAILAND | 46 | THAILAND | 49 | SCOTLAND | 43 | International | 43 | ISRAEL | 39 |
| BULGARIA | 45 | SCOTLAND | 46 | IRAN, ISLAMIC REP. OF | 48 | BULGARIA | 43 | THAILAND | 41 | International | 38 |
| ROMANIA | 41 | IRAN, ISLAMIC REP. OF | 45 | JAPAN | 48 | NORWAY | 42 | BULGARIA | 40 | NORWAY | 38 |
| International | 38 | BULGARIA | 44 | SCOTLAND | 46 | International | 41 | ROMANIA | 38 | SCOTLAND | 37 |
| ISRAEL | 37 | International | 41 | International | 45 | ISRAEL | 41 | NORWAY | 38 | THAILAND | 35 |
| IRAN, ISLAMIC REP. OF | 35 | ISRAEL | 40 | ROMANIA | 39 | ROMANIA | 38 | ISRAEL | 38 | IRAN, ISLAMIC REP. OF | 34 |
| THAILAND | 34 | ROMANIA | 39 | ISRAEL | 38 | IRAN, ISLAMIC REP. OF | 36 | KUWAIT | 38 | CYPRUS | 34 |
| CYPRUS | 31 | CYPRUS | 38 | KUWAIT | 35 | CYPRUS | 34 | CYPRUS | 36 | COLOMBIA | 33 |
| COLOMBIA | 28 | COLOMBIA | 29 | CYPRUS | 35 | COLOMBIA | 34 | COLOMBIA | 34 | KUWAIT | 30 |
| KUWAIT | 16 | KUWAIT | 27 | COLOMBIA | 34 | KUWAIT | 32 | IRAN, ISLAMIC REP. OF | 31 | ROMANIA | 29 |

| Interactions of Living Things | | Human Biology and Health | | Properties & Classification of Matter | | Structure of Matter | | Energy and Physical Processes | | Physical Changes | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| SINGAPORE | 64 | **MINNESOTA, US** | **70** | SINGAPORE | 53 | SLOVENIA | 66 | SINGAPORE | 63 | KOREA, REP. OF | 57 |
| KOREA, REP. OF | 62 | KOREA, REP. OF | 69 | KOREA, REP. OF | 53 | SINGAPORE | 64 | KOREA, REP. OF | 59 | SINGAPORE | 55 |
| **MINNESOTA, US** | **62** | CZECH REPUBLIC | 66 | SLOVENIA | 51 | CZECH REPUBLIC | 60 | JAPAN | 58 | JAPAN | 53 |
| HUNGARY | 60 | ENGLAND | 66 | JAPAN | 50 | RUSSIAN FEDERATION | 60 | ENGLAND | 54 | ENGLAND | 52 |
| SLOVENIA | 60 | HUNGARY | 65 | HUNGARY | 50 | HUNGARY | 57 | HUNGARY | 54 | RUSSIAN FEDERATION | 49 |
| JAPAN | 59 | JAPAN | 65 | CZECH REPUBLIC | 49 | LITHUANIA | 54 | CZECH REPUBLIC | 52 | SLOVENIA | 49 |
| ENGLAND | 58 | ONTARIO, CANADA | 64 | RUSSIAN FEDERATION | 48 | BULGARIA | 53 | HONG KONG SAR | 51 | HUNGARY | 49 |
| ONTARIO, CANADA | 58 | SINGAPORE | 64 | ENGLAND | 47 | JAPAN | 52 | RUSSIAN FEDERATION | 49 | CZECH REPUBLIC | 47 |
| LITHUANIA | 58 | QUEBEC, CANADA | 64 | HONG KONG SAR | 44 | ROMANIA | 50 | SLOVENIA | 47 | LITHUANIA | 45 |
| CZECH REPUBLIC | 57 | SWEDEN | 63 | **MINNESOTA, US** | **41** | IRAN, ISLAMIC REP. OF | 49 | ONTARIO, CANADA | 46 | HONG KONG SAR | 45 |
| **UNITED STATES** | **67** | **UNITED STATES** | **63** | LITHUANIA | 40 | **UNITED STATES** | **48** | SWEDEN | 45 | SWEDEN | 44 |
| HONG KONG SAR | 55 | HONG KONG SAR | 63 | SWEDEN | 40 | CYPRUS | 47 | AUSTRALIA | 45 | ONTARIO, CANADA | 44 |
| AUSTRALIA | 55 | RUSSIAN FEDERATION | 62 | **UNITED STATES** | **40** | **MINNESOTA, US** | **46** | **MINNESOTA, US** | **45** | **MINNESOTA, US** | **43** |
| RUSSIAN FEDERATION | 55 | AUSTRALIA | 62 | AUSTRALIA | 39 | ITALY | 44 | LITHUANIA | 44 | AUSTRALIA | 42 |
| SWEDEN | 53 | ITALY | 61 | ONTARIO, CANADA | 39 | ISRAEL | 44 | SCOTLAND | 44 | **UNITED STATES** | **41** |
| QUEBEC, CANADA | 52 | NORWAY | 59 | QUEBEC, CANADA | 38 | SWEDEN | 44 | **UNITED STATES** | **43** | NORWAY | 40 |
| SCOTLAND | 48 | SLOVENIA | 58 | SCOTLAND | 37 | International | 43 | ITALY | 43 | QUEBEC, CANADA | 40 |
| NORWAY | 46 | THAILAND | 57 | ISRAEL | 37 | ENGLAND | 42 | QUEBEC, CANADA | 42 | SCOTLAND | 40 |
| ITALY | 46 | LITHUANIA | 56 | BULGARIA | 36 | KOREA, REP. OF | 42 | BULGARIA | 41 | ISRAEL | 39 |
| ISRAEL | 44 | SCOTLAND | 54 | International | 35 | QUEBEC, CANADA | 37 | International | 40 | CYPRUS | 39 |
| THAILAND | 43 | ISRAEL | 54 | ITALY | 34 | KUWAIT | 37 | ROMANIA | 39 | ITALY | 38 |
| International | 42 | ROMANIA | 52 | NORWAY | 34 | AUSTRALIA | 35 | IRAN, ISLAMIC REP. OF | 39 | BULGARIA | 37 |
| ROMANIA | 41 | BULGARIA | 51 | CYPRUS | 34 | THAILAND | 35 | NORWAY | 39 | International | 37 |
| BULGARIA | 40 | International | 50 | THAILAND | 33 | COLOMBIA | 33 | CYPRUS | 38 | IRAN, ISLAMIC REP. OF | 36 |
| IRAN, ISLAMIC REP. OF | 38 | CYPRUS | 49 | ROMANIA | 33 | NORWAY | 31 | ISRAEL | 38 | ROMANIA | 34 |
| CYPRUS | 37 | IRAN, ISLAMIC REP. OF | 48 | IRAN, ISLAMIC REP. OF | 32 | SCOTLAND | 30 | THAILAND | 38 | THAILAND | 34 |
| COLOMBIA | 31 | COLOMBIA | 43 | KUWAIT | 27 | HONG KONG SAR | 29 | KUWAIT | 36 | KUWAIT | 28 |
| KUWAIT | 28 | KUWAIT | 38 | COLOMBIA | 24 | ONTARIO, CANADA | 29 | COLOMBIA | 30 | COLOMBIA | 25 |

