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Tech Brief

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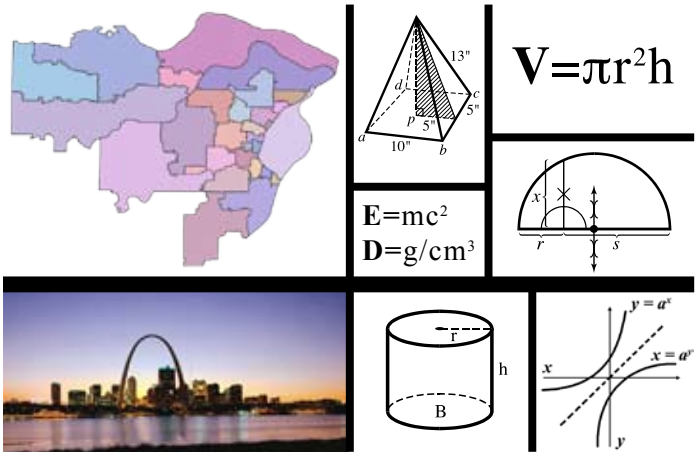
Mathematics Attainment in St. Louis Area School Districts:
Critical Knowledge for Advanced Science Learning



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Center for Inquiry in Science Teaching and Learning (CISTL) St. Louis Regional Database Project

The CISTL St. Louis Regional Database Project strives to provide information to schools and the community about indicators of science attainment at the elementary, middle, and high school levels using local, state, and national data sources. Information on science and mathematics attainment for area students assists the planning and decision-making of teachers, school officials, and policy-makers.

Schools and educators are accountable under the requirements of the No Child Left Behind Act (NCLB) of 2001 in which they participate in standards-based reform to insure all students demonstrate content knowledge and skills at specific mastery levels. Schools monitor their performance closely to show Adequate Yearly Progress (AYP) for increasing student achievement. The movement of high-stakes accountability to drive school improvement has resulted in widespread access to data about schools and districts. With the availability of this data, student performance can be studied for the region as a whole. Comparisons across school districts inform both educational and business communities about student performance variation within the region.

A regional perspective assists in planning for the growing demand of scientists and technicians in the St. Louis area. The region continues to develop into a national technology hub for research and production in medical, biological, engineering, and industrial applications. In order to provide human resources to sustain this scientific and technological growth, the area's schools need to provide high quality education, training, and strong scientific and mathematics coursework.

This is the second in a series of Tech Briefs designed to inform the community about overall trends in science and mathematics attainment for the St. Louis region.

Mathematics Attainment in St. Louis Area School Districts:

Critical Knowledge for Advanced Science Learning

Mark C. Hogrebe and Lydia Kyei-Blankson

The development of mathematical and scientific skills is essential for preparing the future workforce in science, technology, engineering, and mathematics (STEM) careers. These fields have always used mathematics as the language to express basic and advanced concepts. The intricate relationship between science and mathematics is clearly articulated by Wright and Chorin (1999) in a report from the National Science Foundation (NSF).

> All three approaches to science, observation and experiment, theory, and modeling are needed to understand the complex phenomena investigated today by scientists and engineers, and each approach requires the mathematical sciences. (p. 1)
>
> Mathematics and science have a long and close relationship that is of crucial and growing importance for both. Mathematics is an intrinsic component of science, part of its fabric, its universal language and indispensable source of intellectual tools. Reciprocally, science inspires and stimulates mathematics, posing new questions, engendering new ways of thinking, and ultimately conditioning the value system of mathematics. (p. 2)

Many recognize the importance of addressing math and science educational needs simultaneously as evidenced by STEM initiatives, the NSF-funded Centers for Learning and Teaching, and NSF-funded Math and Science Partnerships. All of these programs focus on improving teaching and learning in math and science with the goal of increasing the nation's human resource capacity in STEM-related fields and industries.

In attempting to understand the potential for St. Louis area students to perform well in science/mathematics-related coursework and then to build a workforce that will sustain technology-driven industries, it is essential to know the levels of both science and mathematics attainment.

The purpose of this Tech Brief is to present an overview of mathematics attainment in St. Louis area school districts as determined by the State of Missouri Assessment Program (MAP) in mathematics from 2000 through 2005. The emphasis is on an "overview" of mathematics attainment in St. Louis area school districts. MAP test data from specific schools, districts, and the entire state are available on the Missouri Department of Elementary and Secondary Education (DESE) website http://dese.mo.gov. Anyone can visit the website and examine test scores for a specific school or district; however, the data are not aggregated to give a perspective of regional performance within the state.

This report examines thirty St. Louis area school districts in order to gain an understanding of the level of mathematics proficiency across districts and for the St. Louis region as a whole. Although data in this report are limited to Missouri school districts, Illinois school districts in close proximity are certainly important contributors to the St. Louis region and its employers. Future reports plan to expand coverage to include nearby Illinois school districts.

The Data

The 30 school districts selected to represent the St. Louis area were those with the greatest concentration of school-aged children (5 – 17 years old) based on the 2000 U.S. census data. The districts form a contiguous area westward from the Mississippi River with the St. Louis City district as the eastern anchor.

