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**Supporting Standards-Based Teaching and Learning in  
Mathematics and Science: Lessons from the Minnesota  
TIMSS Data**

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## **Section I: Introduction**

More and more school districts are consciously collecting and using a wide variety of data to inform their decision-making processes. This report is an effort to support Minnesota school districts in using data from the Third International Mathematics and Science Study (TIMSS) to assess the extent to which they are engaging in and supporting standards-based education in these two subject areas.

### **Reflecting on the National Standards**

Using data gathered from Minnesota school districts as part of the Third International Mathematics and Science Study (TIMSS), this report describes the contexts of science and mathematics education in Minnesota at the elementary (grades 3-4), middle (grades 7-8), and high school levels (grade 12). In doing so, it elaborates on issues of curriculum, instruction, and assessment and support for teaching and learning in light of the ideals expressed in the National Council of Teachers of Mathematics (NCTM) mathematics standards and the National Research Council (NRC) science standards.

The NCTM and NRC standards encourage educators to create classrooms where curriculum, instruction and assessment are aligned to promote in-depth investigation and minds-on engagement of students with the major concepts in science and mathematics. Such a setting requires that all students become firmly ensconced in a community of scholars; that is, in a challenging learning environment that fosters inquiry, communication of ideas, discussion, and a respect for evidence and the opinions of others. The standards also recommend ways that school environments can be supportive of teachers and students as they pursue this in-depth learning. Such support includes the opportunity for teachers to engage in substantive conversations and professional development with their peers, and the resources they need to deliver a curriculum that both challenges students and prepares them for the modern world.

The NCTM and NRC standards encourage educators to create classrooms where curriculum, instruction and assessment are aligned to promote in-depth investigation.
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### **International Studies of Mathematics and Science**

The Third International Mathematics and Science Study (TIMSS), was conducted in 1995. TIMSS included extensive data collection designed to examine science and mathematics achievement, the nature of curriculum and instruction, the school context, and other factors influencing teaching and learning in science and mathematics. The richness of the data is evident in the opportunity for an almost limitless number of analyses. Because the TIMSS are survey data, however, it is not possible to look at

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## Section I

our educational practices and outcomes as cause and effect. Rather, the data are intended to highlight the relationships between how we educate our children and what they learn.

The TIMSS data are a representative sample of students from elementary, middle, and upper secondary schools. Although data were collected at the school, teacher, and student levels they are best interpreted with students as the focal point. Having participated in TIMSS as a mini-nation, Minnesota has survey and achievement data that are both representative of the state and comparable to the US and other participating countries. International and national comparisons with the MN data are available from the Educational Testing Service (ETS).

Although ETS provided an overview of these data for Minnesota, their analyses did not consider differences within the state. This presents a serious obstacle for district-level planning since the geographic areas within Minnesota can be quite different in terms of their needs and available resources. For this report the data are coded to provide comparisons by location: urban (Minneapolis and St. Paul), suburban (the seven county metro area), non-metro cities (districts with K-12 populations greater than 2000 including Duluth and Rochester) and rural (districts with K-12 populations less than 2000).

It is not possible to look at our educational practices and outcomes as cause and effect. Rather, the data are intended to highlight the relationships between how we educate our children and what they learn.

Data collection for the TIMSS included school, teacher, and student questionnaires; student achievement tests in science and mathematics; videotapes of classroom instruction; and case studies. The school questionnaire was completed by the principal and asked about school characteristics, policies and procedures; offerings in mathematics and science; and the role of the principal in administrative and teaching activities. Mathematics and science teachers at the elementary and middle school levels completed surveys about their educational backgrounds, the contexts in which they teach, their perceptions of science or mathematics education, their use of different teaching techniques, and the topics covered in their classes. Students completed questionnaires about their social backgrounds and activities outside of school, their attitudes towards mathematics and science, and their school experiences. Elementary and middle school students also took achievement tests covering a variety of content areas in mathematics and science while 12<sup>th</sup> graders were tested on their science and mathematics literacy with an optional test for students taking more advanced science courses.

### How to Read and Use This Report

This report is intended for teachers, curriculum coordinators, school and district administrators, and policy-makers who wish to systematically examine how we educate our children in science and mathematics. It is

organized into five main sections, each of which begins with a summary of the Minnesota TIMSS data on key issues in science and mathematics education at the elementary, middle, and high school levels. At the end of each section are questions to guide educators in reflecting upon their practices at the classroom, school, and district levels and the extent to which these practices promote standards-based teaching and learning.

- Section II describes trends in mathematics and science achievement for elementary, middle, and high school students in Minnesota and places these results in a national and international context;
- Section III reviews what the TIMSS data tells us about students' attitudes and out-of-school activities;
- Section IV presents a picture of our mathematics and science teachers;
- Section V highlights key issues in mathematics and science curriculum, instruction, and assessment and in doing so gives us a sense of what goes on in our classrooms;
- Section VI considers the support for teaching and learning mathematics and science at all levels; and
- Section VII discusses the implications of the TIMSS data for Minnesota educators.

## Section II: Student Achievement in Science and Mathematics

This section examines trends in science and mathematics achievement across and within grade levels and by location. Also highlighted are the topics within each subject area on which our students perform well and areas in need of improvement. The primary measures of student performance in this report are the TIMSS total mathematics and science scores at the elementary and middle school levels and the total scores for mathematics and science literacy at the high school level.

### Minnesota in an International Context

Like their US counterparts, Minnesota's elementary and middle school students perform better in science than in mathematics and reasonably well in mathematics and science when compared to their peers internationally. By 12<sup>th</sup> grade, however, students in Minnesota and across the US have fallen far behind. Although both mathematics and science scores decline from middle school to high school, the decline in Minnesota's mathematics scores is less than the US decline and less than the decline in science scores at either the state or national level (see Figure 1).

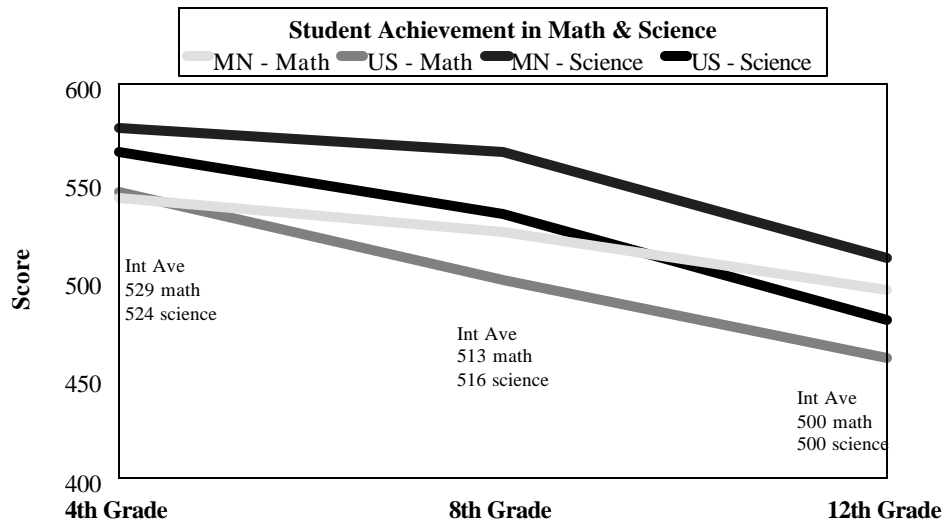


Figure 1: Student Achievement in Math & Science

**Elementary**

Minnesota's 3<sup>rd</sup> and 4<sup>th</sup> graders do well in the international comparisons in both mathematics and science, performing slightly better in science than in mathematics. Our students do particularly well, scoring higher than the international average, in four of the six areas tested (whole numbers; data representation, analysis and probability; geometry; and patterns, relations, and functions) and lower in only two areas (fractions and proportionality; and measurement, estimation, and number sense). In science Minnesota students are higher than the international and US averages in all four areas: life science, earth science, physical science, and environmental issues and nature of science. Minnesota students are highest in life science and lowest in environmental issues as is true internationally.

Minnesota's 3<sup>rd</sup> and 4<sup>th</sup> graders do well in the international comparisons in both mathematics and science.

**Middle School**

Minnesota students' achievement in mathematics and science remain fairly consistent from elementary to middle school while US scores decrease more dramatically. Consequently, Minnesota students score above the international averages and significantly higher than their US peers do in both subjects. As is true at the elementary school level, Minnesota's 7<sup>th</sup> and 8<sup>th</sup> grade students also do better in science than in mathematics. Minnesota students perform above the international average in fractions, algebra and data representation; analysis and probability; below the international average in measurement and geometry; and at the international average in proportionality. Minnesota students score above the international average in all five areas of science. The area of science closest to the international average is physics. The highest areas are earth and life science. Minnesota students score significantly higher than the US students do in earth science.

Minnesota students' achievement in mathematics and science remain fairly consistent from elementary to middle school.

**High School**

At the 12<sup>th</sup> grade level, Minnesota students score just above the international mean in the combined assessment of mathematics and science literacy and significantly better than students in the US. On the individual science and mathematics assessments, the mean score in mathematics is just below the international average and the mean score in science significantly above. These science and math literacy test items focus on reasoning and social utility and were chosen based on their likelihood of arising in real life situations. The mathematics items address number sense including fractions, percentages and proportionality, algebraic sense, measurement, estimation, and data representation and analyses. The science test contains items organized according to three areas of science: life, earth and physical. Scores for different content areas within science and mathematics are not provided.

By 12<sup>th</sup> grade students in Minnesota and across the US have fallen far behind.



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## Section II

### At Home in Minnesota

When the achievement of Minnesota students is examined by location, students attending urban schools have the lowest scores in mathematics and science – below the international average – while students in suburban or large cities tend to score the highest (see Figures 2 and 3).

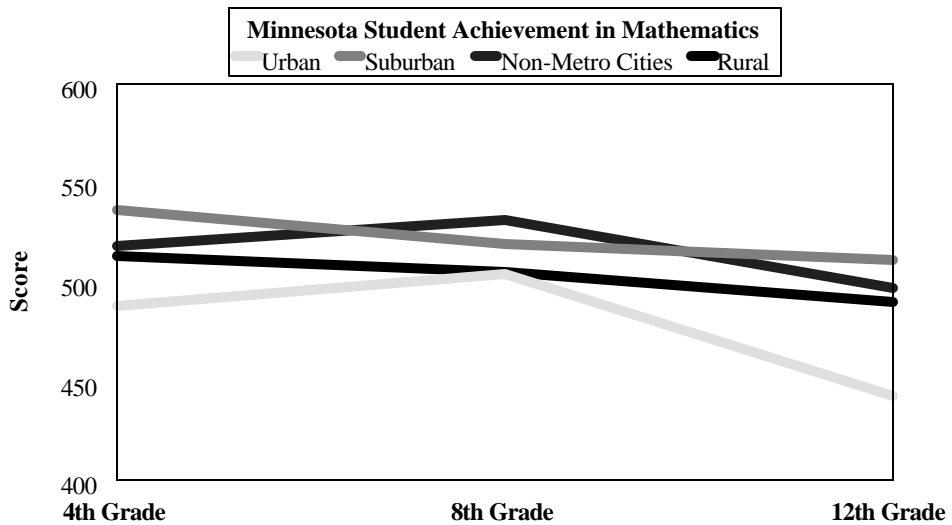


Figure 2: Minnesota Student Achievement in Mathematics

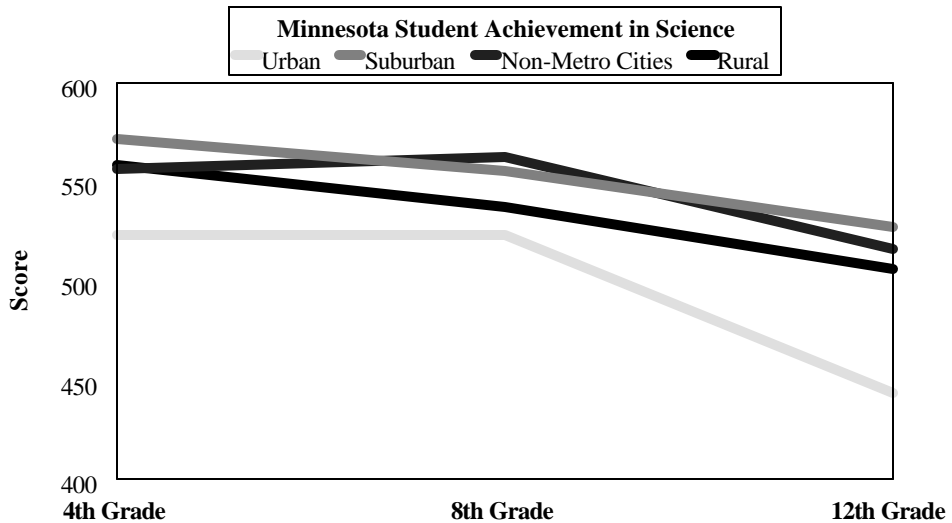


Figure 3: Minnesota Student Achievement in Science

## Questions for Reflection

- What level of achievement is appropriate for our students?
- What might account for the relative decline in mathematics and science achievement from 4<sup>th</sup> to 12<sup>th</sup> grade? What might explain the less precipitous drop in mathematics?
- Are different comparative levels of achievement attained by our students in different grade levels? What factors might be related to these differences? What can be done to improve achievement at all levels?
- What factors might explain the differences in achievement attained by students in the different locations? Would influencing any of these factors help our students learn more?

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## Section III

### Section III: The Students

The effectiveness of teaching practices and the impact on learning depends to some extent on the characteristics of students, their attitudes toward learning, and how they spend their time outside of school. This section draws upon data gathered from questionnaires administered to students at the elementary, middle, and high school level.

When compared to the United States as a whole, Minnesota's children experience less racial diversity, are more likely to live in rural areas, and less likely to live in poverty.

#### Demographics

When compared to the United States as a whole, Minnesota's children experience less racial diversity, are more likely to live in rural areas, and less likely to live in poverty. Eighty-eight percent of Minnesota's school-age children are enrolled in public schools, 65% live in urban areas, 91% are Caucasian, and only 12% live in poverty.<sup>1</sup>

#### Students' Attitudes towards Science and Mathematics

Achievement is based, in part, on students' motivation or desire to do well. This desire stems both from the value the student places on doing well and the extent to which he or she believes it is valued by others. The TIMSS data indicate that Minnesota elementary and middle school students are highly motivated in mathematics and science. They also believe they are doing well. By 12<sup>th</sup> grade, however, these feelings become more mixed.

#### Why do well?

Students in Minnesota and the US at all levels are more likely to think they are doing well in mathematics and science than students in the higher performing countries. They also tend to enjoy learning these subjects and find them interesting and easy to learn. The only real difference in student engagement by location within Minnesota is that the elementary students in urban areas are less likely to find mathematics and science easy.

Although 12<sup>th</sup> graders believe they do well in science and mathematics, their enthusiasm for these subjects wanes. Minnesota high school students are mixed in their attitudes toward mathematics with fewer high school students than elementary or middle school students saying mathematics is

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<sup>1</sup> School District Data Book v. 1.0 [Alaska-Oregon, SDDB 04] on CD-ROM / an information resource of the National Center for Education Statistics, U.S. Department of Education. Developed by The MESA Group, 1995. Available: <http://govinfo.library.orst.edu/stateis.html> [27 July 1999].

enjoyable (58%), interesting (54%), and easy (41%). Additionally 63% say they like mathematics or like it a lot. For science 64% like (or like a lot) biology, 48% like chemistry, 67% like earth science and 38% like physics. These findings are consistent with other countries and the US.

Students in Minnesota at all three grade levels want to do well in mathematics and science and believe that their mothers and their friends also want them to do well. Belief in the importance of doing well declines from elementary through high school. Students generally believe that doing well is less important to their peers than to themselves or their mothers. Students at all grade levels also believe it is more important to do well in mathematics than in science.

Belief in the importance of doing well declines from elementary through high school.
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The middle school data show the different perceptions students have about themselves and their peers in terms of the importance of doing well in mathematics and science. Over half the students agree strongly that they believe they should do well in mathematics (59%) and science (52%). In contrast, only a small percentage of students agree strongly that their friends think it is important to do well in these subjects.

The high school data demonstrate the differences in perceived importance for mothers and students. High school students from all districts overwhelmingly (over 90%) report that their mothers and fathers feel it is important for them to do well in mathematics while only 87% feel it is important to themselves.

There are relatively few geographic area differences in these items within any of the grade levels. For elementary students doing well overall is perceived as somewhat less important in the urban area than the other locations. Middle school students from rural areas are lowest on the importance students believe their mothers place on science. There are no differences for the high school students.

Middle school students were asked why it was important to do well in mathematics and science. For middle school students, the most important reason to do well in both mathematics and science is to get into a desired school. Other important reasons for doing well in mathematics are to get a desired job and to please themselves. In science, wanting to please themselves and please their parents are other key reasons. Interestingly, the perceived link between doing well in mathematics and getting a good job is much stronger (43%) than it is for science (27%).

High school students were not asked why it was important to do well. They were asked if they wanted a job that uses mathematics. Only 39% of these 12<sup>th</sup> graders said they would.

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### Section III

#### What does it take to do well?

Students were asked to what extent doing well in mathematics and science could be attributed to natural talent, luck, or hard work. Across grade levels, students agree that being successful in these areas does indeed take some hard work. They are less in agreement as to what else is required.

Unfortunately, most elementary students in Minnesota believe it takes natural talent to do well in mathematics and science.

Fortunately, most elementary students agree that they need to study hard to do well in mathematics and science. This sentiment is consistent across locations. Unfortunately, most elementary students in Minnesota also believe it takes natural talent to do well in mathematics and science with this belief being even stronger in urban areas. Finally, about half of the elementary students believe it takes good luck to do well in mathematics and science and this is especially true for students in the urban and rural areas. (See Figures 4 and 5).