Figure 32

## Display 4: Grade 8 Science Topics

| Chemical Changes | |
|---|---|
| ENGLAND | 55 |
| SINGAPORE | 55 |
| HONG KONG SAR | 48 |
| JAPAN | 47 |
| SLOVENIA | 45 |
| AUSTRALIA | 45 |
| **MINNESOTA, US** | **45** |
| SCOTLAND | 44 |
| RUSSIAN FEDERATION | 44 |
| HUNGARY | 43 |
| **UNITED STATES** | **43** |
| ONTARIO, CANADA | 43 |
| LITHUANIA | 40 |
| CZECH REPUBLIC | 39 |
| IRAN, ISLAMIC REP. OF | 38 |
| BULGARIA | 38 |
| QUEBEC, CANADA | 38 |
| KOREA, REP. OF | 37 |
| NORWAY | 35 |
| International | 34 |
| SWEDEN | 34 |
| ITALY | 32 |
| ROMANIA | 31 |
| THAILAND | 31 |
| ISRAEL | 30 |
| KUWAIT | 27 |
| CYPRUS | 24 |
| COLOMBIA | 22 |

| Forces and Motion | |
|---|---|
| CZECH REPUBLIC | 49 |
| JAPAN | 49 |
| KOREA, REP. OF | 48 |
| SINGAPORE | 48 |
| ENGLAND | 45 |
| SLOVENIA | 44 |
| HUNGARY | 44 |
| ONTARIO, CANADA | 43 |
| **MINNESOTA, US** | **43** |
| LITHUANIA | 42 |
| HONG KONG SAR | 42 |
| RUSSIAN FEDERATION | 41 |
| SWEDEN | 41 |
| **UNITED STATES** | **40** |
| AUSTRALIA | 38 |
| QUEBEC, CANADA | 36 |
| SCOTLAND | 33 |
| ITALY | 33 |
| NORWAY | 32 |
| ISRAEL | 32 |
| International | 31 |
| THAILAND | 29 |
| BULGARIA | 29 |
| ROMANIA | 28 |
| IRAN, ISLAMIC REP. OF | 27 |
| KUWAIT | 23 |
| COLOMBIA | 18 |
| CYPRUS | 16 |

| Science, Technology, & Society | |
|---|---|
| SINGAPORE | 51 |
| JAPAN | 50 |
| QUEBEC, CANADA | 44 |
| CZECH REPUBLIC | 44 |
| RUSSIAN FEDERATION | 44 |
| ENGLAND | 41 |
| ONTARIO, CANADA | 40 |
| HONG KONG SAR | 39 |
| KOREA, REP. OF | 39 |
| **MINNESOTA, US** | **38** |
| **UNITED STATES** | **37** |
| ITALY | 36 |
| AUSTRALIA | 36 |
| HUNGARY | 34 |
| SCOTLAND | 33 |
| CYPRUS | 32 |
| SLOVENIA | 31 |
| IRAN, ISLAMIC REP. OF | 28 |
| SWEDEN | 26 |
| BULGARIA | 26 |
| International | 26 |
| LITHUANIA | 25 |
| ROMANIA | 24 |
| COLOMBIA | 23 |
| THAILAND | 19 |
| KUWAIT | 19 |
| NORWAY | 17 |
| ISRAEL | 16 |