The indicators of mathematics attainment were the Missouri MAP mathematics scores administered in fourth, eighth, and tenth grades. The MAP mathematics test measures students' progress relative to the Missouri Show-Me standards. The mathematics test assesses six content areas or strands:

- Number Sense
- Geometric/Spatial Sense
- Data Analysis, Probability
- Patterns and Relationships
- Mathematical Systems
- Discrete Mathematics

Test items included three types:

- Multiple-choice items from the TerraNova, a nationally normed test.
- Constructed response items that require students to supply (rather than select) an appropriate response. Sometimes called an open-ended item.
- Performance event items that involve longer and more demanding tasks which require students to work through problems or experiments.

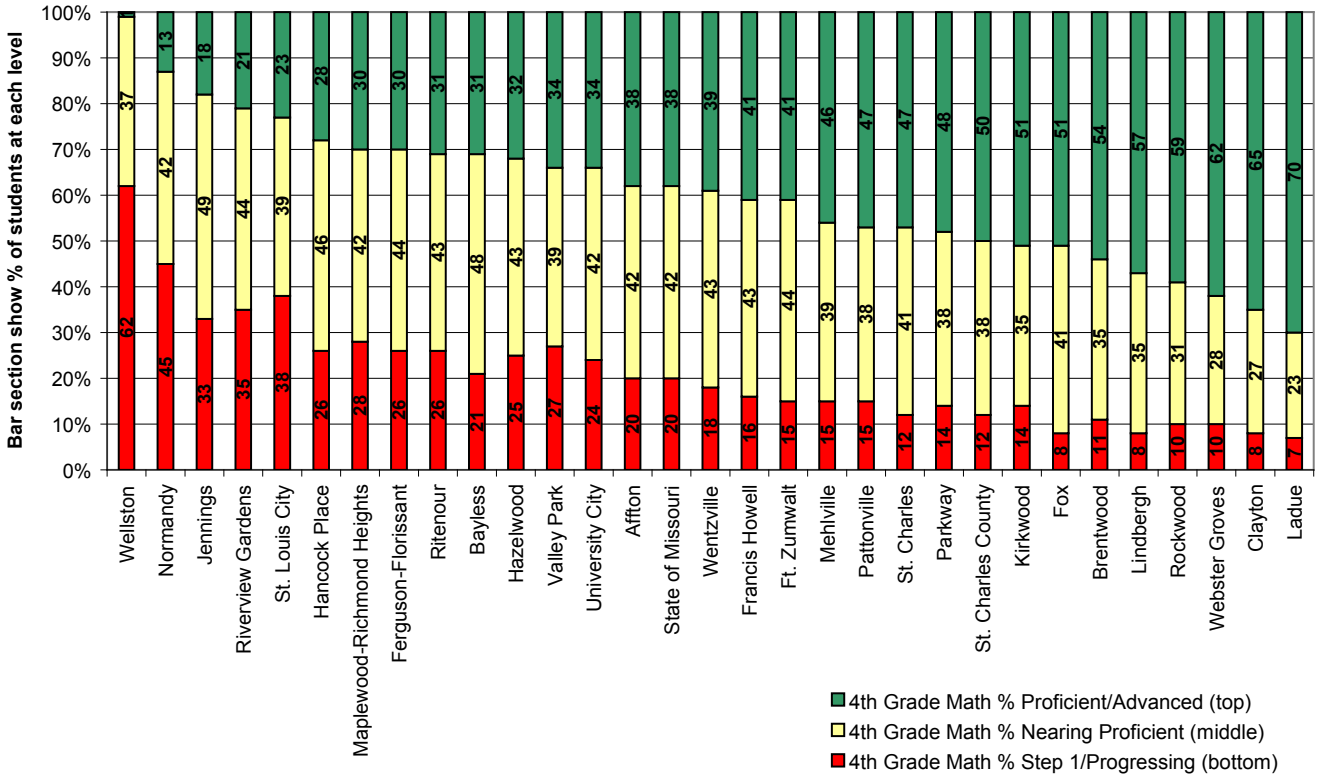
The MAP tests are scored by CTB/ McGraw-Hill and reported as MAP Scale Scores based on students' correct responses and points earned. The Scale Scores are used to indicate the current five achievement levels: Step 1, Progressing, Nearing Proficient, Proficient, and Advanced. Each achievement level provides a description of what students can do in terms of the content area at that grade level. (For more information see the "Missouri Assessment Program: Guide to Interpreting Results, Revised 2005" at the Missouri DESE website: http://dese.mo.gov/divimprove/assess/GIR_2005.pdf). The level definitions below are from the district MAP data tables on the DESE website:

Step 1: Students are substantially behind in terms of meeting the Show-Me Standards. They demonstrate only a minimal understanding of fundamental concepts and little or no ability to apply that knowledge.

Progressing: Students are beginning to use their knowledge of simple concepts to solve basic problems, but they still make many errors.

Nearing Proficient: Students understand many key concepts, although their application of that knowledge is limited.