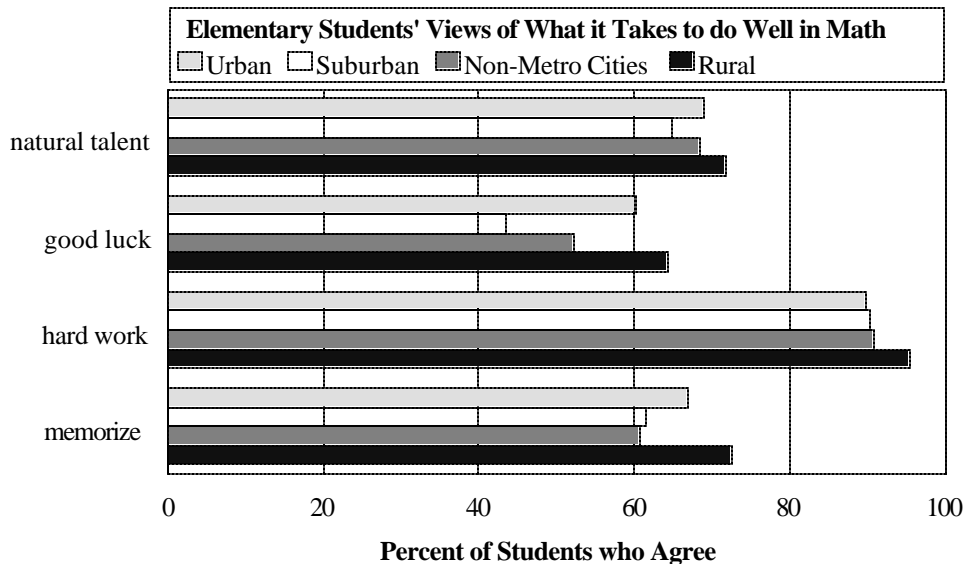


Figure 4: Elementary Students' Views of What it Takes to do Well in Math

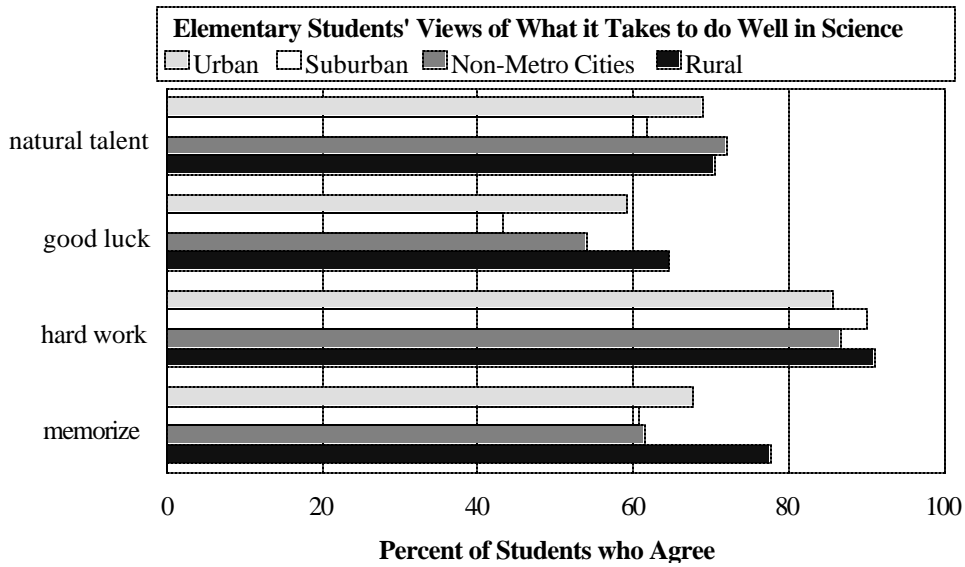


Figure 5: Elementary Students' Views of What it Takes to do Well in Science

Middle school students also believe that hard work and studying are important to success in mathematics and science. They are more mixed in their opinions of what else it takes to do well in mathematics. Beliefs about what it takes to do well in science are much the same as those about mathematics although memorizing notes takes on increased importance. (See Figures 6 and 7).

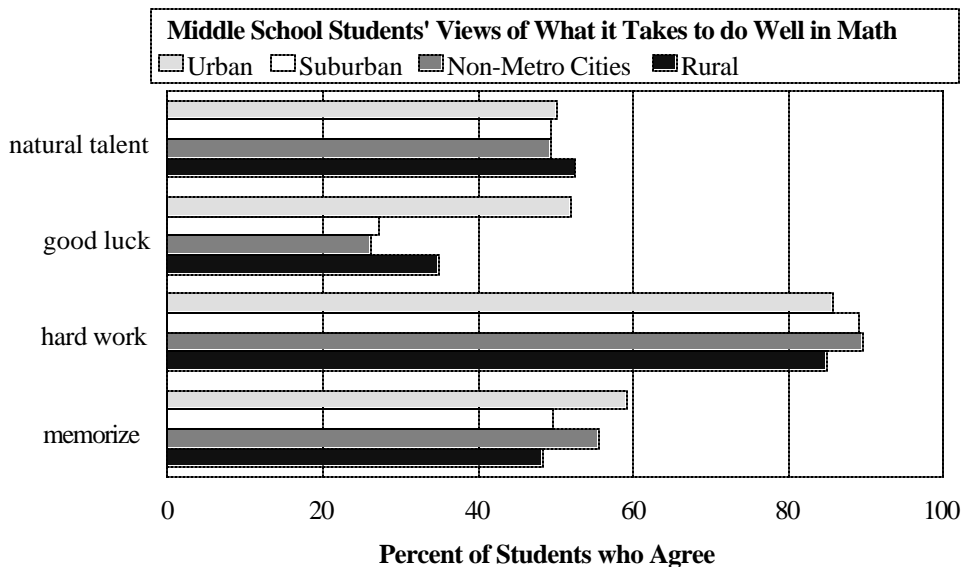
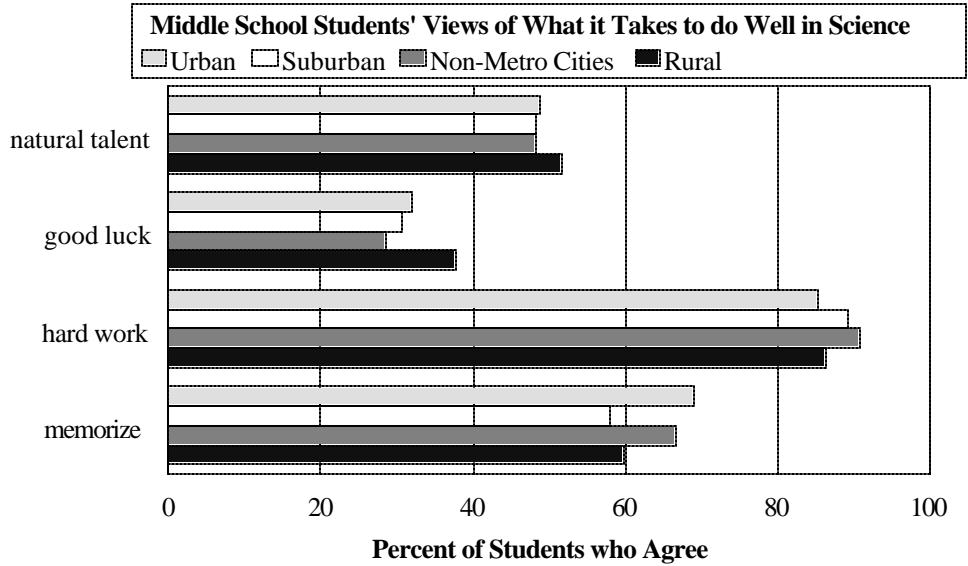


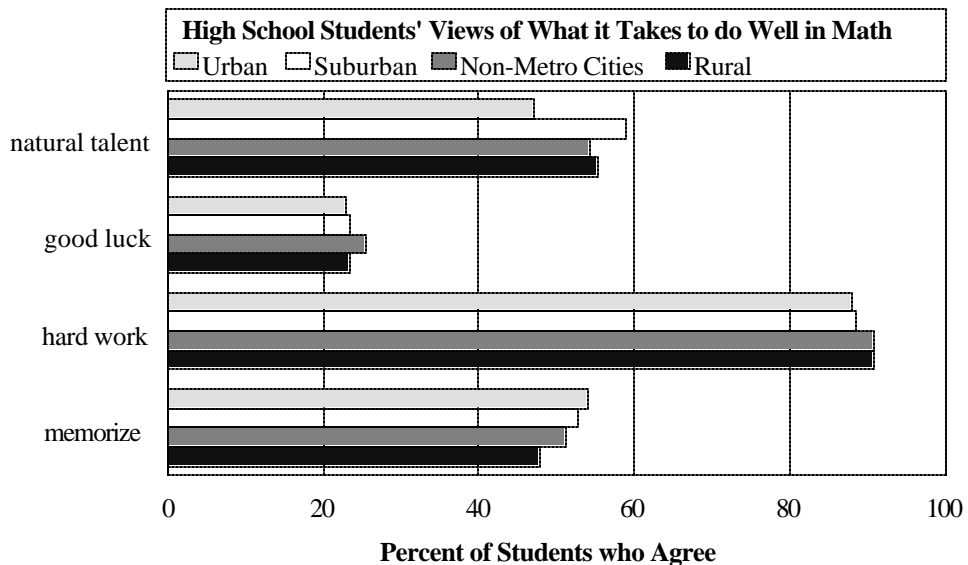
Figure 6: Middle School Students' Views of What it Takes to do Well in Math

**Section III**



**Figure 7: Middle School Students' View of What it Takes to do Well in Science**

Most high school students also feel that doing well in mathematics takes lots of hard work studying although many also think it takes lots of natural talent. Students are even more likely to think that success in science comes through hard work and just as likely as to think that, like mathematics, doing well in science is a result of natural talent. Urban high school students are least likely to believe in the necessity of natural talent. (See Figures 8 and 9).



**Figure 8: High School Students' Views of What it Takes to do Well in Math**

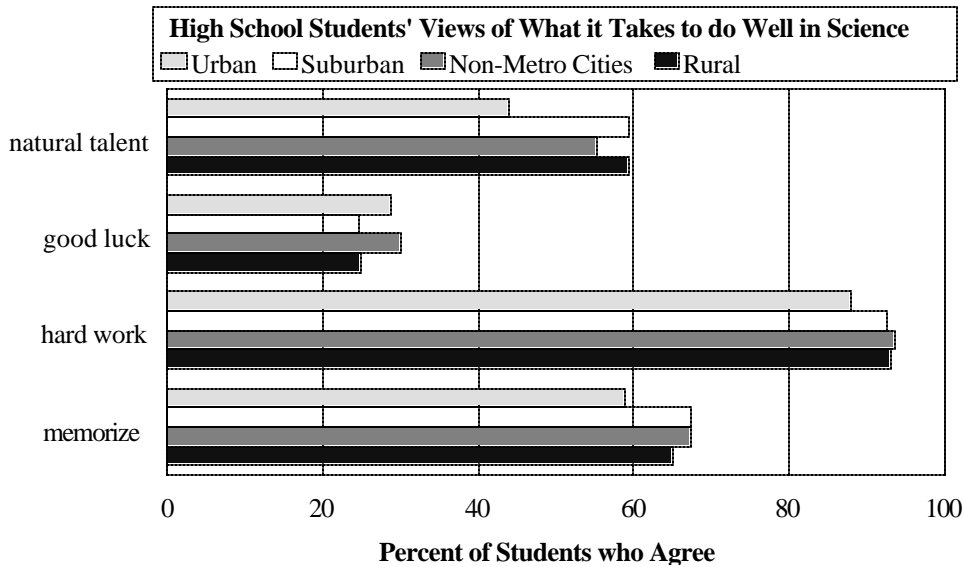


Figure 9: High School Students' Views of What it Takes to do Well in Science

### Students' Out-of-School Activities

How students spend their time outside of school, particularly the amount of time spent on homework, watching television, and working at a job, has an impact on their academic performance. Minnesota students are very similar to students elsewhere in the world except for the large numbers who work outside of school and the little time spent on homework at the high school level.

#### Homework

Minnesota students are similar to their peers internationally in the amount of time they spend on homework outside of school. The relationships between student achievement and homework at the elementary and middle school levels show that moderate or average amounts of homework are associated with higher achievement; that is, students who spend very little or a lot of time on homework do not perform as well. For high school students, there is no correlation between amount of homework and scores on the TIMSS achievement tests.

Students who spend very little or a lot of time on homework do not perform as well.

The majority of elementary school students in Minnesota spend less than 1 hour per day studying mathematics or doing mathematics homework and about ½ an hour per day studying science. About 8% of Minnesota students reported spending no time on mathematics outside of school while 25% spend over 1 hour. In science, 15% of elementary students spend no time on this subject outside of school while another 15% spend more than 1 hour. Students in urban schools are more likely to work on mathematics outside of school than students in other locations.



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### Section III

At the middle school level, students typically spend about the same amount of time on mathematics outside of school as their elementary counterparts (1 hour/day) but are twice as likely to report having no mathematics homework (17%). In science, these students spend less than 1 hour per day on homework with 25% having none at all. At this grade level, students attending schools in suburban areas and non-metro cities are more likely to have mathematics homework. In science, the trend is reversed for students attending schools in non-metro cities – they are the least likely to have homework in this subject.

On average, about half of Minnesota’s 12<sup>th</sup> graders spend no time on mathematics or science homework outside of school. This is consistent with the numbers of twelfth graders actually enrolled in science or mathematics classes. For the students who do have homework, 1 out of 3 is spending less than an hour on each of these subjects. This is significantly less than the international average of 2 to 4 hours of homework each day. When the data are examined by location, it shows that high school students in urban areas are more likely to have mathematics and science homework than their peers elsewhere.

Elementary and middle school teachers were asked to choose the types of homework assignments they require and to describe how the homework is used. Several factors are true of both levels. Homework is mostly routine and often consists of worksheet-type exercises, while keeping a journal is the least common type of homework assignment. Teachers say they ‘sometimes’ use the homework as a basis for discussion. There are really no differences among the teachers from the different geographic areas.

Homework is mostly routine and often consists of worksheet-type exercises, while keeping a journal is the least common type of homework assignment.

Elementary school teachers most often assign worksheets or workbooks, problems or question sets in the textbook, and data gathering for small investigations. They ‘sometimes’ use homework for grading.

Middle school mathematics teachers most often assign textbook problems followed by worksheets while middle school science teachers most often assign worksheets followed by data collecting for small investigations. More middle school teachers than elementary school teachers ‘always’ use homework for grading.

#### Television Watching

As is true for all of the countries participating in TIMSS, in Minnesota elementary and middle school students are most likely to be watching television 1 to 2 hours per day. Students watching this level of television are also more likely to be the highest achievers.

Roughly 1 out of 4 elementary students in Minnesota watch more than 3 hours of television per day; 1 out of 3 watch less than an hour. Students in urban areas watch the least television on a daily basis. In general, students who watch more than 4 hours per day have lower achievement.

At the middle school level the lowest achieving students watch more than 5 hours of television each day. This is true for 9% of the middle school students in Minnesota with students from urban areas being the ones most likely to fall into this category.

As is true in most countries including the US, in Minnesota most high school students spend less than 2 hours a day watching television. In Minnesota half of the students spend less than 1 hour a day. The highest achieving students watch less than 2 hours of television a day. Achievement drops for those watching 3 hours or more which, in Minnesota, accounts for 13% of the students. Students in urban and rural areas watch the least amount of television.

### **Working at a Job**

At the middle school level, not working or working less than 1 hour are associated with higher achievement. Surprisingly, 2 out of 5 Minnesota middle school students hold a paying job outside of school. Students in urban and rural areas are somewhat more likely to have a job. Minnesota's 12<sup>th</sup> graders work far more hours at paying jobs than students around the world with 65%, or 2 out of 3, working 3 or more hours per day. Outside of the US and Canada, no country has more than 30% of its high school students working this much. The amount of time our middle and high school students are spending at work seems to be reflected in their achievement with students who work more scoring lower in both mathematics and science.

### **The Home Environment**

In addition to spending time on their studies outside of school, students need a home environment that supports learning. Students who have more books in their home and access to such common educational resources as a dictionary, computer, and a special place to study are more likely to do better in school. In contrast to many other countries but not as high as some, the US and Minnesota students come from households that have many materials supportive of learning such as the presence of computers and large numbers of books.

Over half of Minnesota's elementary school students have a computer at home (57%) and most have a special place to study (85%). Almost all students have access to reference materials such as a dictionary (93%) and

Minnesota's 12<sup>th</sup> graders work far more hours at paying jobs than students around the world with 65%, or 2 out of 3, working 3 or more hours per day.

Students who work more score lower in both mathematics and science.

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### Section III

58% have a set of encyclopedias. The presence of a large number of books in the home (90% of students have at least one entire bookcase or 26 to 100 books and 38% have 200 or more books) indicates the value placed on literacy. Students in urban areas are less likely to have many books with 12% having few or none and 14% having enough to fill only one shelf (as compared to 4% and 7% overall). They are, however, more likely than students living in other locations to have access to a home computer (62%). Students in rural areas are more likely to have a set of encyclopedias (69%) than a computer (46%).

Middle school students in Minnesota are more likely than elementary students to have a computer at home (63%) and a special place to study (93%). They are also very likely to have reference materials such as a dictionary (98%), a set of encyclopedias (68%), and a large number of books in general (87% of students have at least one entire bookcase or 26 to 100 books and 34% have 200 or more books). Students in urban areas tend to have fewer books with 10% having few or none (compared to 5% overall) and fewer having encyclopedias (58%). Students living in the suburbs are the most likely to have a computer at home (72%) and rural areas the least (56%).