| Environmental & Resource Issues | |
|---|---|
| SINGAPORE | 55 |
| **MINNESOTA, US** | **55** |
| SLOVENIA | 53 |
| ONTARIO, CANADA | 53 |
| ENGLAND | 53 |
| AUSTRALIA | 52 |
| HUNGARY | 51 |
| KOREA, REP. OF | 51 |
| HONG KONG SAR | 50 |
| LITHUANIA | 50 |
| RUSSIAN FEDERATION | 49 |
| **UNITED STATES** | **48** |
| CZECH REPUBLIC | 48 |
| QUEBEC, CANADA | 48 |
| JAPAN | 48 |
| SCOTLAND | 46 |
| SWEDEN | 43 |
| ITALY | 43 |
| NORWAY | 42 |
| THAILAND | 40 |
| ROMANIA | 39 |
| CYPRUS | 38 |
| International | 38 |
| BULGARIA | 36 |
| ISRAEL | 35 |
| IRAN, ISLAMIC REP. OF | 35 |
| COLOMBIA | 28 |
| KUWAIT | 21 |

| Scientific Processes | |
|---|---|
| JAPAN | 56 |
| SINGAPORE | 52 |
| KOREA, REP. OF | 50 |
| **MINNESOTA, US** | **48** |
| ENGLAND | 46 |
| ONTARIO, CANADA | 45 |
| CZECH REPUBLIC | 45 |
| HONG KONG SAR | 43 |
| **UNITED STATES** | **43** |
| SLOVENIA | 42 |
| AUSTRALIA | 42 |
| QUEBEC, CANADA | 40 |
| HUNGARY | 40 |
| LITHUANIA | 40 |
| RUSSIAN FEDERATION | 38 |
| SCOTLAND | 36 |
| ISRAEL | 34 |
| SWEDEN | 34 |
| ITALY | 30 |
| THAILAND | 29 |
| International | 29 |
| NORWAY | 28 |
| CYPRUS | 25 |
| ROMANIA | 25 |
| BULGARIA | 24 |
| IRAN, ISLAMIC REP. OF | 22 |
| KUWAIT | 19 |
| COLOMBIA | 15 |

Significantly higher than MN
Not Statistically Different from MN
Significantly lower than MN

Figure 33

## TEACHING TIME ON SCIENCE TOPICS: A COMPARISON OF 1995 AND 2007 MN DATA

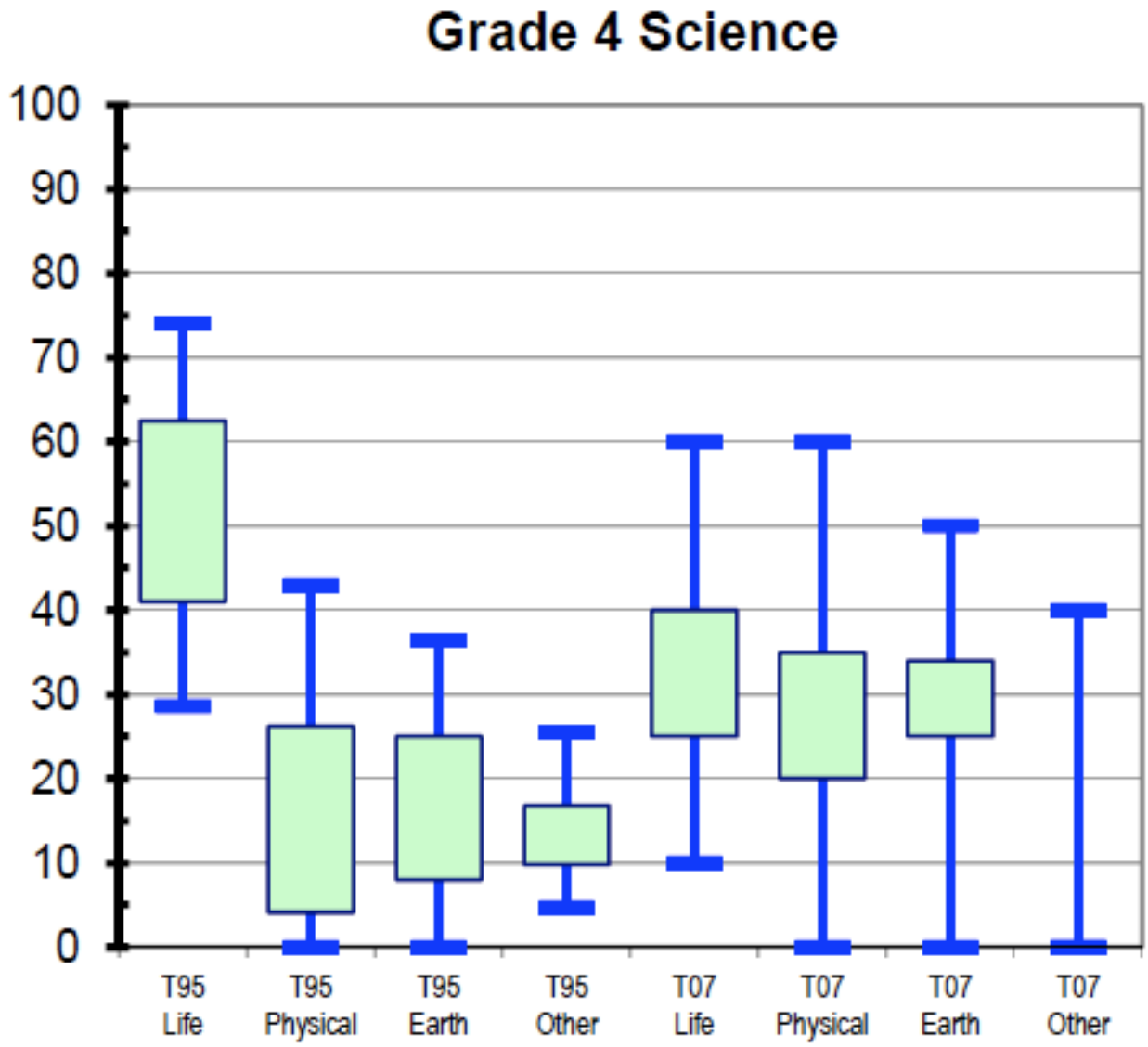


Figure 34

### GRADE 4

- Compared to 1995 when the reported median percent time on Life Science topics was about 50%, the median percent time on these topics decreased in 2007 to about 35%. However, the range in reported time in on these topics in 2007 appears to have widened. (Figure 34)
- The typical percentage of reported time teachers spent on Physical and Earth Science topics show an increase compared to the 1995 data. The increase in typical reported time is coupled with an increase in the variability in time spent on these topics.

