STEM IN MINNESOTA (Science, Technology, Engineering, Math)

Education Disparities

Income: A cradle to college perspective

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Academic achievement is strongly connected to students' family income. Minnesota students from poor and low-income families tend to have considerably lower achievement than their classmates from higher income families. These large achievement gaps begin very early and persist throughout the school years. They represent a major barrier to developing a workforce with the skills to meet the states' current and future needs – such as sufficient numbers of workers with problem-solving skills, technological literacy, scientific reasoning, and mathematical skills.

It is critical to the state's future well-being to increase STEM academic achievement and workforce participation of Minnesotans currently underrepresented in these areas, including those who have grown up in poverty or low-income families. Addressing these gaps is an issue of economics as well as equity.

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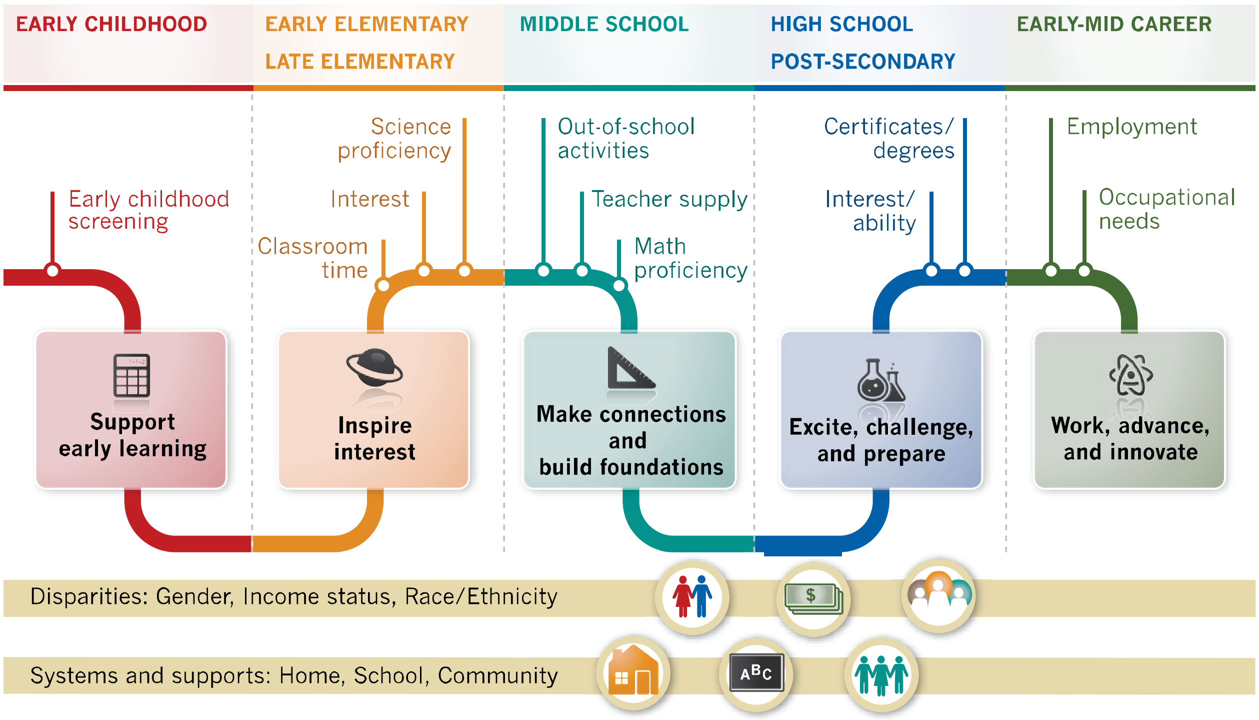
This paper was developed to augment STEM information on the Minnesota Compass website, which provides a common foundation of knowledge and resources that can be used to collectively address concerns and most effectively target resources. The website is organized around a cradle-to-career framework.



While STEM conversations generally take a holistic approach, at this point, data are often available by discipline (e.g., math, science). For this reason, data presented in this paper are often organized by discipline, but sections generally follow along the continuum.

The paper is divided into four sections with each section identifying income gaps, potential contributing factors (some sections), and actions aimed to reduce or eliminate gaps:

- Math, early childhood to high school
- Science, elementary to high school
- College readiness
- Interest in STEM

The STEM acronym stands for science, technology, engineering, and mathematics, but represents much more: a range of disciplines, a way of thinking and knowing, and a set of creative, inventive, and technical skills. STEM includes the basic sciences and mathematics and applied sciences such as agriculture, natural resources, computer science, health care and engineering. Viewed more broadly, everyday science and engineering, from cooking to car repair, are also STEM.