High school students in Minnesota are also more likely than elementary students to have a computer at home (63%) and a special place to study (93%). They are also very likely to have reference materials such as a dictionary (99%) and a large number of books in general (84% of students have at least one entire bookcase or 26 to 100 books and 32% have 200 or more books). Students in urban areas tend to have fewer books with 11% having few or none (compared to 5% overall). Those living in the suburbs are the most likely to have a computer at home (73%).

### Questions for Reflection

- How might the characteristics of students in our science and mathematics classes might affect their opportunity to learn?
- What are students' attitudes towards science and mathematics? Are students excited about learning mathematics? Science? What might teachers do to get them more involved and engaged?
- When students come to school, how prepared are they to learn? What factors outside of school may affect their performance in school?

## **Section IV: The Teachers**

Teachers' demographic characteristics, their training, and years of experience all influence teaching and learning. Unfortunately the TIMSS survey had only very limited information on elementary and middle school teachers and no data on high school teachers.

### **Elementary School Teachers**

Minnesota's elementary school teachers are generally female (79%), over 40 years of age (67%), have a bachelors degree (57%), and have been teaching an average of 17 years.

At this grade level, the urban areas tend to have younger teachers and the rural areas older teachers. The elementary teachers in urban areas are also the most likely to have advanced degrees. On average, elementary teachers in non-metro cities have the fewest years of teaching experience (14 years) while those in suburban schools tend to have the most teaching experience (19 years). Male teachers are also more likely to be found in schools in urban areas and non-metro cities (27% and 26% respectively).

### **Middle School Mathematics Teachers**

Minnesota's middle school mathematics teachers are generally male (55%), over 40 years of age (57%), have a bachelors degree (66%), and have been teaching an average of 15 years.

Middle school mathematics teachers in urban areas are more likely to be younger and less experienced than their peers in other locations. Years of teaching also vary by location with teachers in urban schools averaging only 5 years and those in rural areas averaging 18 years. Teachers in urban areas are the least likely to have a Master's or Ph.D. while half of the mathematics teachers in suburban areas have these advanced degrees. Although overall there are slightly more men than women teaching mathematics at the middle school level, the urban area and non-metro cities are more likely to have female teachers while suburban and rural areas are more likely to have men teaching this subject.

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## Section IV

### Middle School Science Teachers

Minnesota's middle school science teachers are generally male (57%), over 40 years of age (69%), are just as likely to have a bachelors or a more advanced degree (50-50), and have been teaching an average of 17 years.

As is true of mathematics, more men tend to teach middle school science in Minnesota. This trend is especially evident in the urban area and non-metro cities (over 70%) and less likely to be seen in the suburbs where more women teach science. The age and experience of middle school science teachers is also very similar to those for the mathematics teachers. However, science teachers in schools located in non-metro cities and rural areas have, on average, been teaching longer than their peers in urban and suburban locations. Finally, while middle school science teachers are more likely to have a master's or Ph.D. than mathematics teachers are, this is less likely to be true of those in rural areas.

### Questions for Reflection

- Who are our mathematics and science teachers? How do they differ by subject? By grade level?
- To what extent do the characteristics of our teachers reflect those of our students?
- Are many of our teachers ready to retire? If so, when new teachers are hired how will we introduce them to our goals, objectives, and methods?

## Section V: Curriculum, Instruction and Assessment

This section examines curriculum, instruction and assessment practices in Minnesota. Utilizing data from the TIMSS teacher questionnaires at the elementary and middle school levels. Students' perspectives on classroom practices at all three levels are also presented. Curriculum is exemplified through allocated time, topics covered, instructional material and decision bases. Instruction is exemplified through teaching philosophy, sequencing of lesson activities, lesson processes and cognitive tasks. Assessment is represented by time spent, by teachers developing and scoring assessments, and by how assessments are used.

### The Mathematics and Science Curricula

Substantial amounts of school time are allocated to mathematics and science and many topics are covered. The curriculum is predominately textbook-based and heavily influenced by individual teachers and principals. When compared to other countries, the science and mathematics curricula in Minnesota and the US lack rigor, focus and coherence. Minnesota students appear to perform better in areas that are emphasized in the curriculum.

When compared to other countries, the science and mathematics curricula in Minnesota and the US lack rigor, focus and coherence.

### Time Allocated for Mathematics and Science

At the elementary school level more time is allocated each week to mathematics (8.3 hours) than to science (7.7 hours). This is especially true in urban areas (6.6 vs. 4.0 hours/week). Non-metro cities, however, spend the most time on mathematics and science with 5 hours each in mathematics teaching and related planning and 4 hours on each of these tasks in science. The largest differences among the population areas are for mathematics related work with a range of 2 hours for teachers in urban schools and 5 hours for those teaching in non-metro cities.

Minnesota students appear to perform better in areas that are emphasized in the curriculum.

Middle school teachers also spend a large proportion of their time preparing for and teaching science and mathematics. Mathematics teachers at this level spend an average of 7.2 hours per week preparing for mathematics classes and 21.5 hours teaching them. Science teachers spend 7.3 hours preparing for and 21.3 hours teaching science classes. This averages out to teaching approximately 5, 50-minute sections of mathematics or science each day.

Tracking is essentially nonexistent in either mathematics or science at the elementary school level except in a very small percent of the suburban schools. Mathematics classes at the middle school level are tracked in 81% of the schools overall. Urban and suburban schools are most likely to have

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## Section V

tracked mathematics classes. In contrast most science classes (88%) are not tracked and this is especially true in the urban area.

### Topics Covered

In grades 3 and 4, the number of topics taught in each subject area is above the international average in mathematics and slightly below the international average in science. Overall, the elementary students appear to perform best in the areas most emphasized by the curriculum and worst in the areas least emphasized. For example, elementary students perform poorly in fractions and proportionality and nature of science, topics not as commonly covered (see Figures 10 and 11). Further examination of the data shows that the topics taught in 4<sup>th</sup> grade mathematics are the same as those taught the preceding year.

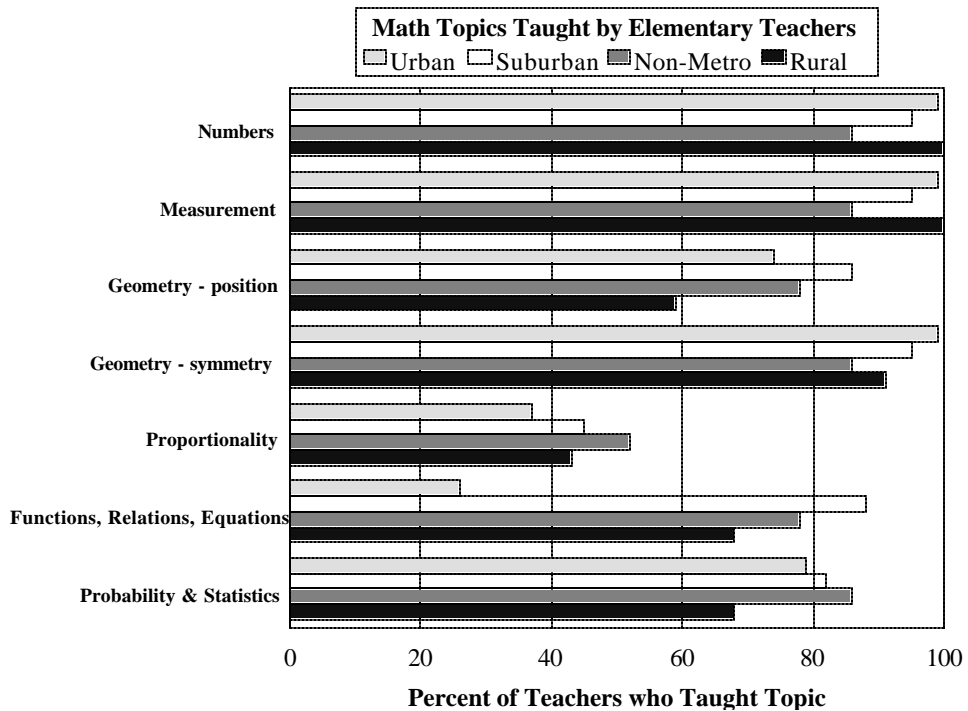


Figure 10: Math Topics Taught by Elementary Teachers

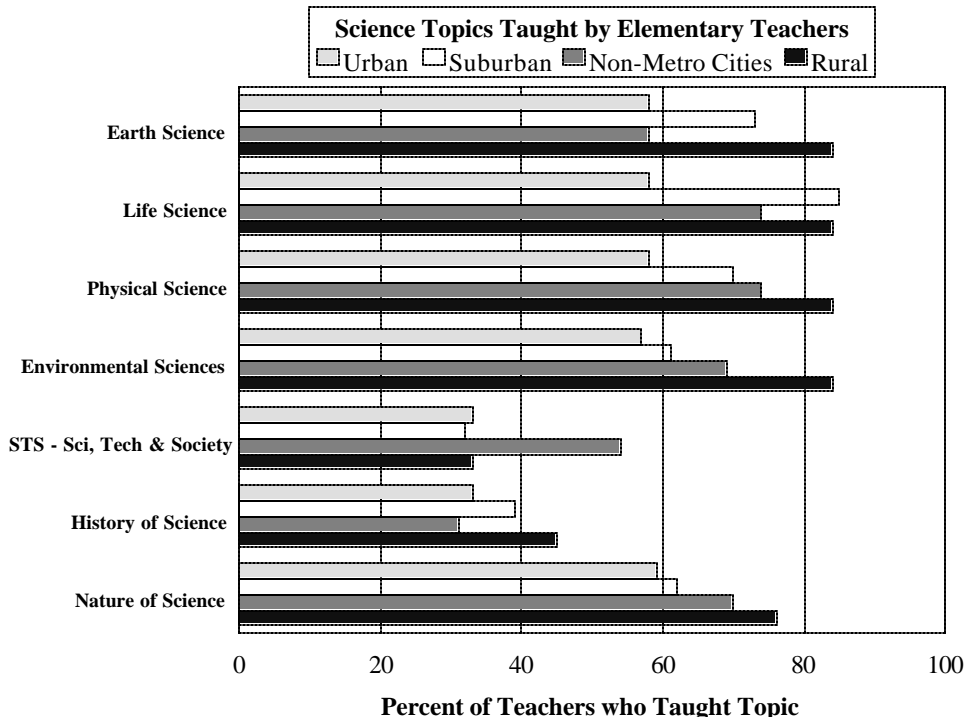
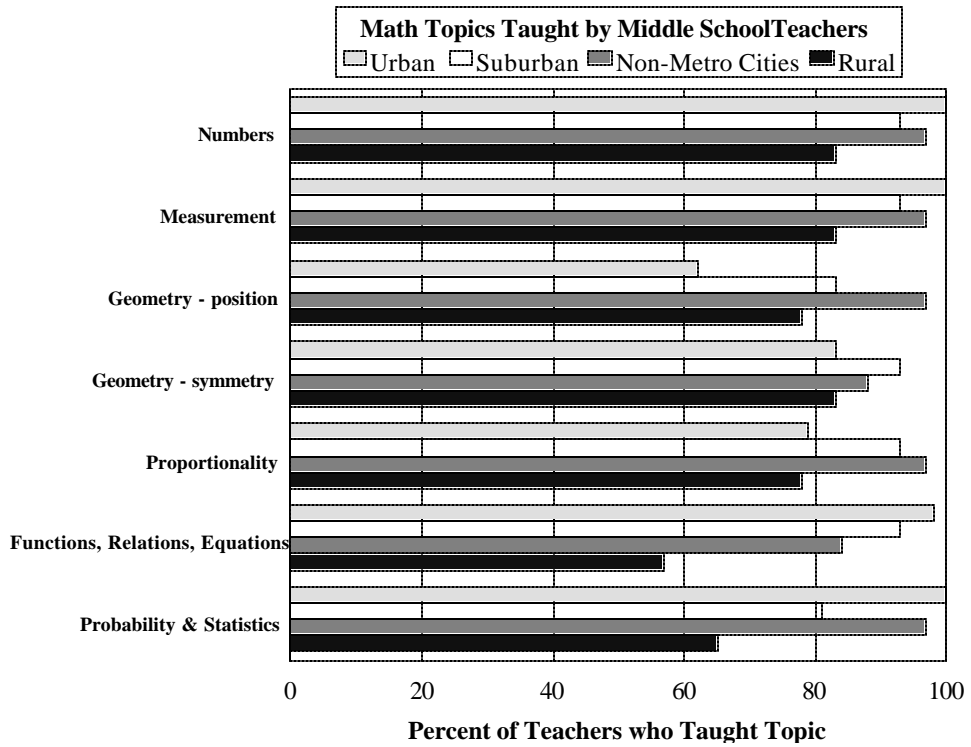


Figure 11: Science Topics Taught by Elementary Teachers

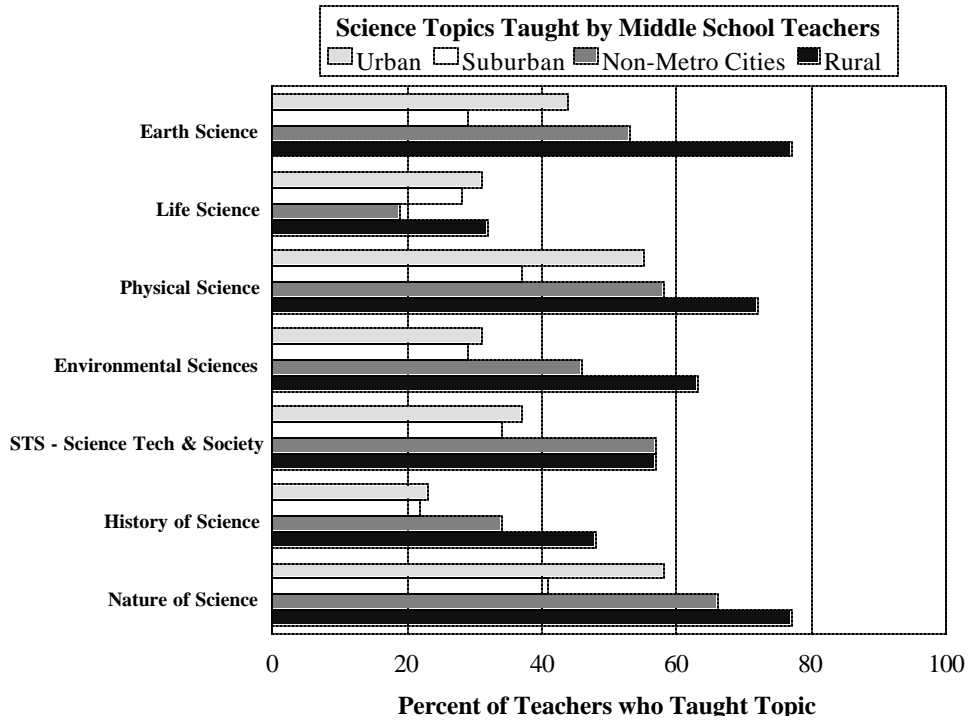
In reviewing the topics taught to Minnesota’s 7<sup>th</sup> and 8<sup>th</sup> graders, it again appears that students learn what they are taught. For example, our students perform poorly in measurement and geometry but highest in the world in earth science, the typical Minnesota 8<sup>th</sup> grade science course (see Figures 12 and 13). Interestingly, rural areas tend to have the smallest percentage of teachers teaching math topics, but the largest percentage of teachers teaching science topics.



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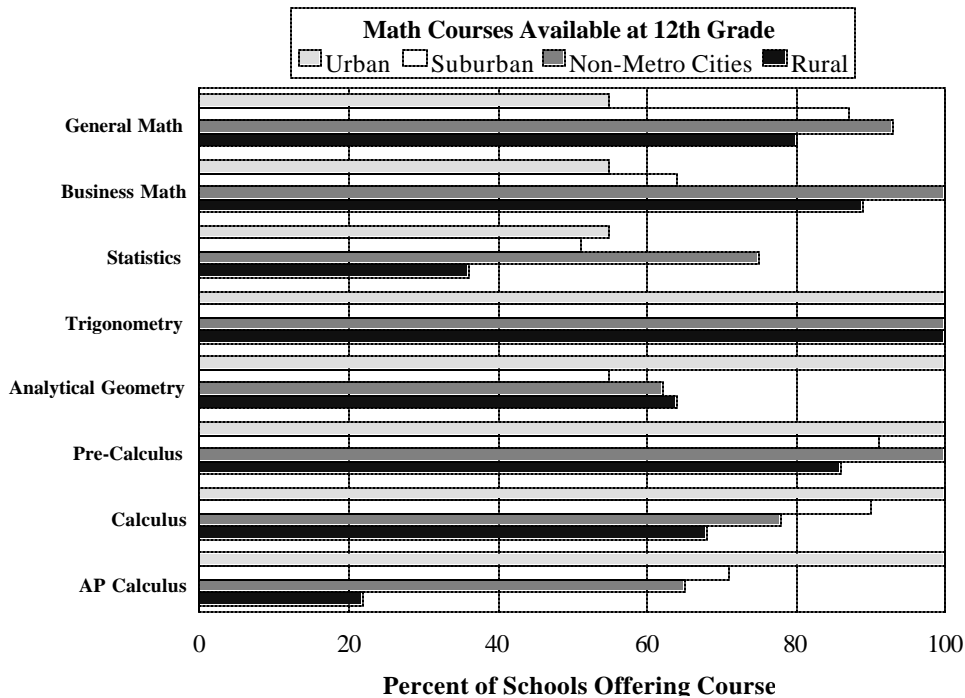
**Figure 12: Math Topics Taught by Middle School Teachers**



**Figure 13: Science Topics Taught by Middle School Teachers**

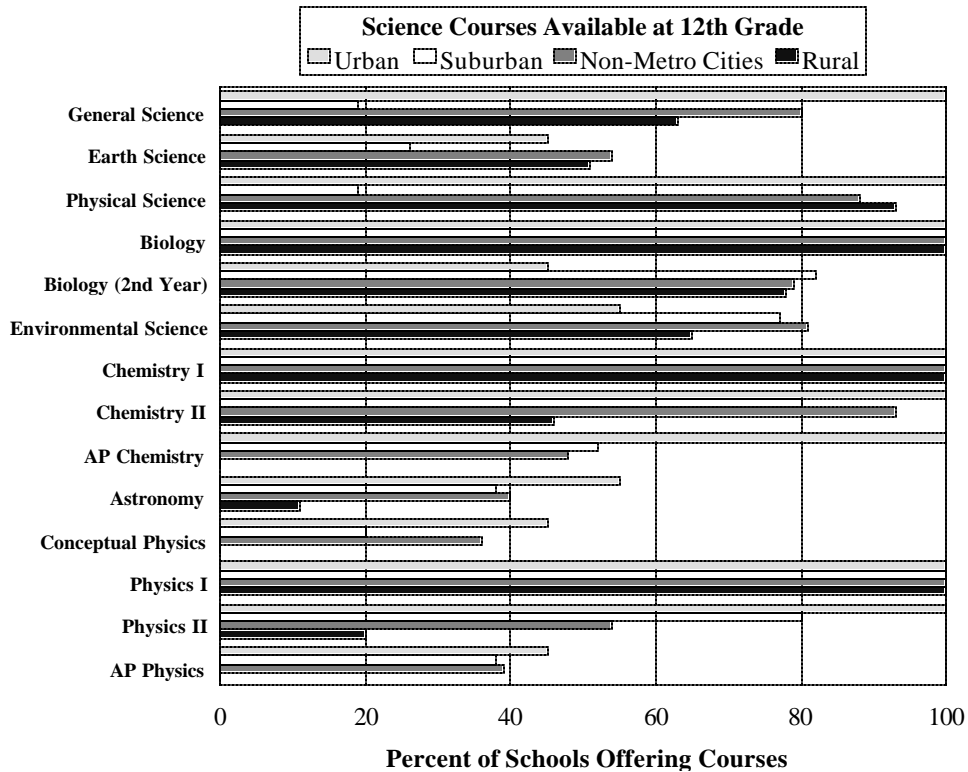
At the high school level in Minnesota and the US, enrollment in mathematics and science courses is not mandatory, while many other countries require science and mathematics throughout high school. In 9 countries 85% or more grade 12 students are taking mathematics compared to 50% in Minnesota and 34% in the US. The pattern is similar for enrollment in science during the final year of high school. In Minnesota 64% of the 12<sup>th</sup> graders are taking science compared to 63% in the US.