Figure 1. Fourth Grade Mathematics MAP Achievement Levels
Median Percentage of Students within Each Level for Years 2000 - 2005



Proficient: This is the desired achievement level for all students. Students demonstrate the knowledge and skills called for by the Show-Me Standards.

Advanced: Students demonstrate in-depth understanding of all concepts and apply that knowledge in complex ways.

The data for the 30 school districts in this report were obtained from the DESE website. The indicator of mathematics attainment for each district was the percentage of students at the Proficient plus Advanced levels, separately, for the fourth, eighth, and tenth grades. The focus is on the percentage of students at the Proficient/Advanced levels because "Proficient" as defined above is the achievement level desired for all students. Proficient means students demonstrate mathematical knowledge and skills that the State of Missouri defined as essential in the Show-Me Standards.

MAP mathematics data were gathered for the years 2000 through 2005. For this report, the median was calculated to summarize each district's percentage of Proficient/Advanced students on the mathematics MAP test during the 2000 – 2005 period. The administration of the mathematics MAP test in grades 3, 4, 5, 6, 7, 8, and 10 became mandatory in spring 2006.

Mathematics Attainment by MAP Achievement Levels

Fourth Grade. The percentages of fourth grade students at three achievement levels are presented in Figure 1. The bars in the graph combine the Proficient and Advanced levels in the top (green) section and the Step 1 and Progressing levels in the bottom (red) section. The yellow section is the middle "Nearing Proficient" level. This graph shows a wide range across school districts in the percentage of students at the Proficient/Advanced levels (1% to 70%). The average percent Proficient/Advanced for all districts was 39.7% (Figure 2). In comparison, the percentage of students in the Step 1/Progressing levels ranged from 7% to 62% with the average at 21%. The St. Louis area as a whole has almost 40 percent of the fourth grade students performing at the Proficient/Advanced levels and 79 percent at the Nearing Proficient level or above (Figure 2).

Eighth Grade. The percentages of eighth grade students at the three achievement levels are presented in Figure 3. In comparison to the fourth grade results, this graph shows a considerably narrower range across school districts in the percentage of students at the Proficient/Advanced levels (0% to 36%). The average percent Proficient/Advanced for all districts was 15%. This was a substantial drop from fourth grade in the percentage of students performing at the Proficient/Advanced levels (39.7% down to 15%). However, the drop from fourth to eighth grade was similar to the decrease reported in the State of Missouri as a whole (38% down to 14%).

The percentage of eighth grade students in the Step 1/ Progressing levels ranged from 29% to 92% with the average at 54.9%. The St. Louis area as a whole had over half of the eighth grade students performing at the Step 1/Progressing levels in mathematics (Figure 2), but was similar to the State of Missouri (53% vs. 54.9%).

Figure 2. Mathematics MAP Achievement Levels
Average Percentage of Students at Three Achievement Levels across 30 St. Louis Area School Districts

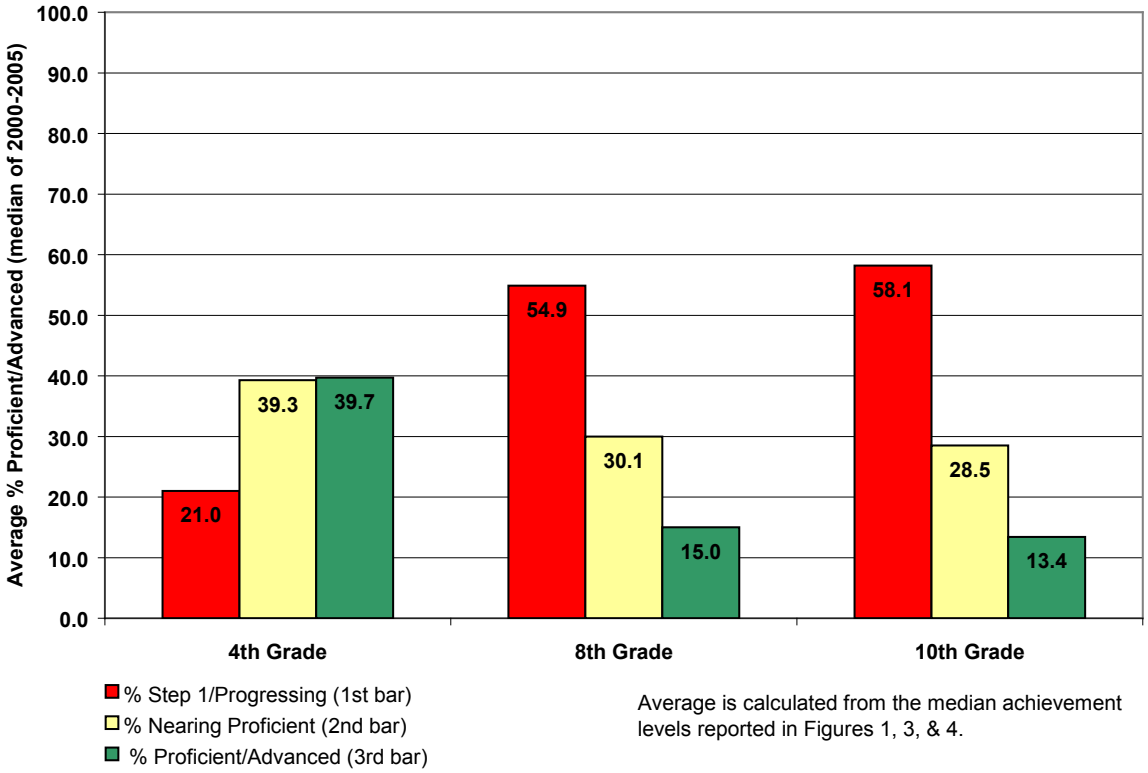


Figure 3. Eighth Grade Mathematics MAP Achievement Levels
Median Percentage of Students within Each Level for Years 2000 - 2005