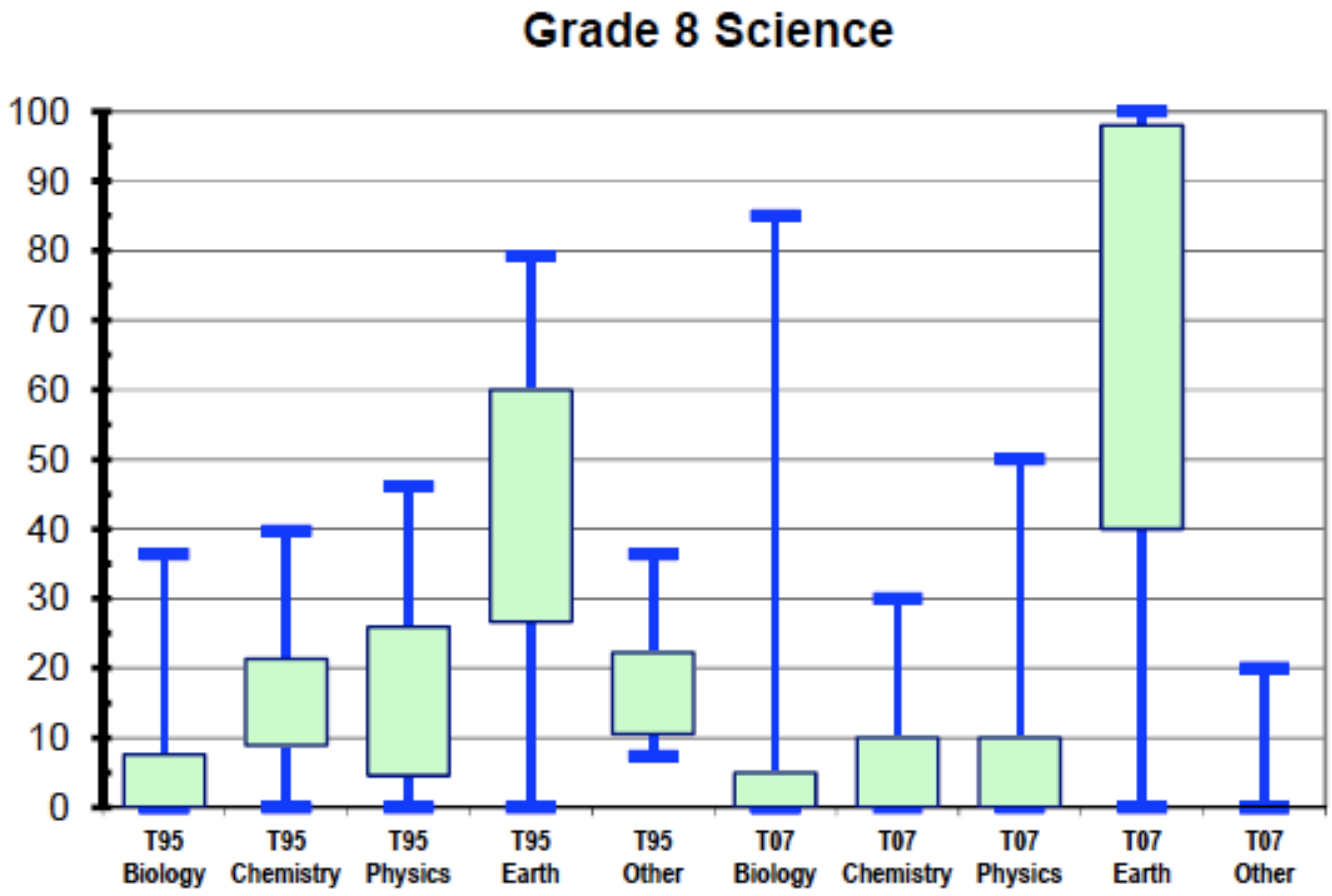


Figure 35

## Grade 8 Science (Figure 35)

- The median percentage of time reported on Earth Science topics in 2007 was approximately 70% compared to about 45% in 1995.
- The increase in typical percent time on Earth Science in 2007 is coupled with increased variability. In at least one classroom teacher reports indicate that no time is devoted to Earth Science. In contrast, there is at least another MN classroom where 100% of teaching time is devoted to Earth Science.
- Compared to 1995, teachers in 2007 report spending less time (on average) on Chemistry, Physics and "other" science topics.
- Although three-quarters of the reported percent time spent on teaching Biology topics in 2007 is less than 5%, there is at least one classroom where the reported percent time on Biology topics is about 85%.

## MN SCIENCE CURRICULUM: COMPARISON TO TOP ACHIEVING COUNTRIES

- Intended topic coverage appears scattered and not coherent compared to the composite of the majority of top achieving countries. The curriculum lacked the structure that is required to allow for the development of concepts as they relate to science themes.

- Too many topics were intended to be covered in the early grades. Too few are intended for coverage in the middle school grades. With the abundance of topics intended for coverage in grades one through four, there is little opportunity to develop any deep understanding of science content.