While the mathematics topics on the TIMSS 12<sup>th</sup> grade achievement tests are typically covered by about the 7<sup>th</sup> grade in most countries and the science topics by 9<sup>th</sup> grade, they are not addressed until later in the US and Minnesota. As can be seen in Figures 14 and 15, there are more science courses available than mathematics courses. It is likely that there is a relationship between the number of courses available and the number of students taking courses. In Minnesota since more science courses are offered, more 12<sup>th</sup> grade students are enrolled in science and students perform better on the science literacy test than on the mathematics literacy test. The premise of students doing better in the areas of curriculum that are emphasized appears to hold (see Figures 14 and 15).



**Figure 14: Math Courses Available at 12<sup>th</sup> Grade**

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**Figure 15: Science Courses Available at 12<sup>th</sup> Grade**

### Instructional Materials

Instructional materials at all levels are mainly textbook based.

Instructional materials at all levels are mainly textbook based. Urban teachers use textbooks slightly less but rely on them more heavily to plan lessons. Materials used for planning science lessons are slightly more diverse than those used for planning mathematics lessons.

Most of the elementary (89%) school mathematics teachers report using textbooks. At the elementary level, 73% of the urban area teachers and 95% of the rural area teachers report using mathematics textbooks.

To plan their lessons elementary teachers rely on the text-related teacher guides with correspondingly less reliance on the guides by the urban teachers. Elementary teachers also rely on previous lessons, especially the rural teachers. While most elementary teachers do not rely on school developed plans, 48% of the urban teachers do rely on these at least sometimes. Elementary teachers across the state rarely or never rely on other teachers to help them plan lessons. Although reliance on external or standardized tests for planning elementary lessons is low overall, consistent with the findings for the schools, the urban teachers report the most reliance on external or standardized tests.

Ninety six percent of middle school mathematics and science teachers use a textbook. Similar to the elementary school findings, urban area teachers report the lowest use of mathematics textbooks at 78%.

Middle school mathematics teachers tend to rely most on previously prepared lessons, student text and teacher textbook guides to plan lessons. Consistent with the years of experience, the use of previous lessons is highest in the rural schools and lowest in the urban ones. Reliance on a mathematics text other than the students' text or other texts is highest in the urban schools, again consistent with fewer years of teaching experience and perhaps closer ties to recent college mathematics courses. Reliance on tests is also highest at the urban schools probably because of their frequent testing.

Middle school science teachers report that textbooks or the teacher guides influence the lessons they teach. The highest influence on the type of lesson taught, however, is previously taught lessons on the same topic. In contrast to the findings for mathematics teachers, this is especially true for the urban area. The science teachers are also more likely to use other textbooks in their lessons than the mathematics teachers are. Perhaps this is because science textbooks tend to be more diverse than mathematics texts at the middle school level.

### **Curriculum Decisions**

Information on how much various entities influence curriculum was obtained from the school questionnaire. Fifteen different entities were listed, ranging from national standards to students. Teachers and principals have the most influence on curriculum.

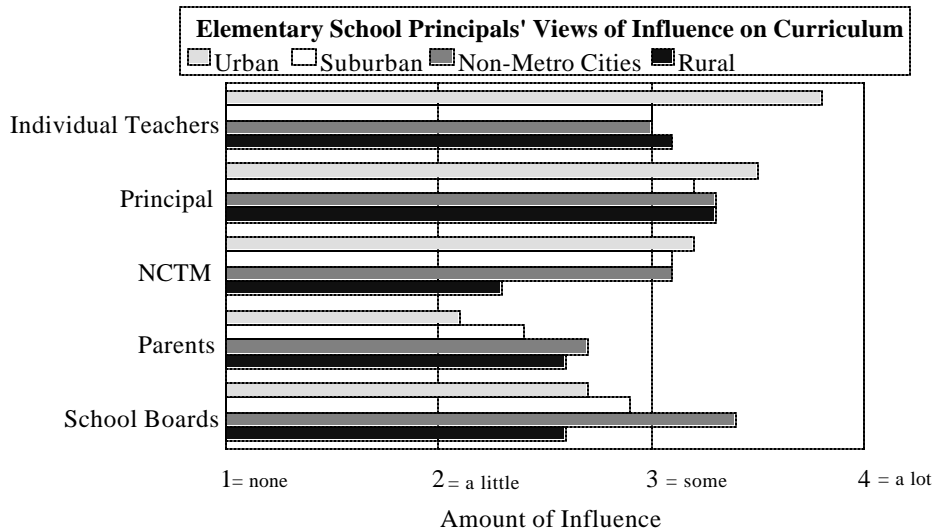
At the elementary school level, subject area teachers and principals are the most influential when it comes to making decisions regarding the curriculum (see Figure 16). Other influential bodies at this level are the National Council of Teachers of Mathematics and the school board. These results suggest that professional development designed to improve the curriculum in science and mathematics needs to focus on individual teacher choices as well as the leadership that can be provided by elementary school principals.

At the elementary school level, subject area teachers and principals are the most influential when it comes to making decisions regarding the curriculum.
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There are many differences among these items for the different geographic areas. The most common pattern among the differences is non-metro cities high and rural low. It appears that the elementary school curriculum in non-metro cities may be more susceptible to external influences than other areas. Schools in non-metro cities report more influence for mathematics associations, educational region, school board, and business community than other areas. Non-metro cities are also high for parent influence but

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instead of rural low, urban is low. In contrast to the generally larger effects for external influences in non-metro cities, urban areas are high on individual teacher influence while non-metro cities are low. Urban is also high on union influence with rural low. This order is reversed for religious group influence where rural is high and urban low.



**Figure 16: Elementary School Principals' Views of Influence on Curriculum**

As is true at the elementary level, principals and individual teachers at the middle school level have a great deal of influence over the curriculum (see Figure 17). In fact, middle school teachers – as a whole, by subject area, or as individuals – are viewed as having the greatest influence on the curriculum. Educational regulations, the National Council of Teachers of Mathematics, and the school board also play an important role in shaping the middle school curriculum. While principals are routinely thought of as influential at the elementary level and included in curriculum improvement efforts, they are less involved in efforts to improve curriculum at the middle school level. These data indicate that more attention might be fruitfully directed toward middle school principals when engaging in curriculum reform.

Some differences also exist by location. As is found at the elementary school level, middle schools in non-metro cities seem to be more responsive to external influences. The curricula for schools in non-metro cities are more likely than other areas to be influenced by religious groups, businesses and textbook publishers. In contrast, urban area principals appear to have the most influence on the curriculum although individual teachers, parents and students also play key roles. This also fits with the findings at the elementary school level where the curriculum at urban schools is more affected by teachers and principals.

As is found at the elementary school level, middle schools in non-metro cities seem to be more responsive to external influences.

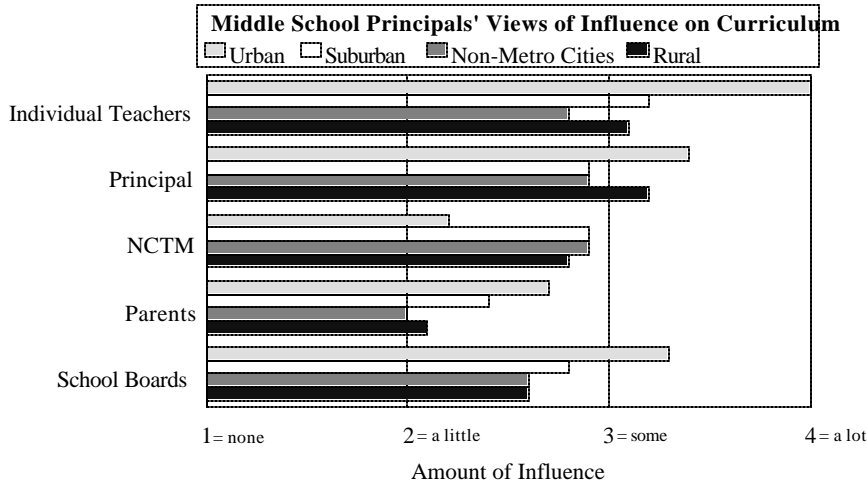


Figure 17: Middle School Principals' Views of Influence on Curriculum

At the high school level, teachers, by subject areas and individually, are again viewed as the most influential in making curricular decisions (see Figure 18). Again, the non-metro cities appear to be more influenced by external entities while urban areas are more influenced by internal entities. Non-metro cities report more curricular influence from both science and mathematics standards than the other locations with the exception of rural areas which report some influence from the NCTM standards. Students are perceived as having the most influence in rural and urban areas.

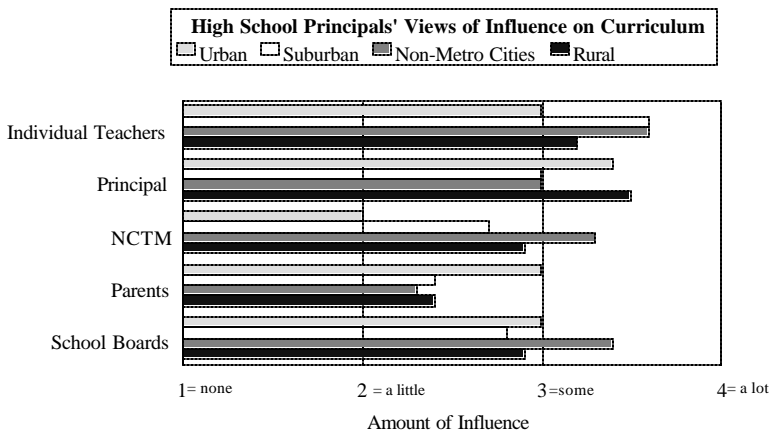


Figure 18: High School Principals' Views of Influence on Curriculum

## Instruction

Although instructional methods in Minnesota include a mix of both standards-based and more traditional approaches, the amount of standards-

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Although instructional methods in Minnesota include a mix of both standards-based and more traditional approaches, the amount of standards-based instruction is below optimal levels.

based instruction is below optimal levels. Teachers generally have standards based philosophies towards teaching, with middle school science teachers the most standards based. There appears to be more time spent on individual work than on introducing or developing new topics through class discussion, especially in mathematics. The cognitive tasks required of students are often at lower conceptual levels.

### Teaching Philosophy

Elementary and middle school teachers were asked about their philosophy of teaching and approach to teaching mathematics and science. Teachers were asked their opinions about 15 different approaches. Overall, Minnesota teachers are moderately standards-based in their philosophies. Middle school teachers are slightly more standards-based than elementary school teachers. The middle school teacher philosophies related to teaching science appear to be more consistent with the standards than those related to teaching mathematics. There are only a few differences by location with rural elementary school teachers appearing more traditional.

Elementary teachers believe that mathematics is an abstract subject and that, consistent with the standards, students should be able to understand concepts, think creatively, provide reasons to support their conclusions, practice to overcome difficulties, and understand how mathematics is used in the real world (see Figure 19). Also in accordance with the standards, these teachers believe that remembering formulas and thinking sequentially are less important. It is reassuring to see that elementary teachers overwhelmingly agree (95%) that tasks in mathematics should be represented in different ways (e.g., pictures, concrete materials, symbol set). The use of manipulatives in mathematics classes can be justified, in part, because students at this level are more likely to perceive tasks differently if presented concretely or abstractly.

There are only very weak differences among the population areas. Although elementary teachers are similar in their responses, it appears that the rural area teachers are slightly more traditional or “back to basics” in their philosophy than teachers from the other areas. Rural teachers are more likely to support remembering formulas, thinking in a sequential and procedural manner and less likely to support thinking creatively, supporting solutions or using real world applications as is recommended in the NCTM standards. Rural elementary teachers are also more likely to agree that mathematics is algorithmic and computational. In contrast, urban teachers seem to be more conceptual and oriented toward real-world mathematics and disagree that mathematics is algorithmic. The urban teachers agree least with remembering formulas and liking mathematics.

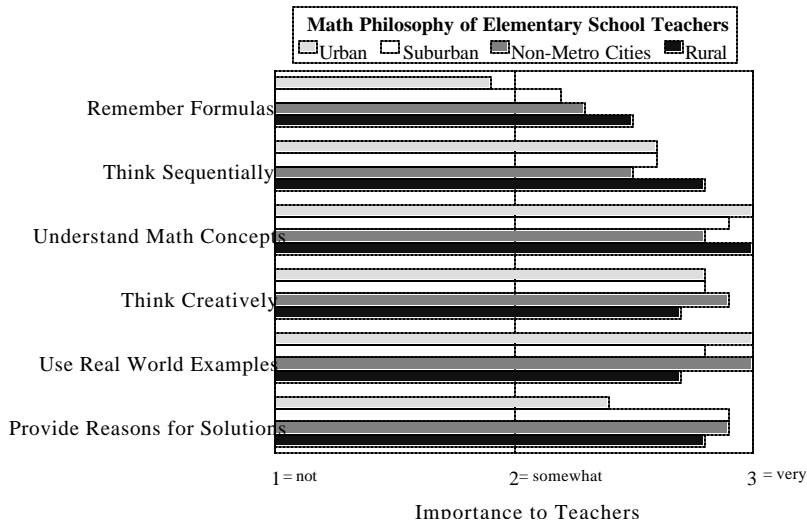


Figure 19: Math Philosophy of Elementary School Teachers

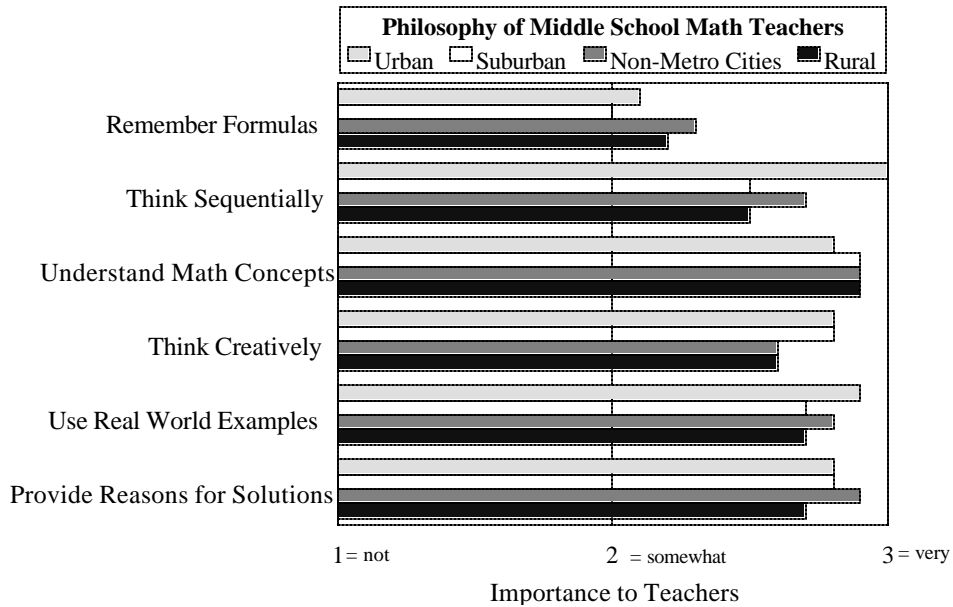
In terms of mathematics, middle school teachers tend to be more standards-oriented than elementary teachers (see Figure 20). Mathematics teachers believe that, most importantly, students should understand mathematics concepts, principles, and strategies and be able to provide reasons to support their conclusions. It is also important, though less so, that students be given time to practice their skills. Teachers also mention the importance of mathematics as a set of algorithms.