– Minnesota STEM Network, 2013

Summary

In discussing student K-12 academic achievement in this paper, income categories are usually based on the students' eligibility for free or reduced-price lunch. The category "lower income" includes those eligible for free or reduced-price lunch at school. Currently, 38 percent of Minnesota's K-12 public school students are eligible for free or reduced-price lunch. These are students from families with incomes up to 185 percent of the federal poverty guidelines (about $42,200 annually for a family of four in 2011). Hence, "lower income" refers to poor and near poor families. The category "higher income" includes those not eligible for free or reduced-price lunch (incomes above 185% of the federal poverty guidelines). Thus, "higher income" includes a wide range of family incomes from quite modest incomes to the highest incomes. When another definition of income categories is used in presenting information, this will be indicated. When we refer to the student's income or income level in the paper we mean the income of the student's family.

Key findings for Minnesota students

Math

- Minnesota ranks among the top five states in overall math skills with gaps by students' income level near the national average.
- Differences in children's math skills by income level emerge early, before school entry.
- Large gaps in math skills by income level occur at each grade level measured, elementary through high school.
- Math teacher preparation and instructional resources differ just slightly by students' income level.

Science

- Overall, Minnesota ranks among the top 10 states in science with average gaps by income level compared to other states.
- Although similar to other states, there are large gaps in science proficiency by income level among Minnesota students from elementary through high school.
- Science teacher preparation, classroom time spent on science, and resources for instruction differ just slightly by students' income level.

College readiness in STEM

- About one-quarter of college-bound lower-income students were ready for college coursework in STEM compared to 45 percent of higher-income students.

STEM interest

- Lower-income students have as much interest in STEM as higher-income students, and sometimes even more.
- Fourth graders' interest in science is very similar across income levels.
- Eighth graders' participation in non-school science activities doesn't differ by income level.
- Lower-income, college-bound students express more interest in STEM majors than their higher-income counterparts.
- Overall, interest in STEM majors seems low relative to projected workforce needs.

Suggested actions:

Math

- Increase lower-income children's participation in high-quality preschools with a strong math component.
- Provide timely math interventions in early elementary grades to avoid later difficulties.
- Increase the number of top-performing math teachers in classrooms that need them the most.
- Seek to replicate the success of high poverty, high performing schools more widely.
- Provide guidance to parents in how they can work with their children to improve their math skills.

Science

- Hold schools accountable for students' science achievement.
- Improve K-12 science teaching including integrating science teaching with other STEM subjects.
- Increase opportunities for all children to participate in informal STEM education programs.

College readiness in STEM

- Offer more opportunities for lower-income students to take advanced courses in high school, including dual enrollment opportunities.
- Improve the preparation of lower-income students for advanced courses in high school.
- Offer other evidence-based programs to help lower-income students prepare for college.

STEM interest

- Improve the teaching of science.
- Provide more coordinated and aligned informal STEM education to build on students' initial interest.
- Increase students' awareness of STEM careers.

Math proficiency

Key findings

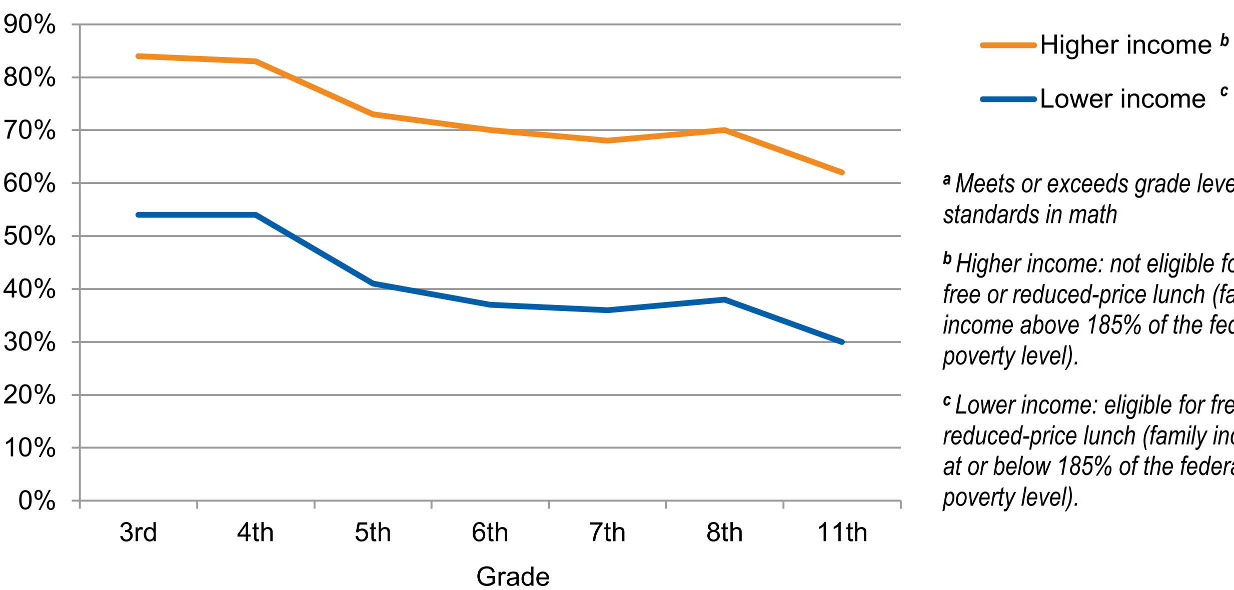
Differences in children's math learning by income level emerge early, before school entry