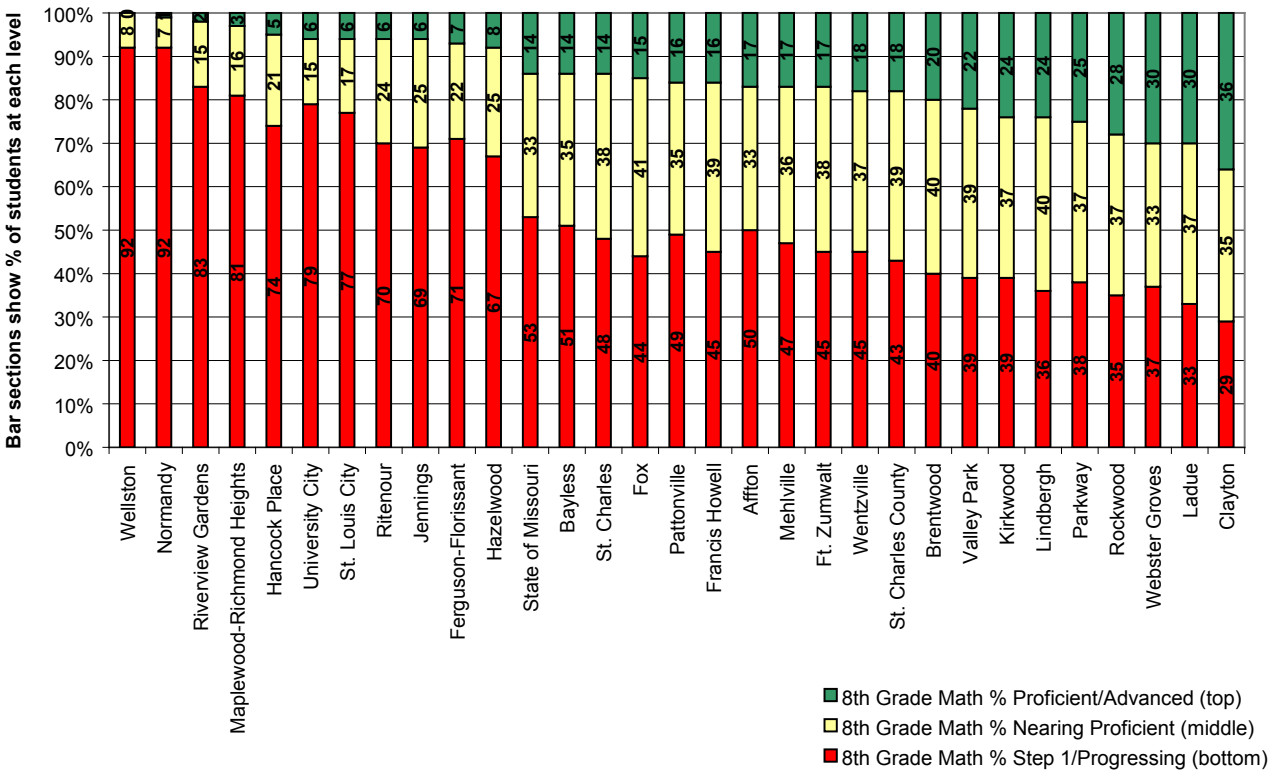
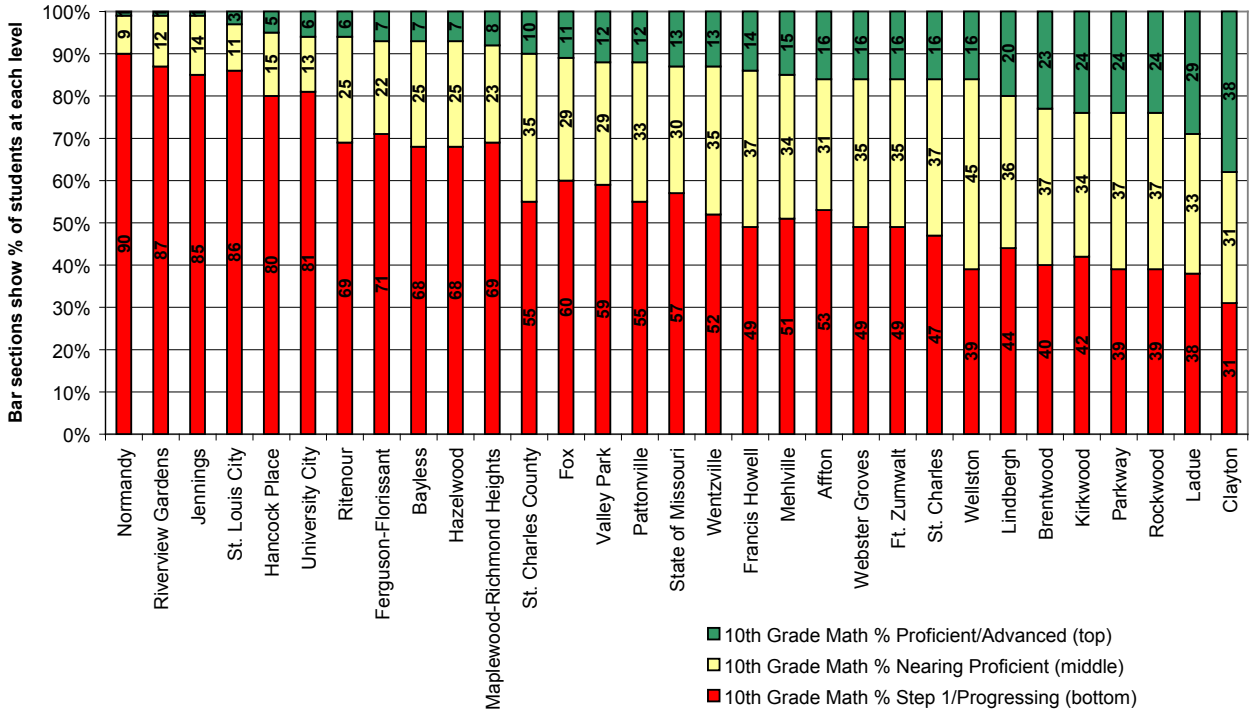