In terms of mathematics, middle school teachers tend to be more standards-oriented than elementary teachers.

There are no strong differences among the geographic areas in terms of philosophies toward mathematics at the middle school level. Despite the similarities, the importance of thinking sequentially is higher for the middle school urban teachers. This may be an important area for reflection for urban middle schools.



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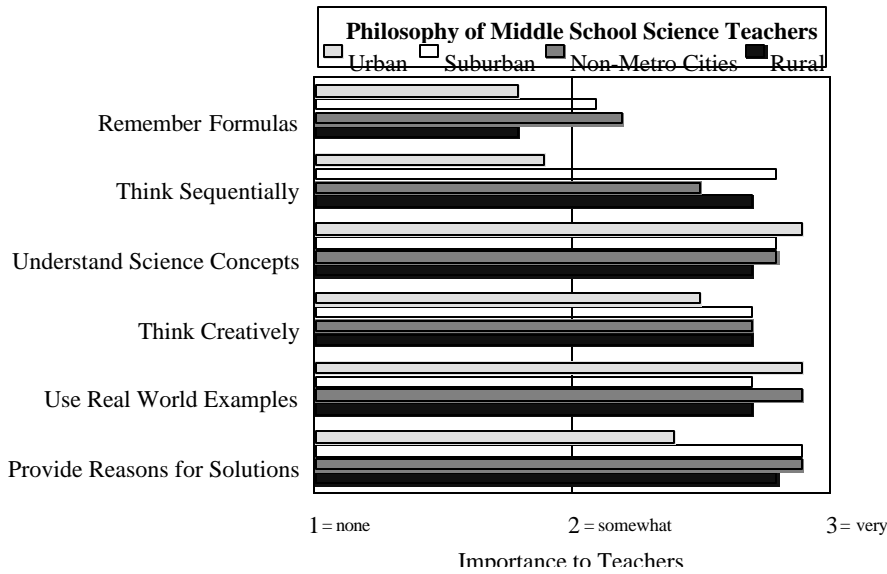
**Figure 20: Philosophy of Middle School Math Teachers**

Middle school science teachers have mixed beliefs about standards-based approaches across the locations (see Figure 21). They agree that students should like science and that science is a formal representation of the world and a practical and structural guide for addressing real situations. Science teachers feel it is important that students be able to provide reasons to support their conclusions. Contrary to the standards, however, science teachers feel that it is important for a teacher to give students prescriptive and sequential directions for experiments (27%).

Contrary to the standards, however, science teachers feel that it is important for a teacher to give students prescriptive and sequential directions for experiments.

Middle school science teachers in urban areas best reflect the mixed approach to the standards. They are least likely to believe in two non standards-based techniques – remembering formulas and thinking in a sequential manner, but also least likely to believe in a standards-based technique – providing reasons for solutions.

Comparing Figures 20 and 21 shows how similar the middle school mathematics and science teachers are in their beliefs. The most substantial difference is in thinking sequentially where the urban science teachers are quite a bit lower than the urban mathematics teachers. Another interesting urban finding is the consistently higher importance for use of real world examples in both mathematics and science.



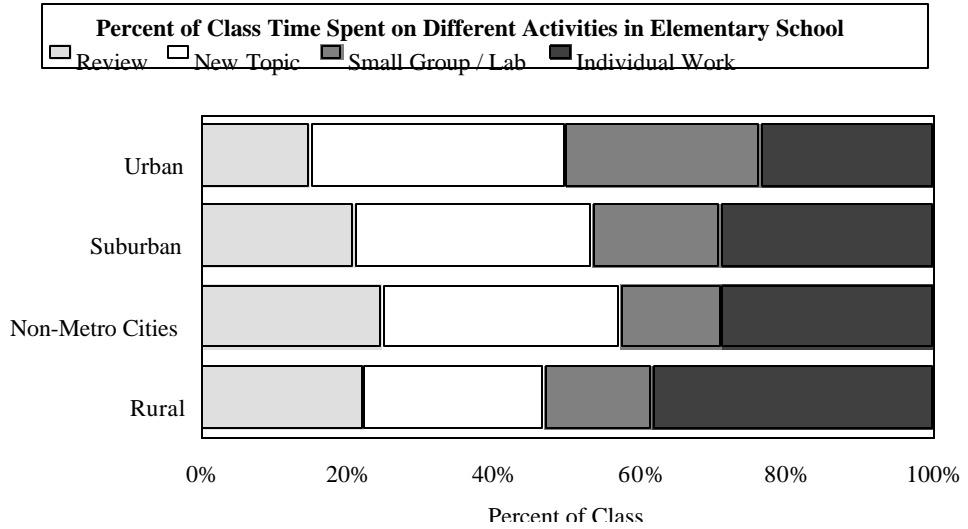
**Figure 21: Philosophy of Middle School Science Teachers**

### Lesson Activities

What takes place during a typical lesson is critical to what students learn. The TIMSS teacher questionnaires at the elementary and middle school levels asked questions about the types of activities engaged in and the amount of time spent on the activities. Overall, students spend substantial amounts of time doing individual work. Less time is spent on group or laboratory work.

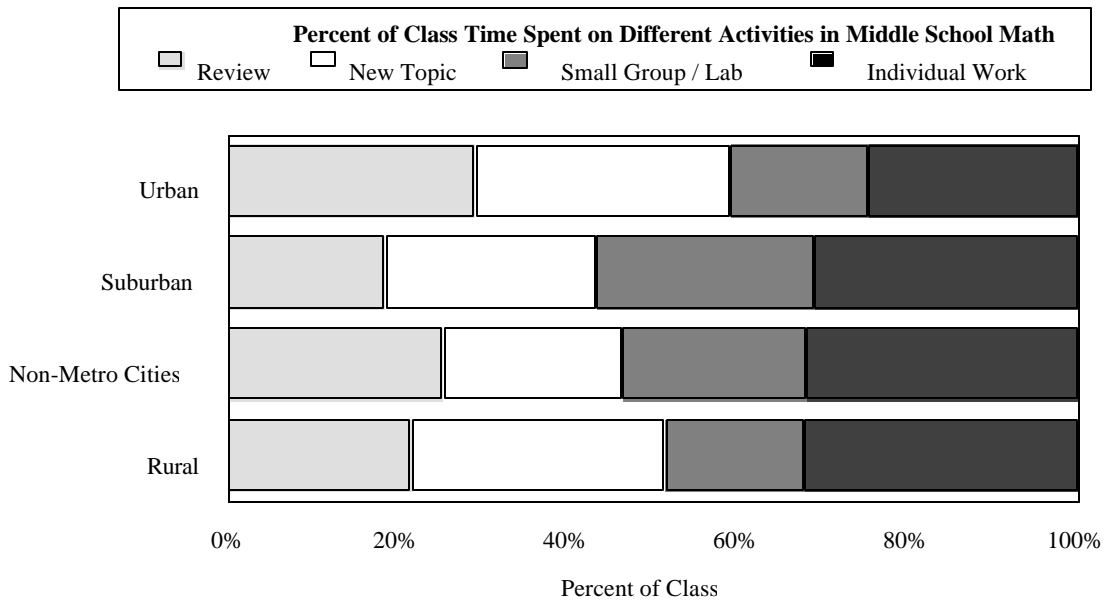
Figure 22 shows that about half the class is spent on review and introducing new topics. The least amount of time is spent on small group and/or lab work. Urban schools spend the least time on reviewing primarily because they do not assign homework. Rural schools appear to spend the most time on individual work.

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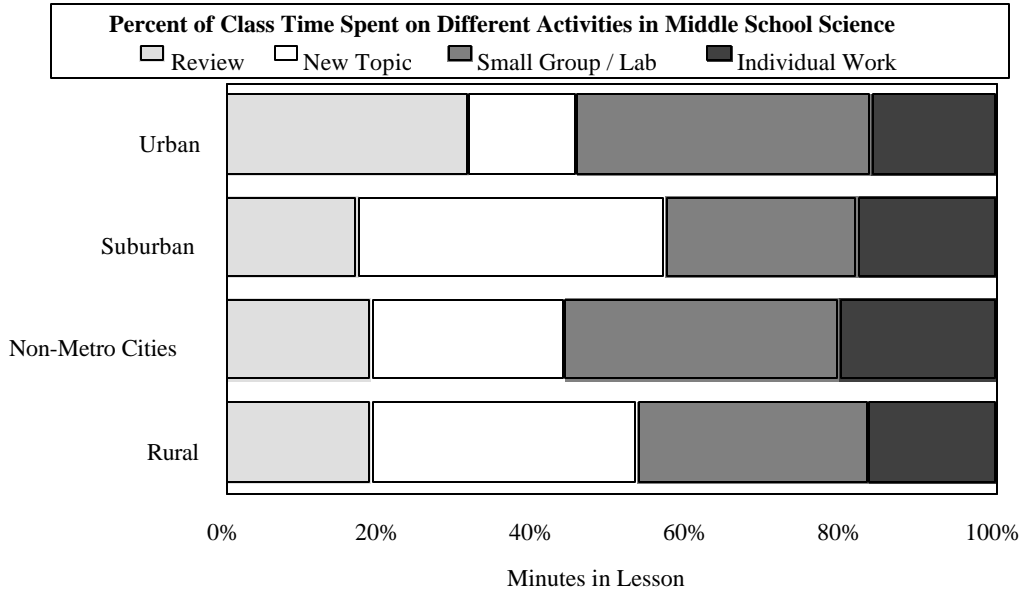
**Figure 22: Percent of Class Time Spent on Different Activities in Elementary School**

Figure 23 shows the relative time in middle school mathematics classes. The urban schools spend more time reviewing at the middle school level, while all schools appear to spend a significant portion of time having students do individual work.



**Figure 23: Percent of Class Time Spent on Different Activities in Middle School Math**

Figure 24 shows a slightly different pattern. Science classes tend to spend significantly more time in small group and lab activities than mathematics classes, and less time on individual student work. Review still makes up at least 20% of class with urban schools spending even more time reviewing.



**Figure 24: Percent of Class Time Spent on Different Activities in Middle School Science**

**Lesson Processes and Cognitive Tasks**

The activities engaged in during a class are essential to helping students learn. These activities can be divided into processes that are descriptions of what takes place in a class and cognitive tasks that are descriptions of what students are required to produce. This section is based on elementary, middle and high school student perceptions of processes taking place in their classes, and on elementary and middle school teacher and high school student views of cognitive tasks required. There are generally 15 processes and 8 cognitive tasks.

Both types of activities can be directly related to the standards. The use of standards-based activities varies across grade levels and locations but in general is less than optimal. There are differences in the process and cognitive tasks in science and mathematics classes. In mathematics, teachers typically instruct the class as a whole and allow some time for students to work individually with help from the teacher. Science instruction is somewhat different with more time spent having the students respond to each other while working in small groups. Standards-based processes and cognitive tasks are mixed at all grade levels but are most common at the high school level.

The use of standards-based activities varies across grade levels and locations but in general is less than optimal.

Figure 25 shows what percent of students report a particular activity happening in most of their elementary mathematics classes. As can be seen, the most common activities are doing worksheets individually and solving problems from everyday situations. Without information on the

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content of the worksheets and problems it is difficult to determine if these activities align with the standards. In contrast to the standards the least common activities are using calculators and computers and working in groups. In international comparisons, Minnesota, at 14%, has the lowest percentage internationally of students with teachers who agree that practice in class is an effective approach for helping students with mathematics difficulties. This seems quite contradictory to the amount of time reported doing worksheets and may be a place to begin discussion about classroom processes.

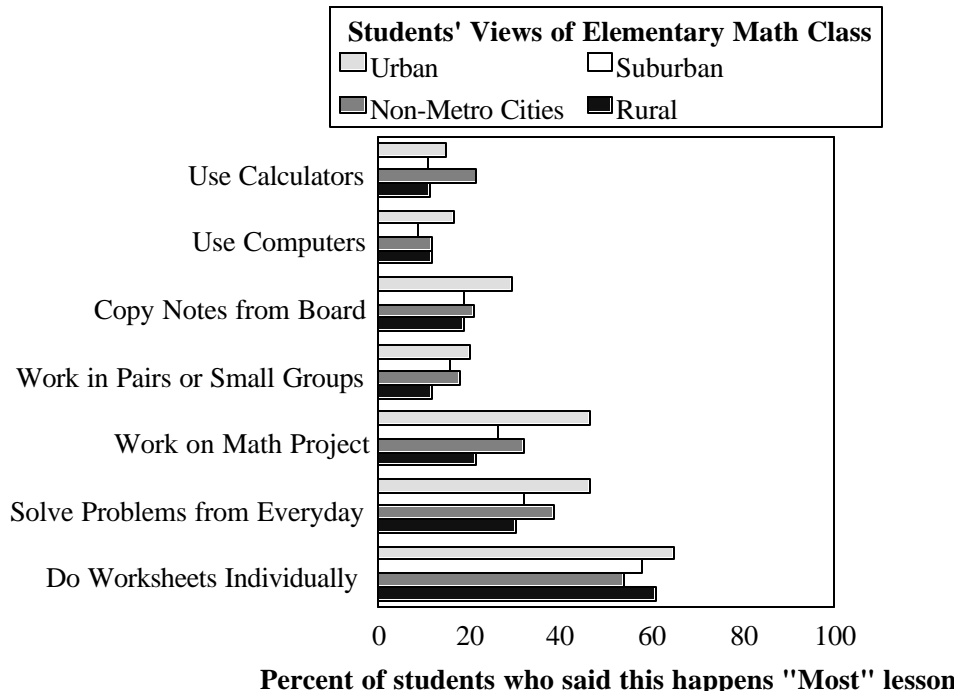


Figure 25: Students' Views of Elementary Math Class

In accord with the standards elementary students are often asked to explain their reasoning, but contrary to the standards they spend little time using charts, tables or graphs.

Figure 26 shows only some evidence of standards-based instruction related to cognitive tasks. In accord with the standards elementary students are often asked to explain their reasoning, but contrary to the standards they spend little time using charts, tables or graphs, doing problems with no immediate solutions, or writing equations. The large amount of time spent on practicing computations could be standards-based; certainly some practice is supported by the standards.

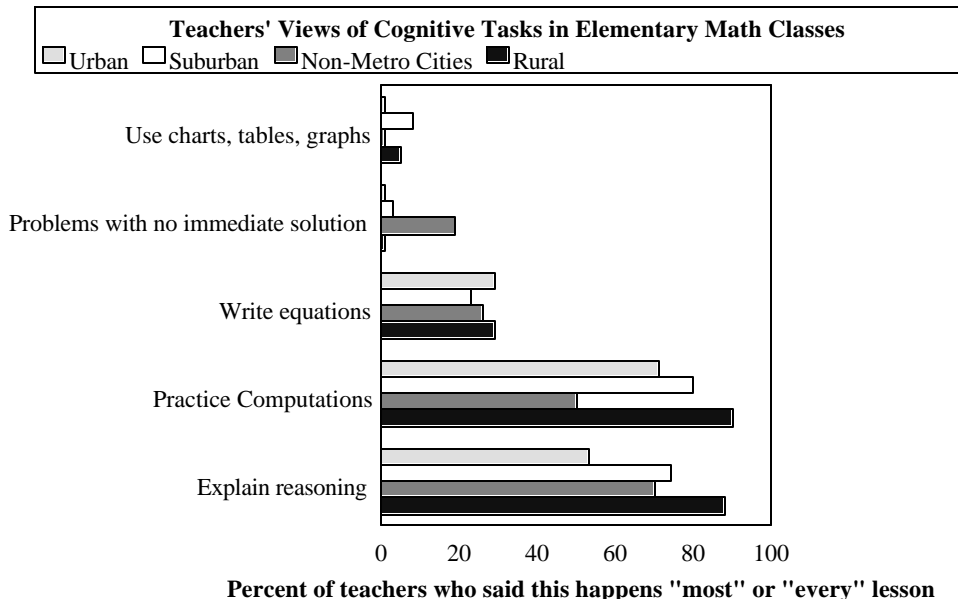


Figure 26: Teachers' Views of Cognitive Tasks in Elementary Math Classes

Figure 27 shows what elementary school students believe occurs in their science classes. The activities are very similar but with slightly more group work. The use of teacher demonstration and doing experiments in about 40% of the classes shows alignment with the standards.