- Some topics were intended for coverage too early, before their time, and then dropped from coverage, and therefore not developed fully throughout the middle grades. Examples are: Atoms, Ions, and Molecules; Chemical Changes of Matter; Sound & Vibration; and Magnetism. Content related to these topics should be included in the curriculum during the middle grades so that students can establish a foundation of knowledge that will enable them to grasp more complex ideas related to chemistry and physics when they reach high school.

- All courses specific to a discipline – earth, life, or physical science – carry a high concentration of content areas in their discipline. This is expected but coverage of physical science topics appears to be particularly weak. Physical science topics intended in only one grade or never intended include: Classification of Matter; Atoms, Ions, and Molecules; Chemical Properties of Matter; Chemical Changes of Matter; and Explanations of Physical Changes.

- Other topics from other disciplines were not specifically intended for coverage in any of the eight grades. They include: Earth's Composition; Land, Water, Sea Resource Conservation; Material & Energy Resource Conservation; Pollution; and Human Nutrition.

- On a positive note, one topic, Energy Types, Sources, Conversions, was intended in four consecutive grades. This likely allows for very thorough development of content related to this topic.

(Figure 36)

## Science Topics Intended at Each Grade in the state of Minnesota

| Topics | Grade 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|---|---|---|---|---|---|---|---|---|
| Organs, Tissues | ● | | ● | ● | | | ● | |
| Physical Properties of Matter | ● | ● | | ● | | ● | | ● |
| Plants, Fungi | ● | ● | ● | ● | | | ● | |
| Animals | ● | ● | ● | ● | | | ● | |
| Classification of Matter | | | | | | ● | | |
| Rocks, Soil | | ● | | | ● | | | ● |
| Light | | | ● | | | ● | | |
| Electricity | | | | ● | | ● | | |
| Life Cycles | ● | ● | | | ● | | | |
| Physical Changes of Matter | | ● | | ● | | ● | | |
| Heat & Temperature | | | | ● | | ● | | ● |
| Bodies of Water | | ● | | ● | ● | | | ● |
| Interdependence of Life | ● | ● | ● | | ● | | ● | ● |
| Habitats & Niches | | | ● | | | | | |
| Biomes & Ecosystems | | | | | ● | | ● | |
| Reproduction | | | ● | | | | ● | |
| Time, Space, Motion | | ● | | | | ● | | |
| Types of Forces | ● | | | ● | | ● | | ● |
| Weather & Climate | ● | | | | | | | ● |
| Planets in the Solar System | | | ● | | | | | ● |
| Magnetism | ● | ● | | ● | | ● | | |
| Earth's Composition | | | | | | | | |
| Organism Energy Handling | | | | | ● | | ● | |
| Land, Water, Sea Resource Conservation | | | | | | | | |
| Earth in the Solar System | ● | | ● | ● | ● | | | ● |
| Atoms, Ions, Molecules | | | | | | ● | | |
| Chemical Properties of Matter | | | | | | | | |
| Chemical Changes of Matter | | | | | | ● | | |
| Physical Cycles | | | | ● | ● | | | ● |
| Land Forms | | | | | ● | | | |
| Material & Energy Resource Conservation | | | | | | | | |
| Explanations of Physical Changes | | | | | | | | |
| Pollution | | | | | | | | |
| Atmosphere | | ● | | | ● | | | ● |
| Sound & Vibration | | | ● | | | ● | | |
| Cells | | | | ● | | | ● | |
| Human Nutrition | | | | | | | | |
| Building & Breaking | | | | | ● | | | ● |
| Energy Types, Sources, Conversions | | | | | ● | ● | ● | ● |
| Dynamics of Motion | | ● | | | ● | ● | | |
| Organism Sensing & Responding | | | | | | | ● | |