Figure 4. Tenth Grade Mathematics MAP Achievement Levels
Median Percentage of Students within Each Level for Years 2000 - 2005



Tenth Grade. The percentages of tenth grade students at the three achievement levels are presented in Figure 4. The range of Proficient/Advanced students (1% to 38%) was similar to the range in the eighth grade. The average percent Proficient/ Advanced for all districts was 13.4% (Figure 2), which was a slight drop from 15 percent Proficient/Advanced in the eighth grade. The average percentage of tenth grade students at the Proficient/Advanced level was similar to the State of Missouri (13% vs. 13.4%).

For the Step 1/Progressing levels, the percentage of students ranged from 31% to 90% (Figure 4) with the average at 58.1% (Figure 2). There was more variation across districts in the Step 1/Progressing levels than in the upper two levels of Proficient/ Advanced. At the lower achievement levels the average across St. Louis area districts was similar to the State of Missouri (57% vs. 58.1%).

Mathematics Attainment Summary

Below are the major points suggested by the data.

- There was wide variation across St. Louis area school districts in mathematics attainment for the three grade levels assessed by the Missouri Mathematics MAP test. The second section of this report explores the variation in more detail.
- Mathematics attainment in fourth grade (Figure 2) was much closer to the goal of having all students perform at the Proficient level than in the eighth and tenth grades. Almost 80% of fourth graders were at the Nearing Proficient, Proficient, or Advanced levels.
- The average percentage of students at the Proficient/ Advanced levels in the eighth (15%) and tenth grades (13.4%) dropped substantially from the fourth grade (39.7%).
- The decline from fourth grade to eighth in percentage of students at the Proficient/ Advanced levels occurred across all districts. For example, the district with the highest percentage of students at the Proficient/ Advanced levels in the fourth grade (70%) had only 30% in those levels by the eighth grade.
- In the fourth grade 21% of students were at the Step One/Progressing levels, but by eighth grade 55% of students were at these lower levels and by tenth grade the percentage of students was 58%.
- The trends and average percentages of students at the various achievement levels in the St. Louis area closely parallel the State of Missouri as a whole.

Exploring Variation in Mathematics Attainment across Districts

In order to understand the variation in mathematics attainment demonstrated in the previous bar graphs across school districts, the data are presented using “geographic information systems” (GIS) mapping which uses student and school data to create powerful spatial maps based on school district boundaries. Variation and patterns in data are not as apparent as when they are plotted spatially on a regional school district map.

The following three maps of St. Louis area school districts show the percentage of students at the Proficient/Advanced levels in grades four, eight, and ten. The variation in the Proficient/

Advanced levels was used since this is the ultimate objective for mathematics attainment of St. Louis area students. As the definition for Proficient states, "this is the desired achievement level for all students. Students demonstrate the knowledge and skills called for by the Show-Me Standards."

Fourth Grade. The percentage of fourth grade students at the Proficient/Advanced levels are plotted for each school district in Figure 5. The range of percentages is broken down into categories that divide the scores into three approximately equal units. These categories are not definitive, and one could argue for using other break points. The primary objective in this exercise is to show variability among the districts. The school districts with under 30% Proficient/Advanced include St. Louis City and an adjacent cluster to the northwest of St. Louis City. There is a small cluster of three districts just west of St. Louis City where 61% or more of the students scored at the Proficient/Advanced levels. The map shows that about two-thirds of the districts (19) had 31% to 60% of the students at the Proficient/Advanced levels.