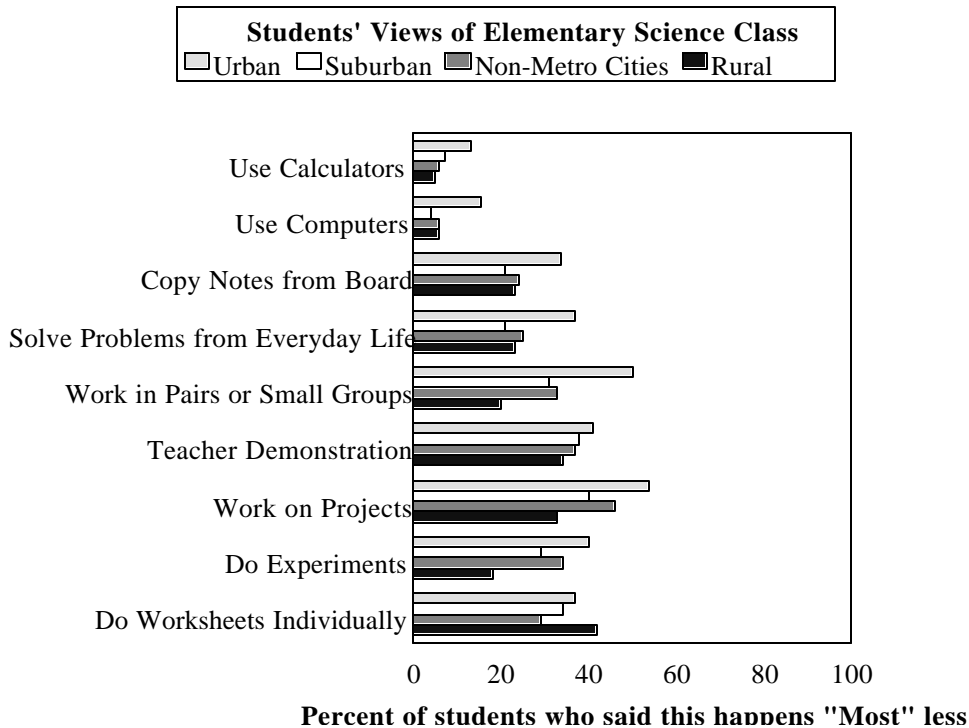


Figure 27: Students' Views of Elementary Science Class

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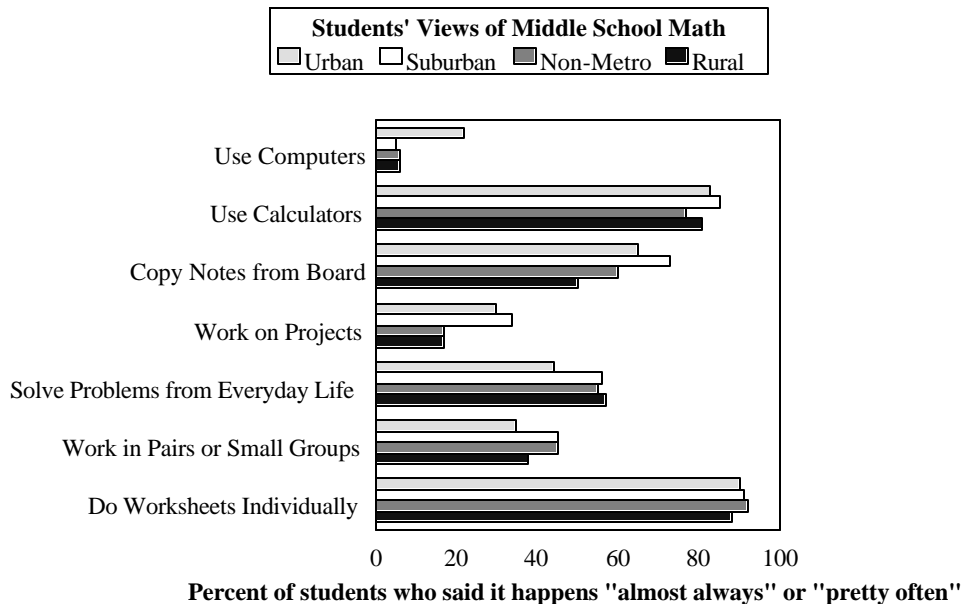
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Across most countries, the majority of 7<sup>th</sup> and 8<sup>th</sup> grade students are in classes that work as an intact group with the teacher teaching the whole class. In Minnesota about 46% of students are taught this way for most or every mathematics lesson. In contrast, although most students throughout the world have science classes taught this way, only 11% of Minnesota students are taught this way in most or every lesson. Next to students working individually this is the least popular science classroom organization. In Minnesota, 38% of middle school science students typically work in pairs or small groups.

In Minnesota, 38% of middle school science students typically work in pairs or small groups.

Figure 28 shows the mix of standards-based and non standards-based activities that occurs in middle school mathematics classes. There is a large amount of calculator use and some group work that is in accord with the standards. On the other hand, the large amount of time spent on copying notes or doing worksheets is not standards based.



**Figure 28: Students' Views of Middle School Math**

Figure 29 shows that the middle school science classes are similar to the mathematics classes but slightly more standards-based. There is still a substantial amount of time spent on individual worksheets and copying notes from the board. There is, however, more group work in science and, of course, more time with teacher demonstrations and doing experiments. The use of calculators, on the other hand, is higher in mathematics classes.

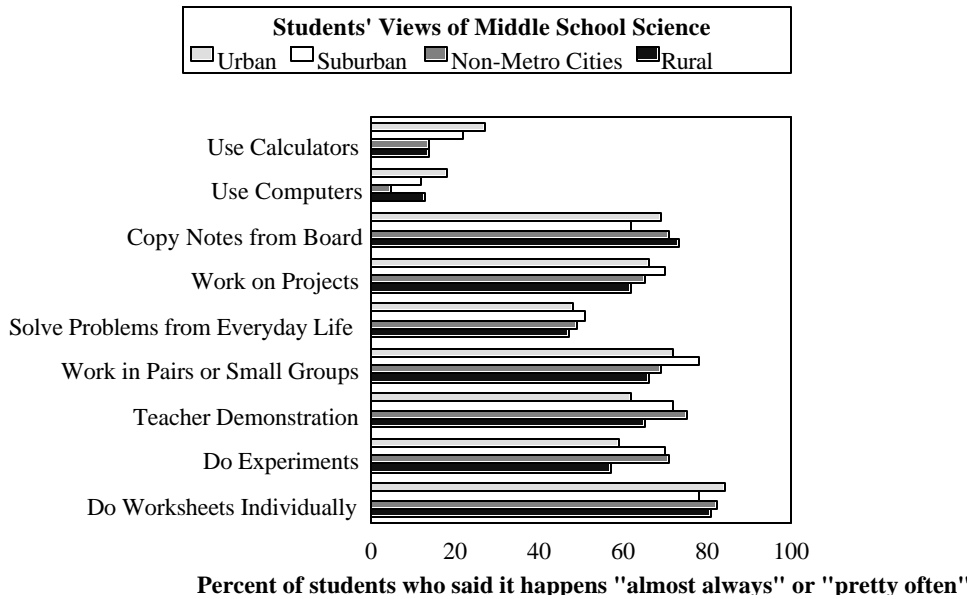


Figure 29: Students' Views of Middle School Science

Middle school mathematics and science teachers are mixed in using standards-based cognitive tasks. In keeping with the standards, students of both subjects spend substantial amounts of time explaining their reasoning. Urban mathematics students also spend a great deal of time writing equations. In contrast to the standards, however, neither mathematics nor science students spend much time using charts, tables or graphs or doing problems with no immediate solutions. (See Figures 30 and 31).

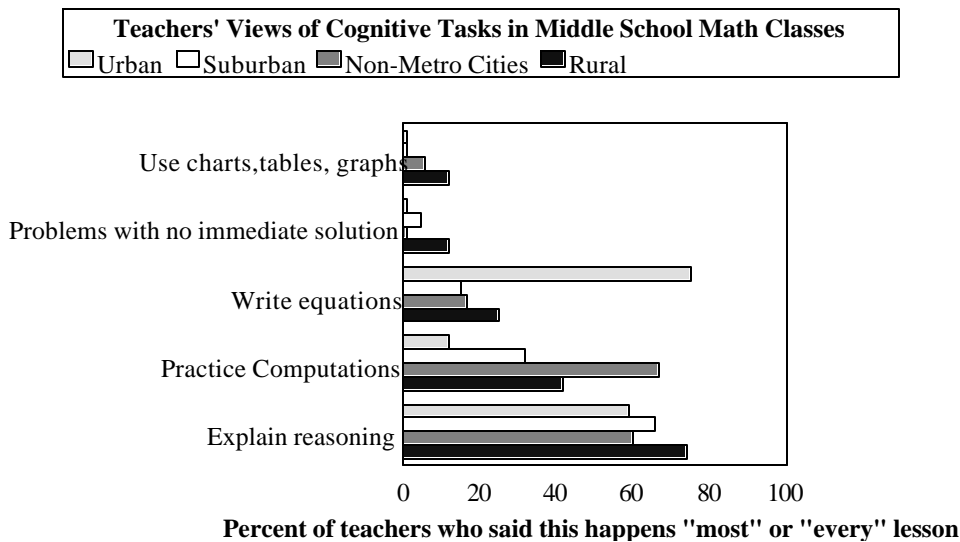
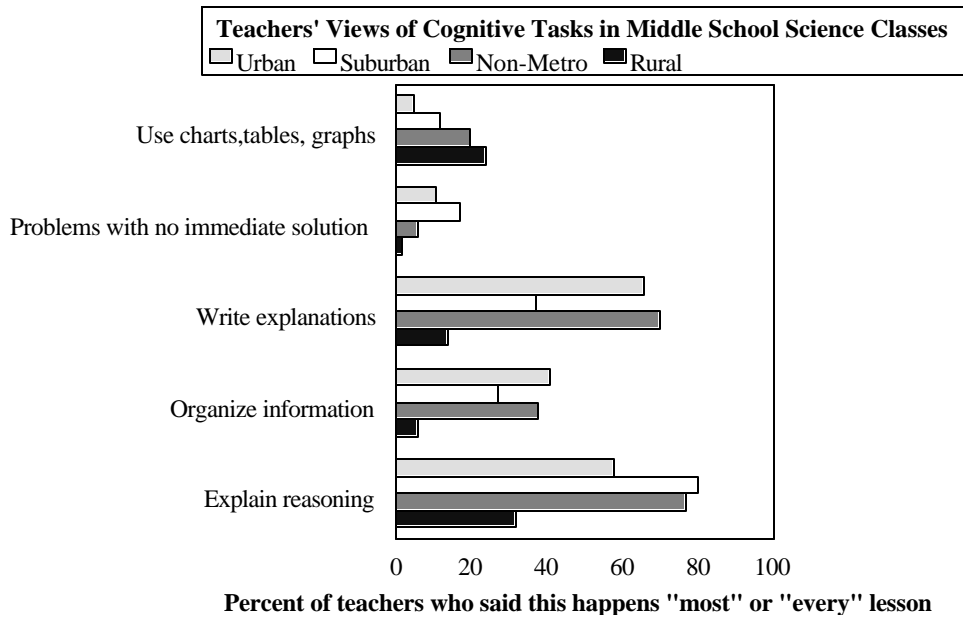


Figure 30: Teachers' Views of Cognitive Tasks in Middle School Math Classes



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**Figure 31: Teachers' Views of Cognitive Tasks in Middle School Science Classes**

Grade 12 students were asked about both processes and cognitive tasks in their classes and how often various types of activities occur in their science and mathematics classrooms. There are no substantial differences among the geographic areas on any of these items.

Although there is some evidence for standards-based activities like solving problems from everyday life, a substantial amount of time is spent on copying notes and doing homework.

Figures 32 and 33 present some of the mathematics and science processes. Although there is some evidence for standards-based activities like solving problems from everyday life, a substantial amount of time is spent on copying notes and doing homework. The use of computers is particularly low.

The most common process in mathematics is watching the teacher demonstrate how to do a problem followed by beginning homework before the class ends and copying notes from the board. In science the two most common processes are copying notes from the board and watching the teacher demonstrate concepts. The least common activities are going on a field trip to collect data and using computers to solve problems.

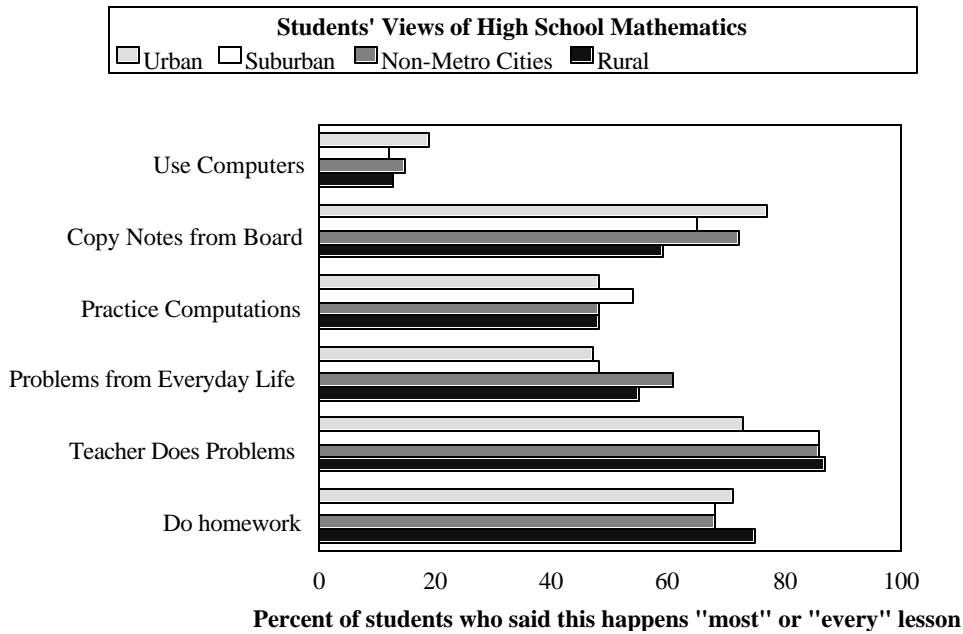


Figure 32: Students' Views of High School Mathematics

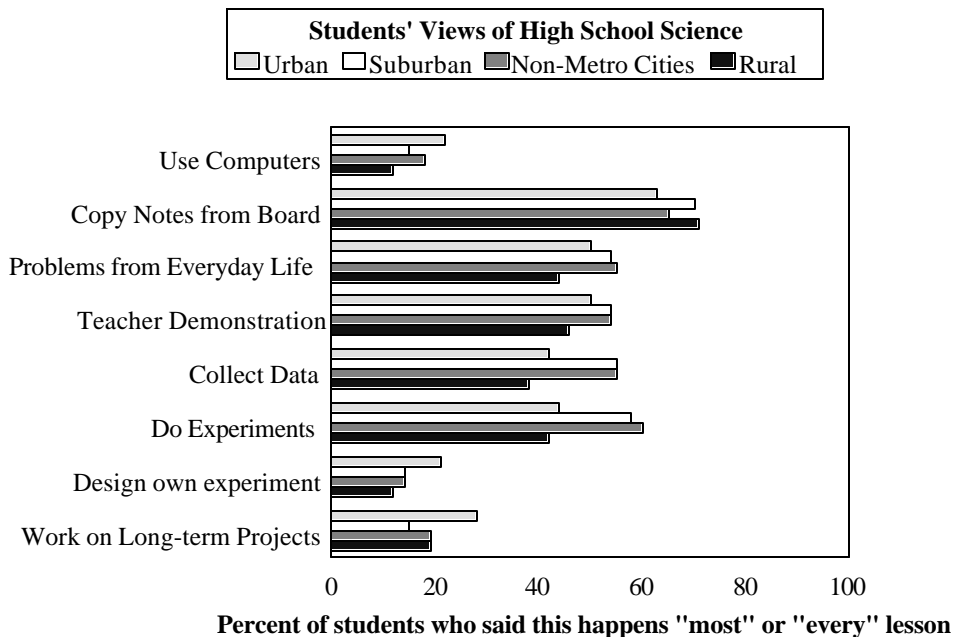
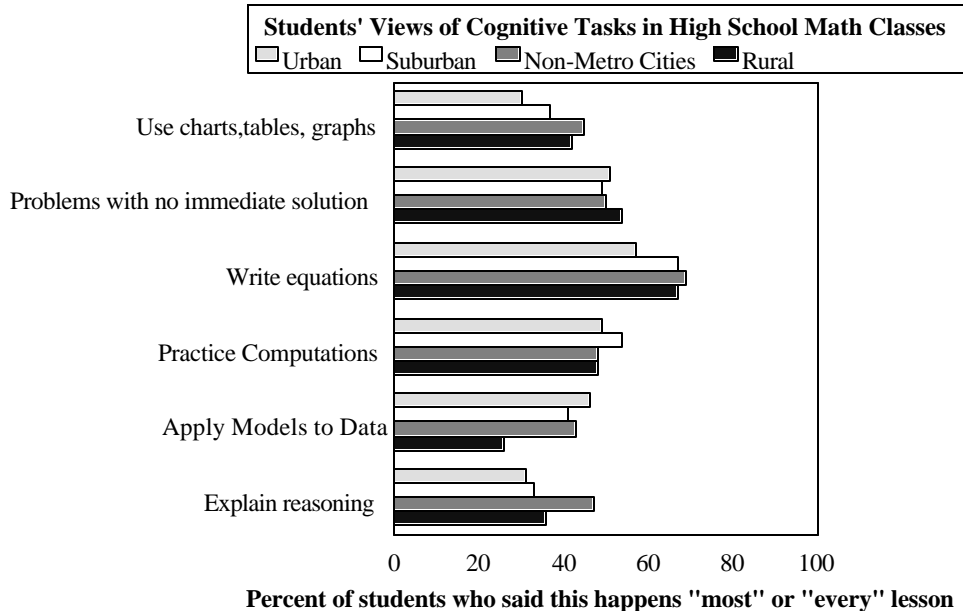


Figure 33: Students' Views of High School Science

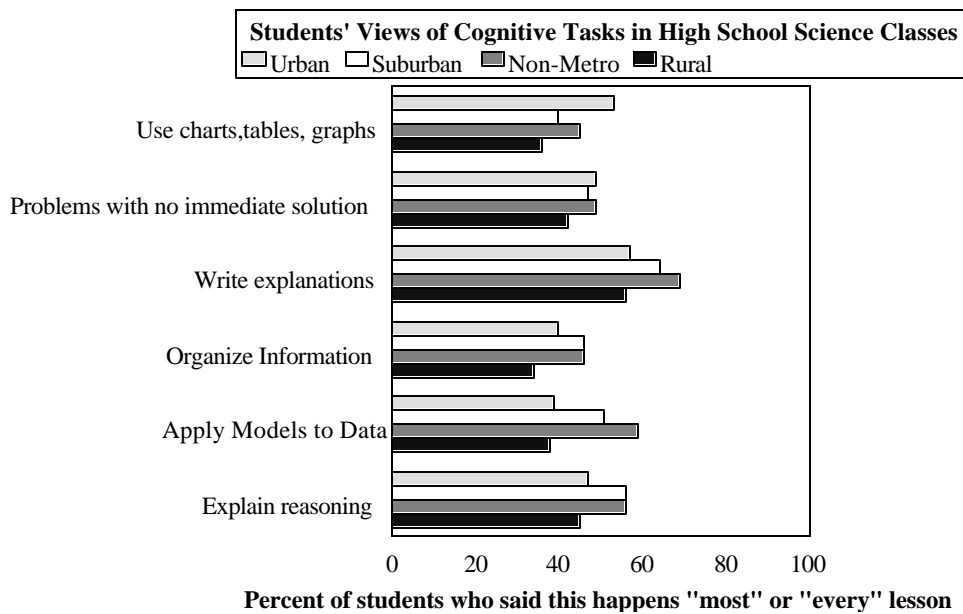
Figures 34 and 35 present some of the cognitive tasks. The types of activities in the two subject areas are quite similar. The most common high school mathematical cognitive tasks are solving equations, writing equations to represent relationships and memorizing rules and procedures. The most common scientific cognitive tasks are writing an explanation of

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what was observed and why it happened, applying science to everyday problems and explaining the reasoning behind an idea. Comparing these figures with the figures for elementary and middle school shows that the grade 12 classes are somewhat more standards-based than the lower grades.