Figure 36

## NUMBER OF SCIENCE TOPICS INTENDED IN MINNESOTA SCHOOLS BY GRADE LEVEL (OUT OF 41 TOPICS)

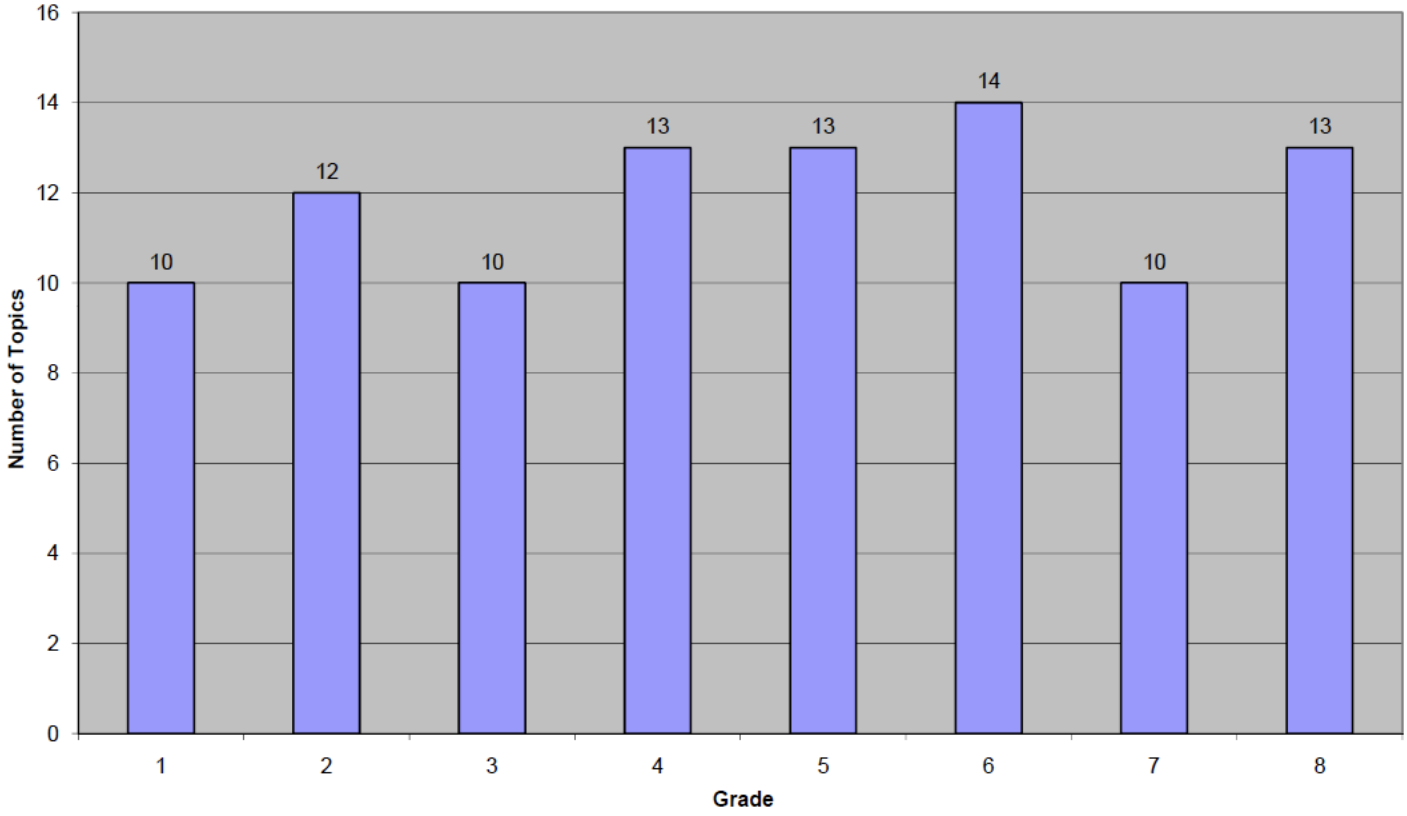


Figure 37

The above analysis is based upon implementation of the 2005 MN science standards. Those standards were revised in 2009 to address a number of concerns, including a number mentioned above. (Figure 37)

Figure 38 shows the comparison between 1995 and 2007 in time spent on the most important topics at grade 4 in science. Notice how the amount of time spent on "other" (non-important) topics is reduced in 2007. Figure 39 shows how the 2007 time spent compares to the international focus and TIMSS test.

Figures 40 and 41 show the same information for grade 8 science.