Eighth Grade. As discussed in an earlier section, the percentage of students at the Proficient/Advanced levels decreased substantially in the eighth grade for all districts and the differences between them narrowed.

Figure 6 presents the data using three category breaks. As discussed in the fourth grade section, these are not definitive break points but are meant to display variation among districts in a logical way. In eighth grade, eleven districts with percentage of "proficient" students in the 10% or less category included St. Louis City and a cluster to the northwest. Eight districts with percentage of "proficient" students in the 21% or higher category form an east-west corridor through the southern part of the region. The remaining eleven districts with "proficient" percentages in the 11% to 20% category border the northern and southern parts of the St. Louis region.

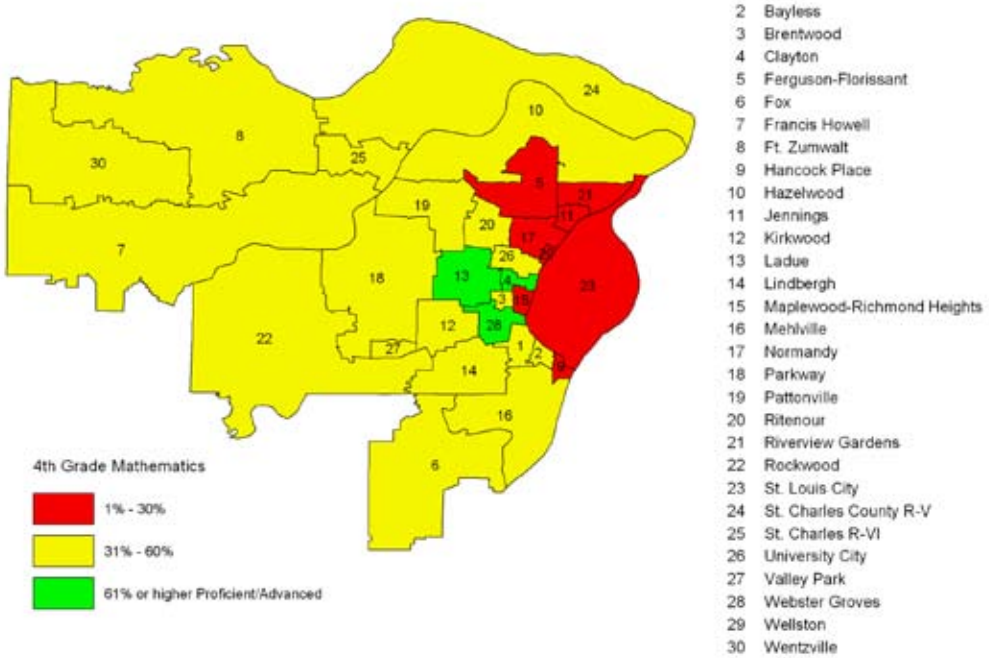
Tenth Grade. In the tenth grade, the range of students across districts at the Proficient/Advanced levels (1% to 38%) was very similar to the range in the eighth grade (0% to 36%) so the same category breaks were used. Figure 7 shows that by the tenth grade, only 6 districts had 21% or more students at the Proficient/Advanced levels. Twelve districts had 1% to 10% of their students at the Proficient/Advanced levels and another twelve districts had 11% to 20% of their students at the highest two levels. In comparison to eighth grade, not only was the *range* of "proficient" students across districts similar in tenth grade, but the *distribution* of districts was similar within each of the Proficient/Advanced categories created for the mapping. This similarity between eighth and tenth grade proficiency levels can be seen by examining Figures 6 and 7.

Discussion

The purpose of this Tech Brief is to present an overview of mathematics attainment in St. Louis area school districts as determined by the State of Missouri Assessment Program (MAP). Knowing the mathematics attainment of the students is important for understanding how well they are being prepared for science and math-related coursework in college. Students proficient in high school mathematics are more likely to pursue majors in college that require mathematical thinking and skills than those who have not mastered the content during high school.

Graduates proficient in mathematics are critical for the region as it attempts to compete for jobs in STEM-related industries (Coble & Allen, 2005). In general, increased mathematics literacy helps all people function more effectively in our technological society. Although some jobs such as those in science and engineering demand a great deal of mathematical knowledge, most jobs in other industries require some mathematical understanding at various levels depending upon the application.

Figure 5. Variation in Percentage of Fourth Grade Students at Proficient/Advanced Levels



How successful are St. Louis area school districts in developing the mathematics proficiency of students?

In fourth grade, 79% of students were at the Nearing Proficient, Proficient, and Advanced levels. Although there was substantial variation among the districts, the region's fourth graders appear to be demonstrating mathematics content knowledge and skills as defined in the Show-Me standards. However, by the eighth grade there was a substantial decline from the fourth grade in the percentage of students at the Proficient/Advanced levels across all districts. The average percentage of students at these levels was 15%. By the tenth grade, the average percentage in the Proficient/Advanced range dropped slightly more to 13.4%. The mathematics levels of students in the St. Louis region are comparable to those across Missouri.