**Figure 34: Students' Views of Cognitive Tasks in High School Math Classes**



**Figure 35: Students' Views of Cognitive Tasks in High School Science Classes**

## Assessment

The elementary and middle school teachers were asked only a few questions about classroom assessment. There are no data from grade 12. Teachers at both levels were asked how much time they spend preparing tests and reading student work, how much they rely on standardized tests, and what other sources they use for tests.

As is true for curriculum and instructional practices, the teachers report a mix of standards-based and non standards-based assessment practices. The middle school science teachers appear to use the most standards-based approaches but there is certainly room for more.

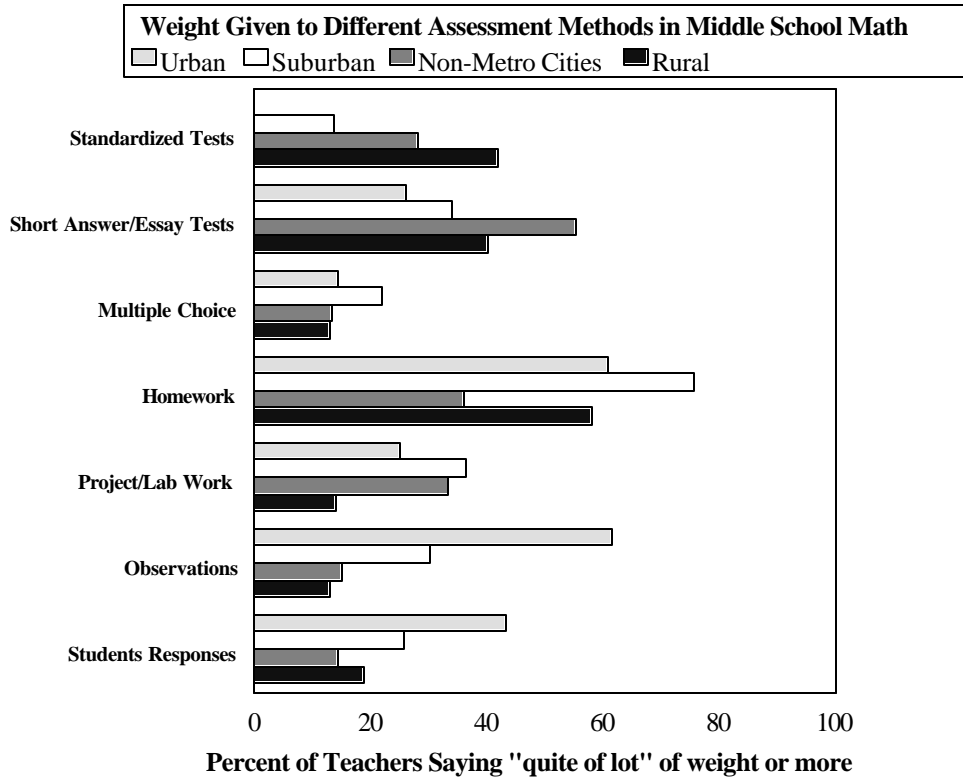
Elementary school teachers generally spend 1 to 2 hours preparing tests outside of school. Elementary school teachers from the urban area and non-metro cities are most likely to spend 1 to 2 hours outside of school reading student work. The suburban and rural teachers spend slightly more time with about 1/3 reporting more than 4 hours. Most of the elementary school teachers report a little reliance on standardized tests but teachers in non-metro cities are more likely to report none at all. Most elementary school teachers use their teacher's textbook edition as a source for assessments with urban elementary teachers also using their schools' curriculum guide.

Teachers report a mix of standards-based and non standards-based assessment practices.
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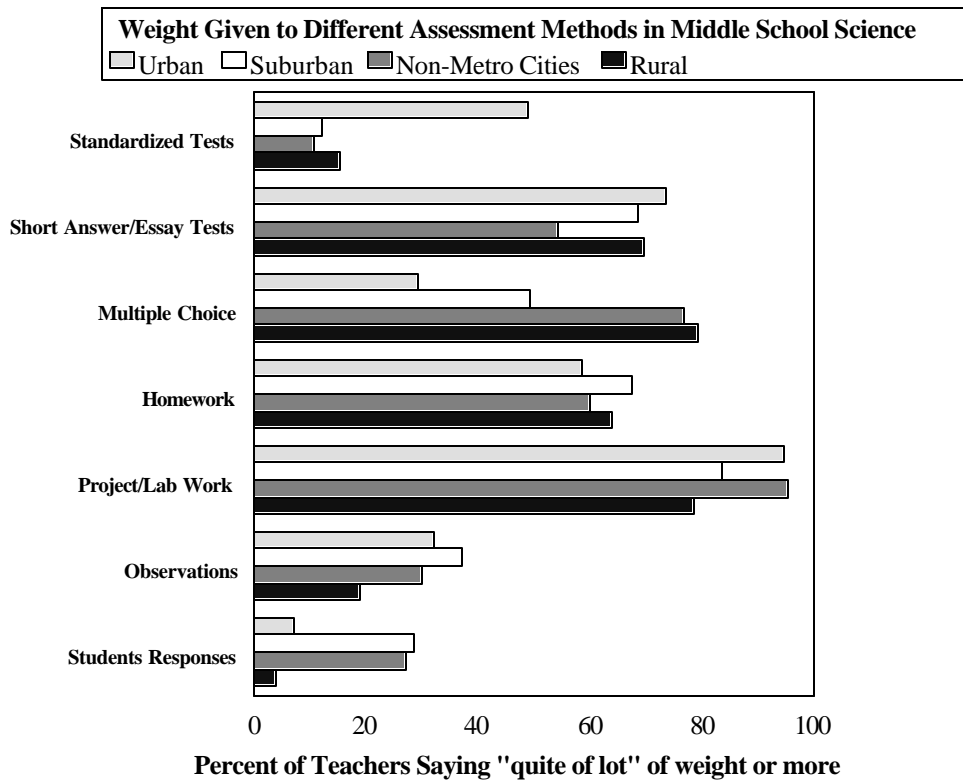
Middle school mathematics and science teachers from all geographic locations generally spend 1 to 2 hours preparing tests outside of school. The mathematics teachers spend 1 to 2 hours reading student work with the urban and rural teachers spending slightly less time than the others do. The science teachers report spending slightly more time than the mathematics teachers with urban and rural teachers spending slightly more time than the others. Middle school teachers rely a little or not at all on standardized tests with science teachers reporting less reliance on them than mathematics teachers. Most middle school teachers use their teacher's textbook edition as a source for assessments, and urban teachers at both the elementary and middle school levels are also likely to use the student textbook edition or other resources.

Additionally, mathematics and science teachers at the middle school level were asked how much weight they give to 7 types of assessments and how assessment information is used. As can be seen in Figure 36, the most popular basis for mathematics grading is homework and observations of students, particularly for the urban teachers. In science several factors contribute to grading including reasoning tests and projects as well as homework. Urban science teachers are more likely to use standardized tests.

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**Figure 36: Weight Given to Different Assessment Methods in Middle School Math**



**Figure 37: Weight Given to Different Assessment Methods in Middle School Science**

Mathematics and science teachers most commonly and consistently use assessment information to provide grades and ‘quite a lot’ to plan future lessons. In addition, they use this information a ‘little to quite a lot’ to provide feedback to students and to report to parents. There are some differences by location and subject. Urban area mathematics teachers use assessment information slightly more for grading and reporting than the other areas. Science teachers in suburban areas and non-metro cities are more likely to use assessment information to provide feedback to students while urban area teachers are more likely to use it to report to parents.

### **Questions for Reflection**

- Are the topics covered in our curriculum appropriate? Is enough time allocated to each topic to attain in-depth understanding? Is the curriculum aligned with the standards?
- How do our mathematics and science curricula vary across grade level? To what extent is our scope and sequence aligned across grades?
- How well is the delivered curriculum aligned with the standards? What activities take place in our classes? What cognitive tasks are required? Are these sufficient to provide in-depth understanding?
- How do instruction and assessment in mathematics and science differ across grade levels? How are they the same?

## **Section VI: Support for Teaching and Learning**

This section describes the educational context in Minnesota and the barriers and supports for teaching and learning in standards-based environments. Key topics include the school climate, the impact of school shortages on instruction, the role of the principal in teaching and learning, and the presence of professional community among teachers. The data for this section is taken from the TIMSS principal, teacher, and student questionnaires.

### **School Climate**

The needs and behaviors of students both play important roles in learning. Principals and teachers report only some prevalence of behavior problems or other factors limiting instruction.

While some behavior problems exist at the elementary school level, they are limited to a small proportion of the students, with most schools reporting the involvement of at most 10% of their students and generally less than 5%. Surprisingly, suburban areas are most likely to report significant behavioral problems, most notably, the intimidation of or injury to staff (16% each). From the students' perspective the most pressing problem is students hurting one another.

As is true at the elementary school level, behavioral problems in Minnesota's middle schools, though present, are not widespread (again, involving less than 10% of the student body). Classroom disturbances are the most commonly reported problem with 60% of the principals saying this occurs on a daily basis. Other daily issues include student tardiness and absenteeism (42% and 40% of schools, respectively). With the exception of absenteeism among students, the most pressing problems vary by location. Principals in urban schools are the most likely to report a greater number of problems. Classroom disturbances, profanity and intimidation of students, however, are more problematic in non-metro cities. From the students' perspective the most common problem is stealing followed by students' skipping class and fears for their personal safety, although the incidence of these occurrences is low (once or twice a month). No major differences are noted among the geographic areas although the urban students consistently report the most incidences.

As is true at the elementary school level, behavioral problems in Minnesota's middle schools, though present, are not widespread.

The most common behavior problems at the high school level are students skipping classes and using profanity. Other important issues include cheating, arriving late for school, and absenteeism. Fortunately, physical injury to teachers or staff is rarely mentioned, but still occurs on a monthly basis. As is true in middle schools, urban high schools are more likely to

report a number of problems related to students' behavior. Arriving late is more common at urban schools while the use of tobacco is highest at urban and suburban schools. Schools in non-metro cities are least likely to cite students arriving late at school and use of tobacco as key issues. When students were asked to report their perceptions of school problems, the most common behavior is skipping class (about 3 times a month) while the least common is feeling that another student might hurt them (never). No substantial differences exist among the students in the different locations.

When elementary teachers are asked to what extent certain factors limit their ability to teach mathematics they note the different academic abilities of their students, students' special needs, and disruptive students as the most limiting factors. Other issues, such as uninterested parents, low morale among students, and threats to safety, are raised when the data are examined by location. Teachers in urban schools are more likely to report several limiting factors that could be grouped more generally into student-related issues (e.g., needs, attitudes, and behavior) and shortages of instructional resources.

Middle school science and mathematics teachers were also asked about limiting factors. Mathematics teachers feel the factors are more limiting than science teachers do, although no factors are seen as severely limiting by either. Mathematics teachers find uninterested students and different academic abilities as most limiting. Science teachers, on the other hand, report disruptive students, high student-teacher ratios and different academic abilities as most limiting. These perceptions may be related to predominant instructional styles since science teachers have more small groups where disruptive students and high student-teacher ratios might be most troublesome. There are no substantial differences among the teachers from the different locations although, as in the elementary schools, urban teachers report the most shortages of instructional resources.

## **School Shortages**

Principals were asked to rate the extent to which shortages or inadequacy of materials and other resources affect their schools' capacity to provide instruction using a scale of "none" (1) to "a lot" (4). Resources to be considered included: instructional materials and supplies, computers and other technology, lab equipment, library materials, and facilities and utilities. Generally there were only some shortages, most commonly in areas related to technology.

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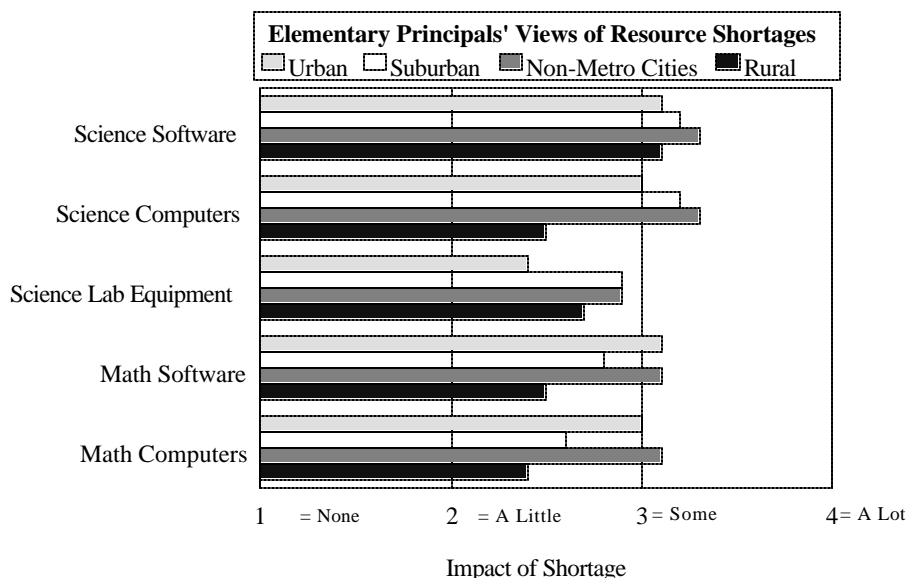
Overall, the elementary schools report few serious shortages (no more than 24% of students attend schools where such shortages have a large impact on instruction). The most serious shortages are of technology, software and science laboratory equipment. Despite the absence of serious



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problems, however, all schools note some degree of shortage or inadequacy on at least one item. (See Figure 38).

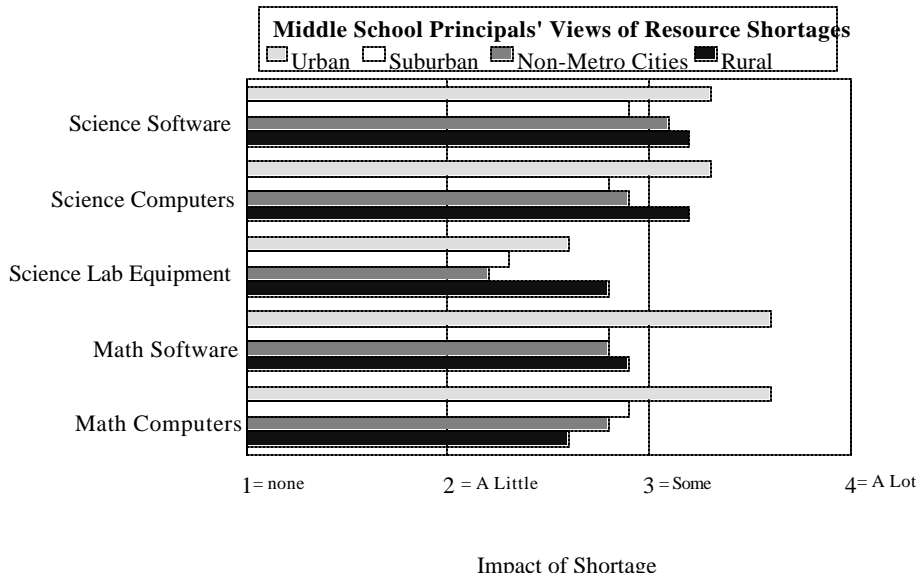
The different locations report different types of shortages. Generally urban areas report the most shortages. Rural areas are most affected by the need for special equipment to accommodate handicapped students. Schools in suburban areas report a much greater need for mathematics calculators than other locations. Non-metro cities are much more likely to have a shortage of calculators and computers for use in science as well as significant shortages of hardware and software for mathematics. Urban schools are more likely to report a shortage of computers and software, audiovisual, and library materials for mathematics.



**Figure 38: Elementary Principals' Views of Resource Shortages**

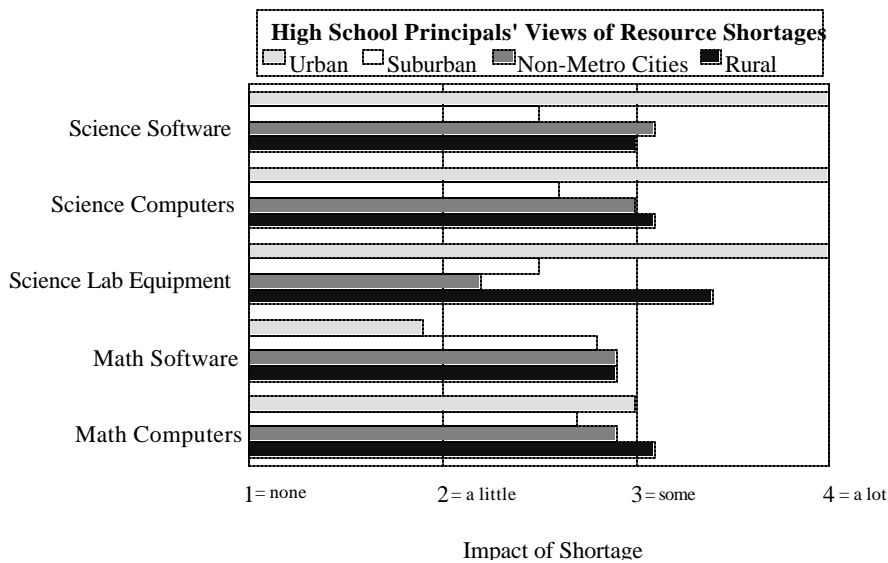
The most serious shortages are of computer hardware and software for mathematics and science although the need is slightly greater for science.