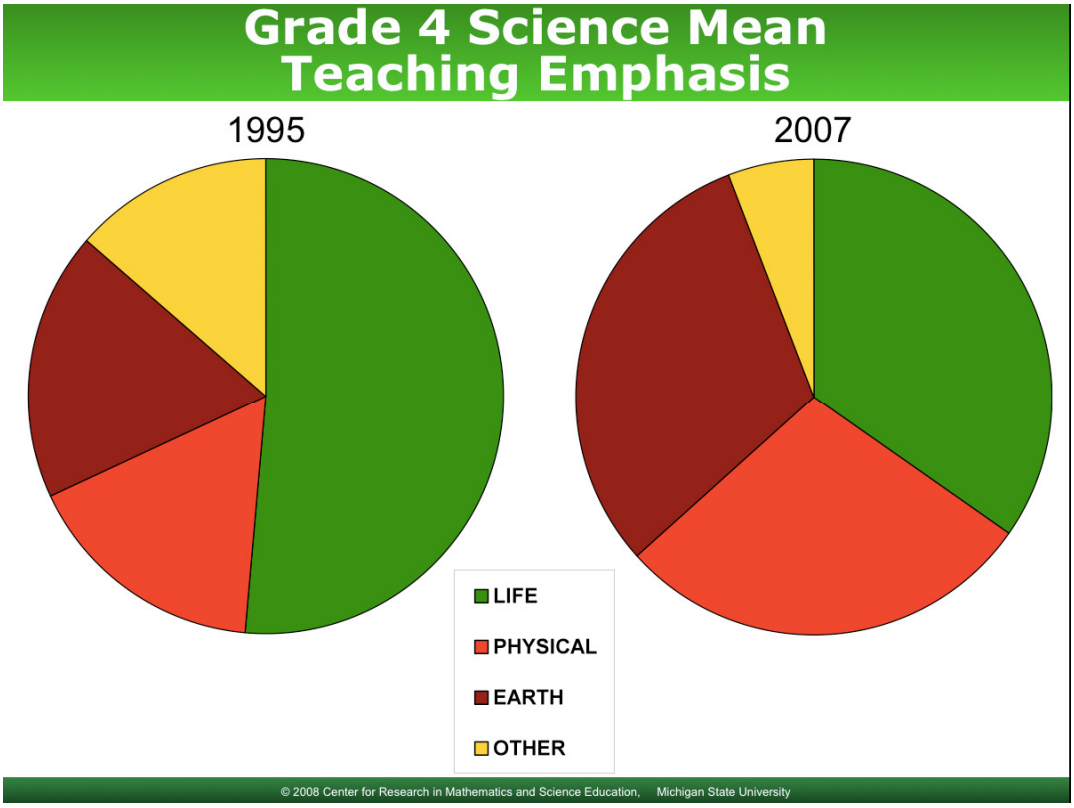


Figure 38

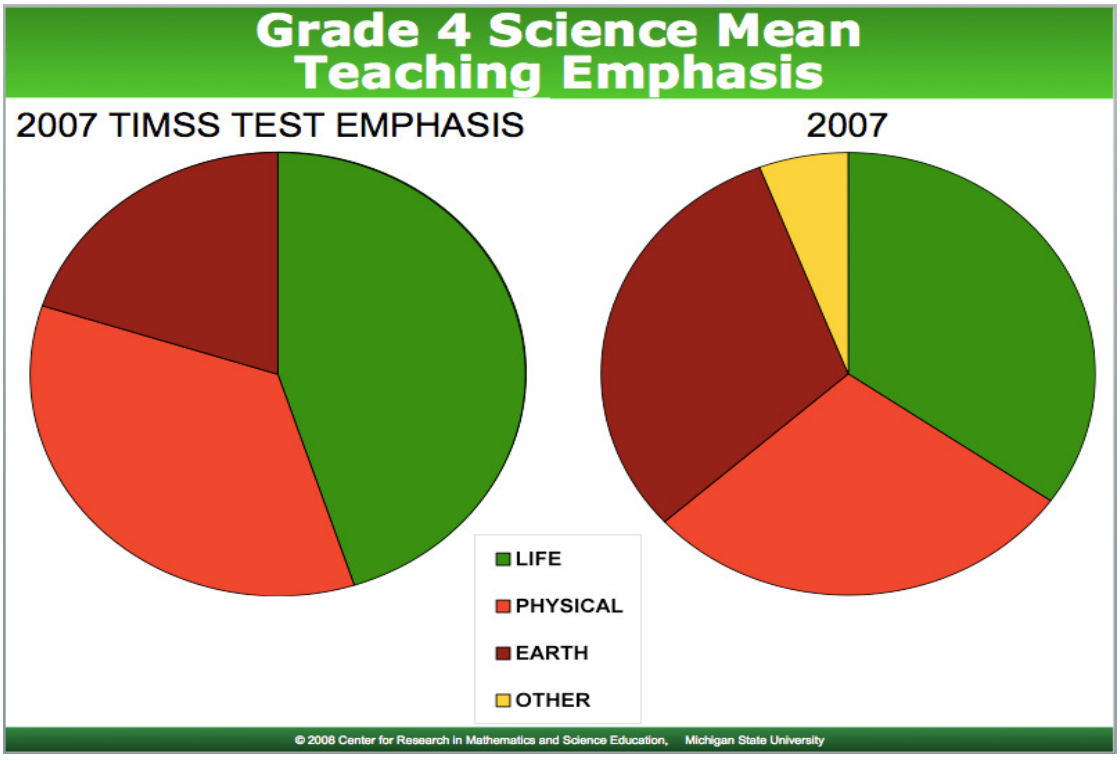


Figure 39

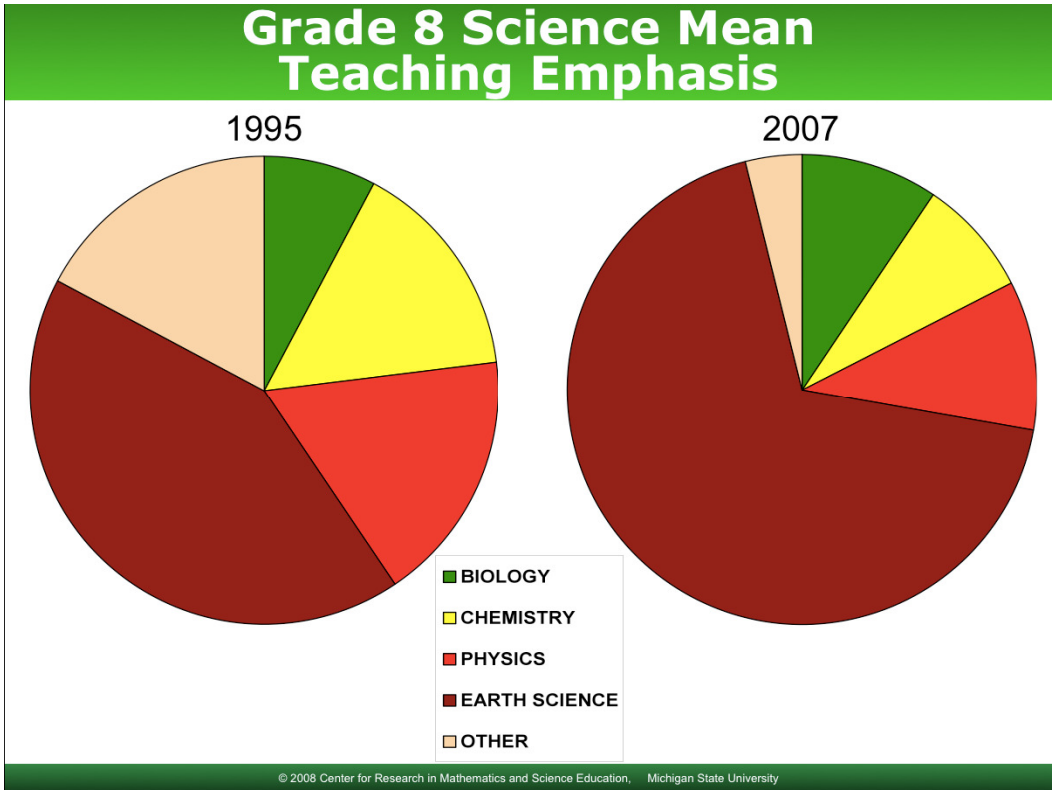


Figure 40

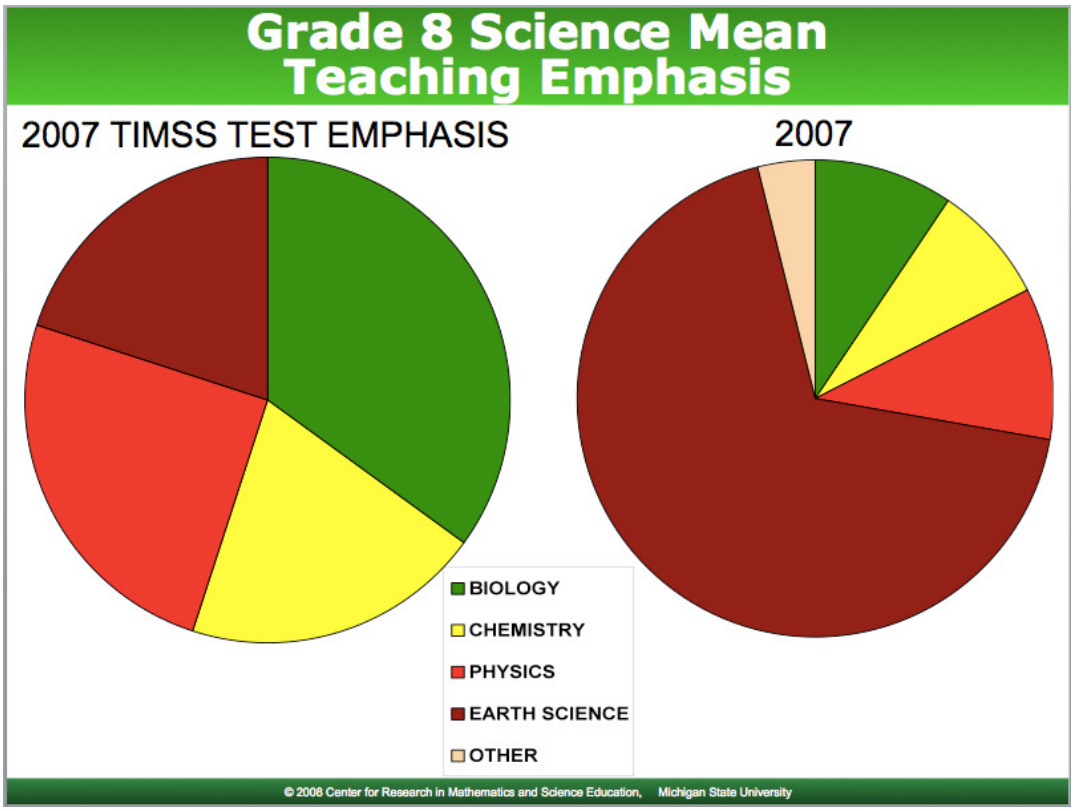


Figure 41

## CONCLUSIONS: WHAT CAN MINNESOTA LEARN FROM TIMSS 1995 AND 2007?

Minnesota has made great progress since 1995; it appears that internationally benchmarking our standards has brought significant benefit to our state in achieving a focused, rigorous and coherent set of standards.

For MN students, the competition for jobs will not be just the surrounding states - rather our students will compete for jobs globally and must be prepared to compete successfully at that level. Those nations are not standing still - and neither can Minnesota. We must seek to continually improve our standards and our success in delivering that information to all students.

The TIMSS substrand information provides excellent insight into which particular topics in math or science need greater emphasis in the curriculum. This may be best accomplished through development of Standards Frameworks and quality statewide staff development.

As the national efforts for Common Core Standards evolve, it may be possible to achieve efficiencies in resource development by collaborating with Massachusetts and other states.

It is clear that some Minnesota students are being left behind - particularly student subgroups that are in poverty. Though solutions to this problem have been elusive, the TIMSS analysis brings to light the fact that students in poverty are often not exposed to the correct level of rigorous content, therefore they might not even have the opportunity to learn that content.