In attempting to answer the question of how successful are area schools in developing mathematics proficiency in students, it is important to distinguish between two success criteria. There is a discrepancy between the *desired* outcome of *all students* reaching the Proficient achievement level and demonstrating knowledge called for by the Show-Me standards, and the *actual target* for the percentage of students expected to reach the Proficient level. Generally, the actual targets for percentage of students at the Proficient level or above are in the 30% range; however, this target can vary widely by content area and district.

If the expectation is that *all* students reach the Proficient level in mathematics, then on the average for the region, 85% of the eighth graders and 87% of the tenth graders have not reached the Proficient level. This leaves quite a gap between the "ideal" proficiency level and "actual" mathematics attainment. Coble and Allen (2005) express the view that an actual proficiency percentage of less than one-third may not be sufficient to produce enough qualified students to fill the science and engineering jobs of the future. Important to this notion is the definition of "proficiency" which lacks agreement among various constituencies.

Are enough students prepared for college science/math-related coursework and technical training?

If a more realistic target (such as 30% of tenth grade students reaching the Proficient level) guides expectations for the foreseeable future, will there be enough students prepared for college math-related coursework and technical training? Will there be an adequate supply of technically trained people to support the region's STEM-related industries?

Assume the percentage of Proficient/Advanced students in the tenth grade is predictive of the percentage at these levels in the senior class. Various scenarios can be created by using different target percentages at the Proficient/Advanced levels to calculate *actual* numbers of students graduating at these levels (see Table 1). Looking at the 18,000 or so tenth graders in the entire region, an average Proficient/Advanced percentage of 13% at the tenth grade level means that only 2,340 students would be "proficient" in mathematics according to the Missouri MAP test based on the Show-Me standards. If the Proficient/Advanced levels are indicators of readiness for further high school math-related coursework, then 2,340 out of 18,000 may not be enough to meet the future needs of the region. This does

Figure 6. Variation in Percentage of Eighth Grade Students at Proficient/Advanced

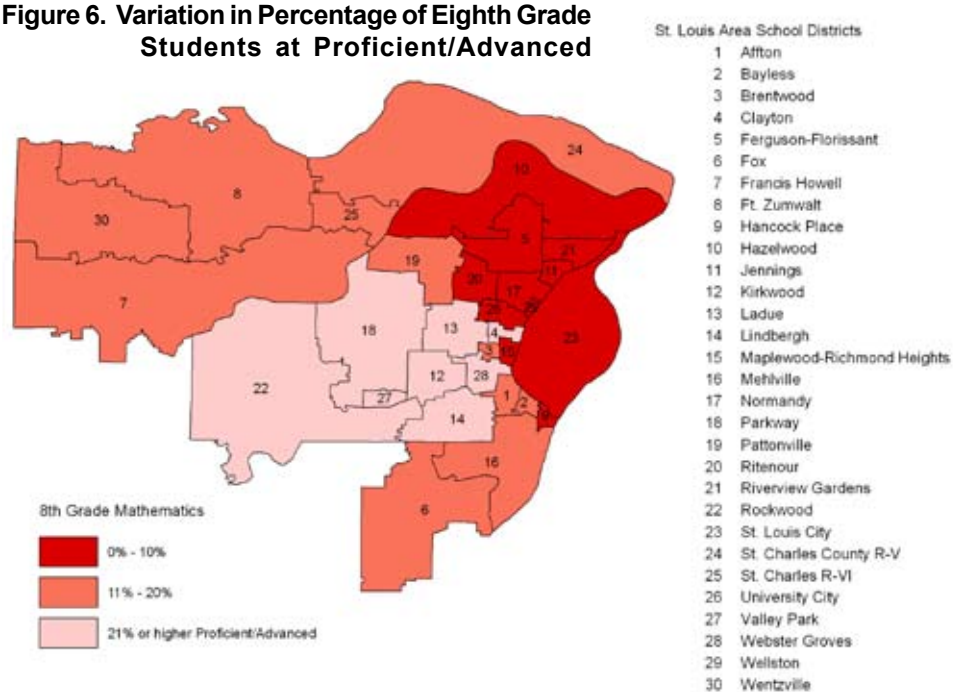
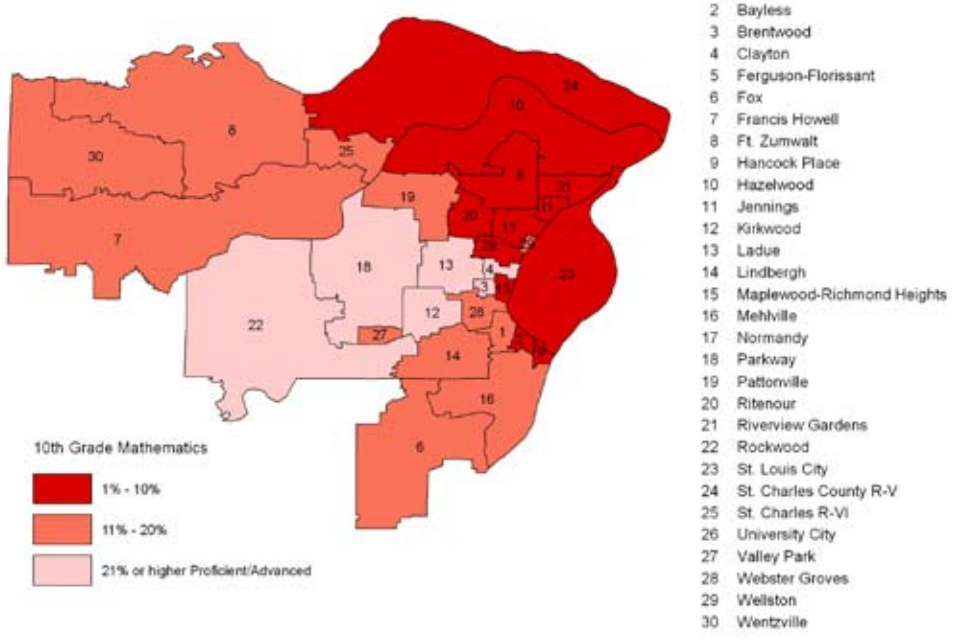