Middle schools, too, report very few serious shortages that might affect instruction. The most serious shortages are of computer hardware and software for mathematics and science although the need is slightly greater for science. A lack of instructional space is thought to have from “some” to “a lot” of impact on instruction in middle schools with shortages being most acute in the urban and rural areas. Despite the absence of serious problems, however, all schools note some degree of shortage or inadequacy on at least one item. (See Figure 39).



**Figure 39: Middle School Principals' Views of Resource Shortages**

At the high school level, the shortages that most affect instruction are the lack of computer hardware and software and materials for science laboratories. Again, the urban areas report the most shortages except for school buildings where the rural areas are more likely to report a shortage. (See Figure 40).



**Figure 40: High School Principals' Views of Resource Shortages**

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## Section VII

### School Leadership

Principals were asked how they allocate their time on a monthly basis. Categories of 14 tasks or responsibilities include activities that are within and outside of the school itself and acknowledge that principals play both administrative and instructional roles. Generally principals spend the most time on internal administration although this varies by location.

Elementary school principals play different roles in the different locations. Overall, though, they report spending the most time on internal administrative tasks (an average of 23 hours per month) followed by counseling students and talking with parents (see Figure 41). Urban principals spend the least time on internal administration, and the non-metro area principals spend the most time talking to parents.

Elementary school principals also function as instructional leaders. Although the time spent giving demonstration lessons accounts for only 0.2 to 3 hours per month, urban principals spend far more time on this task than the others do. Principals also spend 8 to 19 hours per month discussing educational objectives with those in non-metro cities putting in the most time. They spend 2 to 8 hours per month on teaching and preparation with rural principals spending the most time (perhaps due to more small schools that require staff to play multiple roles) and those in non-metro cities the least. Professional development activities require 7 to 13 hours per month with principals in non-metro cities logging the most time followed closely by principals in urban areas.

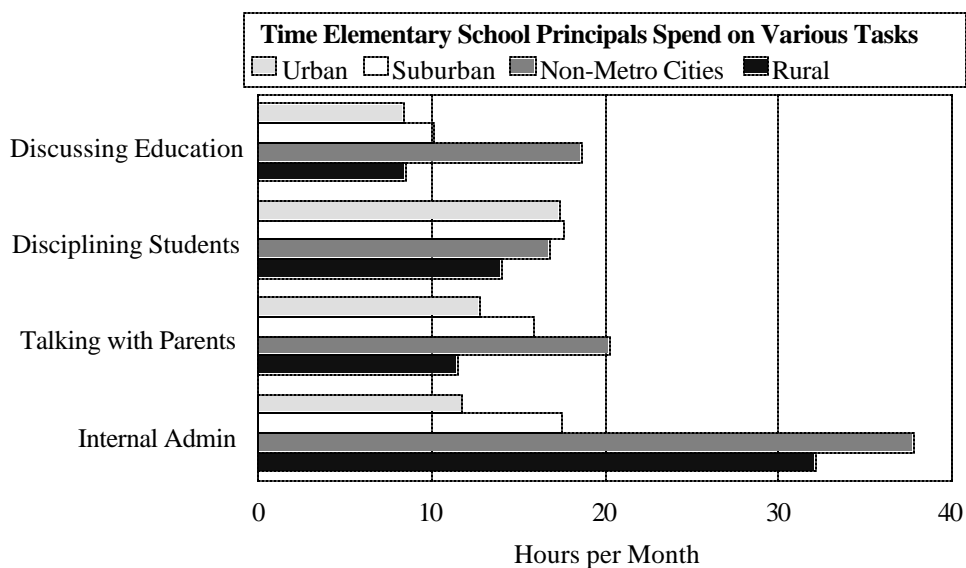
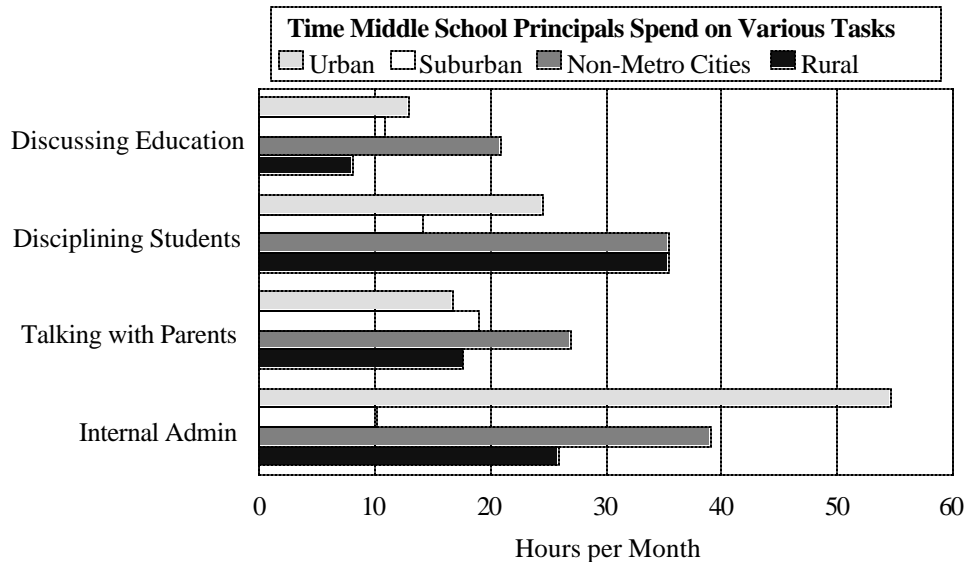


Figure 41: Time Elementary School Principals Spend on Various Tasks

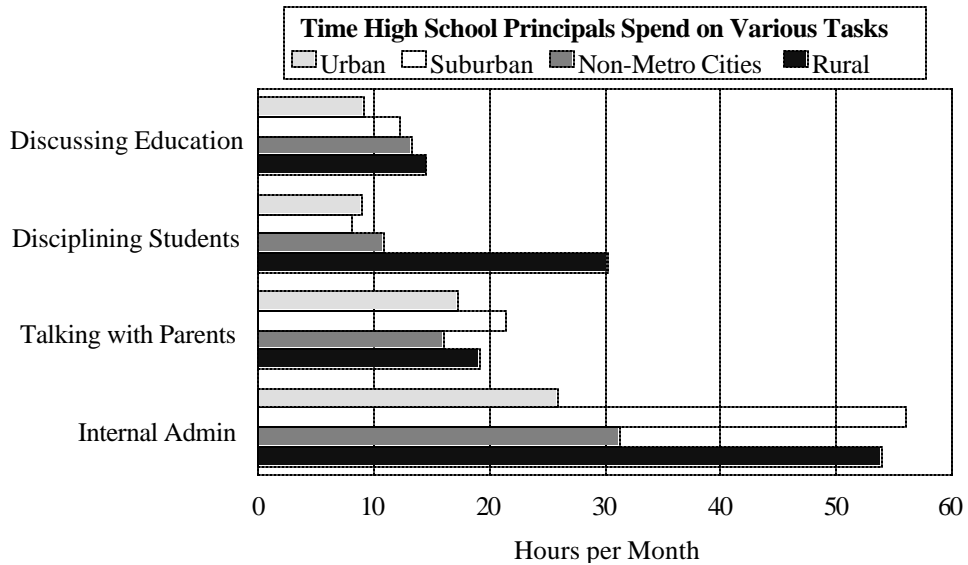
Middle school principals play a role in teaching although most of their time is spent in administrative activities, especially in the urban areas (see Figure 42). Time spent on counseling is also high and is highest in the non-metro cities and rural areas, perhaps because school counselors are less common at these locations.



**Figure 42: Time Middle School Principals Spend on Various Tasks**

Internal administration is the most common activity for high school principals, taking up an average of 46 hours per month, followed by representing the school at official meetings and talking with parents, each for 19 hours per month (see Figure 43). Again, in comparison to the other areas, urban principals spend the least amount of time on internal administration. Rural area principals spend the most time counseling and disciplining students, perhaps because specialized staff is not available in smaller schools to perform these tasks.

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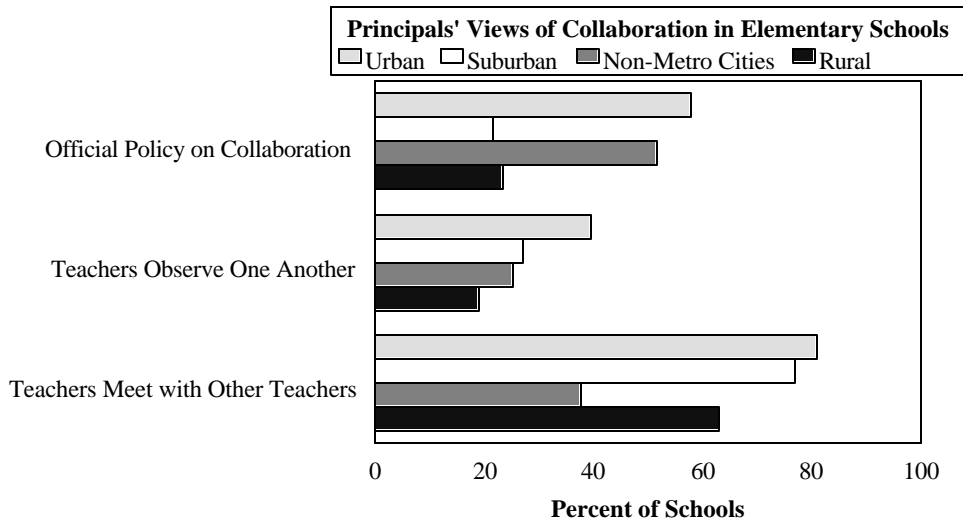
**Figure 43: Time High School Principals Spend on Various Tasks**

## Professional Community

Teachers meeting and discussing ideas are the first steps in moving toward the type of excellent instruction recommended in the standards. While it appears that Minnesota teachers do have some opportunities to meet with their colleagues, the TIMSS data does not provide information on what takes place during these sessions making it difficult to understand the effects of such meetings.

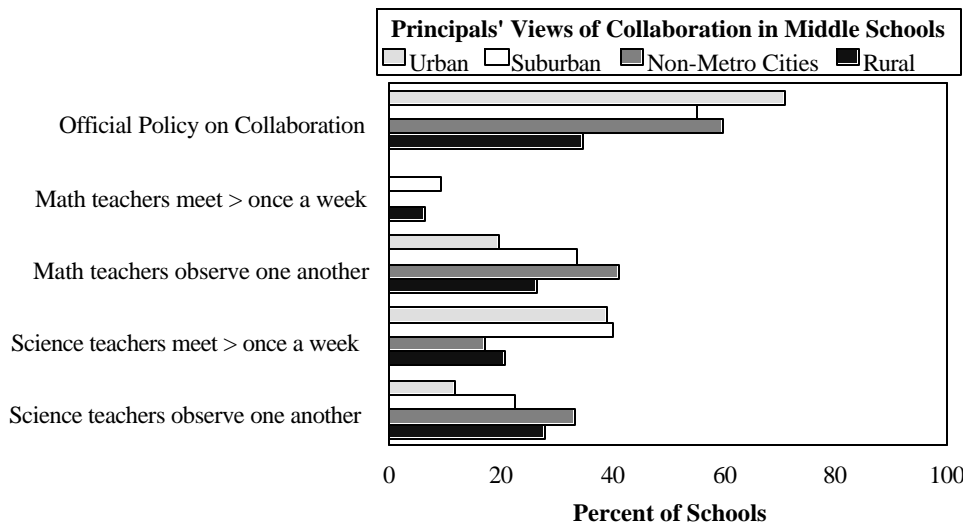
Although all schools encourage their teachers to share and discuss instructional ideas and materials, more urban and non-metro schools have official policies about cooperation.

Elementary schools are supportive of teacher cooperation with some differences by location. Although all schools encourage their teachers to share and discuss instructional ideas and materials, more urban and non-metro schools have official policies about cooperation. In addition, all of the urban, non-metro, and rural schools hold regular meetings to discuss instructional goals, while only 74% of the suburban schools do. Urban areas report the most visits between teachers, about twice a year. (See Figure 44).



**Figure 44: Principals' Views of Collaboration in Elementary Schools**

At the middle school level, the overall level of collaboration among teachers is low. (See Figure 45). Although middle schools in all geographic areas encourage cooperation among teachers, schools in the urban areas are most likely to have official policies supporting it. Urban areas and non-metro cities are most likely to have regular meetings for cooperation. Science teachers tend to meet more often than the mathematics teachers do.



**Figure 45: Principals' Views of Collaboration in Middle Schools**

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## Section VII

### Questions for Reflection

- What is the school climate and what is its influence on teaching and learning?
- What kinds of resources are needed (e.g., personnel, equipment, instructional materials, and facilities)?
- How does the principal spend his/her time? Is the principal's role primarily instructional or administrative?
- How often are teachers meeting with their colleagues? What is the purpose of these meetings?

## Section VII: Concluding Remarks

Where is Minnesota in relation to the NCTM and NRC standards? What can we be proud of and what do we need to change? International comparisons and careful use of the TIMSS data can provide some clues. Minnesota children attend schools that have fewer problems and more resources than other students in the United States and throughout the world. Our teachers are better prepared academically than those in many other countries and the US. Our students say they enjoy science and mathematics and believe they are important subjects to learn. And yet, the achievement levels of our students do not seem to reflect these favorable conditions. In international comparisons Minnesota students do well in grades 3-4 and 7-8 but are significantly outperformed by their peers in grade 12. Why do we fall behind over time? Although our students improve their knowledge each year, it appears that students in the rest of the world improve even more. What can we do to assure that Minnesota students receive the best science and mathematics education possible?

In international comparisons Minnesota students do well in grades 3-4 and 7-8 but are significantly outperformed by their peers in grade 12.

The data presented in this report shows that there is room for improvement in Minnesota schools both in terms of our curriculum, instruction, and assessment and in terms of the support for teaching and learning that includes professional development and educational resources. Given the differences among schools by location it seems that a school- or district-level approach to reflection and reform is the most appropriate. However, enough similarities exist among Minnesota's schools that pooling resources and coordinating improvement efforts is also a viable option.

A school- or district-level approach to reflection and reform is the most appropriate.

Schools and districts should continue to examine their curriculum, instruction and assessment practices to determine if these fit with what they hope their students will be able to understand and do. It is critical that these three curriculum instruction and assessment be aligned to achieve optimal effects. If the curriculum gives one message and the teaching or assessment another, students will be confused and their efforts to learn diluted. Although it is impossible to say what would be most needed in any specific school, the trends in the data for Minnesota give some indication of where problems may exist.

The curriculum in Minnesota grades 3-4 and 7-8 is both more diverse and more repetitious than is thought to be beneficial. This is especially true in mathematics. The repetition shows up both in the list of topics covered for these grade levels and in the lesson scripts which show significant amounts of time spent on individual or worksheet-type work.

There is only some evidence of standards-based instruction and the use of standards-based techniques is mixed across grade levels and across



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science and mathematics classrooms. Lessons do not begin with inquiry, exploration or the framing of problems as recommended by the standards. Lessons typically begin with review or drill and practice. The use of rote learning or more algorithmic methods appears to be more common in Minnesota than may be desirable.

As for assessment techniques, little data exists in TIMSS to allow an in-depth examination of such practices although what is there indicates that classroom assessment is only partially supportive of the type of instructional goals espoused by the standards. Given these findings, it is important that Minnesota schools explore how we assess students' progress along with their curriculum and instruction.

At grade 12, the situation is different from that at grades 3-4 and 7-8. The most important contributor to student achievement at this level seems to be the low enrollments in science and mathematics classes.

At grade 12, the situation is different from that at grades 3-4 and 7-8. The most important contributor to student achievement at this level seems to be the low enrollments in science and mathematics classes. Some evidence exists that students who do take mathematics and science in the upper high school grades are likely to experience instruction that is more consistently standards-based than students at the lower grade levels. This coupled with more opportunities to learn science would no doubt help to improve the mathematics and science understanding of Minnesota's graduates.

The structures of Minnesota schools could also be better aligned to support standards-based education. The schools appear to have met the basics in terms of environmental conditions although this does vary across districts. This is, of course, the first priority – the lowest level of a needs hierarchy, but it is not sufficient. If Minnesota is to achieve excellence in its schools, all levels of needs must be met. Availability of resources seems most likely to affect the technological parts of curriculum and instruction.

Minnesota's teachers have few opportunities to meet and discuss education with each other.

Based on the TIMSS data, it appears that the most common need is intellectual support. The data show that Minnesota teachers are isolated in their classrooms and make many important educational decisions on their own. Vesting responsibility in our teachers is appropriate given the high quality of our teaching force. However, even the best professional benefits from collegial discussion and support. Minnesota's teachers have few opportunities to meet and discuss education with each other. Although there is little support for these types of meetings, there appears to be more collaboration in the urban areas and in science.

Additionally, the principals at most schools do not appear to have the time to engage in the sorts of educational leadership that would inspire teachers and help them to grow and improve. This is especially problematic since principals are seen as having an important influence on the curriculum. Obviously, issues of support and educational leadership are school and

district based and the data show these mixed results. Teachers in larger districts appear to have more time to work with each other but there appears to be little opportunity to use that time productively. Schools and districts need to carefully consider how they will structure teacher time and the use of that time in order to help all students achieve in mathematics and science.