Further analysis will bring additional insights into next steps for Minnesota educators and policymakers, especially in the area of Science. Check the SciMathMN website for updates to this TIMSS report. (www.scimathmn.org)

## FOR FURTHER INFORMATION ABOUT TIMSS…

For U.S. TIMSS Information:

- NCES U.S. TIMSS Website http://www.ed.gov/NCES/timss
- Boston College TIMSS Website http://timss.bc.edu/
- Michigan State University U.S. 1995 TIMSS Website http://ustimss.msu.edu

For Minnesota TIMSS Information:

- Call SciMath$^{MN}$ at 612-209-1739
- E-mail info@scimathmn.org
- Visit the SciMath$^{MN}$ website at www.scimathmn.org
- Summer 2008: Release of complete Minnesota TIMSS Report (expanded version of this preliminary summary) by SciMath$^{MN}$.
- This document as well as the preliminary report will be posted on the SciMath$^{MN}$ website and may be downloaded in full color to enhance the interpretation of graphs.

## ABOUT SCIMATH$^{MN}$…

Founded in 1993, SciMath$^{MN}$ is a partnership among business, education and state government pursuing statewide improvement in the teaching and learning of K-12 mathematics, science and technology education based on the national mathematics, science and technology education standards. SciMath$^{MN}$'s mission 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.

*SciMath[MN] gratefully acknowledges the generous support of the Minnesota Legislature, the Minnesota Department of Education, Michigan State University (under the leadership of William H Schmidt) and the following Minnesota businesses and organizations in ensuring the 2007 TIMSS participation, as well as the 2008-2009 analysis and informational events.*