Figure 7. Variation in Percentage of Tenth Grade Students at Proficient/Advanced



not suggest that only 2,340 actually take mathematics courses in area high schools, but it does raise the question as to the overall preparation for higher level courses.

At 30% Proficient/Advanced, 5,400 out of 18,000 students would be "prepared' for further study that requires higher level mathematics, so increasing the percentage in the Proficient/Advanced levels from 13% to 30% has a significant impact on the actual number of students demonstrating mathematical knowledge necessary for subsequent coursework. Of course, this does not mean that all students who are at the Proficient/Advanced levels will choose to pursue math-related coursework, especially at advanced levels. Likewise, tenth graders who are not at the Proficient/Advanced levels can enroll in junior and senior mathematics or math-related courses.

Table 1

Percent Proficient/ Advanced	Actual Numberof Students Out of 18,000
13%	2,340
20%	3,600
30%	5,400
40%	7,200
50%	9,000

Although this brief is not a predictive study about how many tenth grade students eventually enter science and technology fields that depend upon mathematics, the small average percentage at the Proficient/Advanced levels in the tenth grade certainly raises questions about how many of the region's high school graduates will pursue majors in college that require math-related skills and ultimately make STEM career choices.

What happens when achievement level categories are changed?

The State of Missouri is currently setting new achievement levels for the MAP test. This involves establishing revised definitions of "proficiency" to coincide with those used by the National Assessment of Educational Progress (NAEP). Missouri intends to reduce the current five levels of proficiency to the four NAEP classifications: Below basic, Basic, Proficient, and Advanced. According to a recent news release on the Missouri DESE website (December 2005), the MAP advisory committee intends to set the MAP achievement levels so that 30% to 35% of Missouri students score at the Proficient level and about 10% to 12% score at the Advanced level. For science, however, the present five level classification will remain for Spring 2006.

The article suggests that at least for math, the MAP test standards are higher than those in the NAEP testing. The implication is that adjusting the break scores downward to increase the number of students at the Proficient and Advanced levels is simply aligning the MAP achievement levels with the national NAEP standards.

Missouri results on the 2003 and 2005 NAEP fourth grade mathematics assessments do not appear to support this reasoning (National Center for Education Statistics, 2006). On the NAEP mathematics assessment, 33% of Missouri's fourth grade students scored at the Proficient/Advanced levels in 2003 and 34% in 2005. These results are lower than the 38% of fourth students who were classified as Proficient/Advanced according to the State of Missouri MAP average for fourth graders. If the NAEP results are used as benchmarks, it doesn't appear that the Missouri MAP break scores for fourth graders need to be adjusted downward to classify more students as Proficient/Advanced.

The results for eighth graders present a different picture. Missouri results on the NAEP eighth grade mathematics assessments show that 32% in 2003 and 30% in 2005 scored at the Proficient/Advanced levels. These percentages are much higher than the State of Missouri MAP average of 14% Proficient/Advanced for eighth graders. If aligning to the NAEP results is a goal, then a case can be made for adjusting the Missouri MAP break scores downward at the eighth grade level in order to classify about 30% of the students as Proficient/Advanced.

The important point is that the achievement level break scores have significant educational consequences for area schools and their progress in meeting NCLB requirements. In addition, how the achievement level categories are determined have implications for St. Louis region policy-makers and employers. As demonstrated in the previous section, there is a big difference between classifying 30% (5,400) of tenth grade students as Proficient/Advanced as opposed to 13% (2,340).

Certainly, changing the break scores for the achievement levels does not alter the actual amount of mathematical knowledge retained by students. The salient question is whether students who are classified as "Proficient" have mastered the mathematics content and processes defined in the Show-Me standards. In order for a student to be "Proficient," what percent of questions must be answered correctly? If the MAP test is aligned to the standards, then the percent of correct answers should reflect content mastery.

The appropriateness of the achievement level break scores will have to be validated by investigating questions such as, "Does the percentage of tenth grade students classified as Proficient/Advanced by MAP mathematics scores align with enrollment and performance in high school mathematics courses?"

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