Gaps in children's academic skills by family income begin early, before children are old enough to enter school. A Minnesota Department of Education assessment of children's school readiness upon kindergarten entry was conducted in 2008 using a statewide sample. This study assessed students' math readiness by using the Mathematical Thinking items from the Work Sampling System. Results from this assessment revealed a substantial gap in Mathematical Thinking proficiency between children from lower-income families (incomes at or below 250% of the federal poverty level) and children from higher-income families (incomes above 250% of the federal poverty level). The proficiency rates were 33 percent and 55 percent, respectively, a gap of 22 percentage points. Hence, lower-income children overall are already behind their higher-income peers in math learning when they enter school (Human Capital Research Collaborative, a Partnership of the University of Minnesota and the Federal Reserve Bank of Minneapolis, 2011). Most recently this study was conducted in the fall of 2012 and found that overall school readiness had improved compared to previous years' studies. Of the five domains assessed in 2012, children were least likely to be proficient in math (58%). The study found that overall children's proficiency rose as family income increased, but separate analyses were not conducted of the relationship of family income to proficiency in Mathematical Thinking (Minnesota Department of Education, 2013a).

Large gaps in math skills by income level occur at each grade level

The gaps in math learning by students' family income upon school entry persist, and may grow, in the elementary school grades. Minnesota public school students in grades 3 through 8 are tested in math each spring using the Minnesota Comprehensive Assessments, Series III (MCA-III), and in eleventh grade using the MCA-II. In third grade in spring 2013, 72 percent of all students were proficient in MCA-III math. This included 54 percent of lower-income students and 84 percent of higher-income students, a 30 percentage point gap. While this suggests that the math learning gap by students' family income has increased from school entry to spring of third grade, caution in drawing such a conclusion is warranted due to differences in how income categories were defined and math learning was measured at the two time points. The proficiency gap by income seen in third grade was also seen throughout elementary and middle school, increasing slightly (from a gap of 29-30 percentage points in grades 3 and 4 to a gap of 32-33 percentage points in grades 5-8). In eighth grade, 59 percent of all Minnesota students were proficient in math, including 38 percent of lower-income students and 70 percent of higher-income students, a 32 percentage point gap. In eleventh grade, the proficiency rate in MCA-II math was 52 percent for all Minnesota students, including 30 percent of lower-income students and 62 percent of higher-income students, again a gap

1. Math proficiency by grade: Minnesota students, 2013, percent proficient [a]



[a] Meets or exceeds grade level standards in math

[b] Higher income: not eligible for free or reduced-price lunch (family income above 185% of the federal poverty level).

[c] Lower income: eligible for free or reduced-price lunch (family income at or below 185% of the federal poverty level).

Source: *Minnesota Department of Education, 2013b*

Note: *Math proficiency is based on results of the Minnesota Comprehensive Assessments, Series III (MCA-III), in math for grades 3-8, and the MCA-II in Math for grade 11.*

of 32 percentage points (Figure 1). Overall, and within the income categories, math proficiency rates declined from third to eleventh grade – from 54 to 30 percent for lower-income students and from 84 to 62 percent for higher-income students. The largest single year decline was from fourth grade to fifth grade overall, and for both income groups. There has been little change in income gaps within each grade over the last three years (Minnesota Department of Education, 2013b).

Minnesota ranks among the top five states in math skills with gaps by student income level near the national average

Fourth- and eighth-grade math results from the National Assessment of Educational Progress (NAEP), often called the Nation's Report Card, are available for Minnesota in 2013. These results show similar gaps in proficiency by students' family income to those seen in the MCA math results. NAEP results are based on a representative sample of Minnesota fourth and eighth graders. NAEP fourth-grade math results indicated a proficiency rate of 37 percent for lower-income students and 72 percent for higher-income students, a 35 percentage point gap. Minnesota ranked first among the states in NAEP fourth-grade math achievement but had a gap in achievement by income level similar to the national average (U.S. Department of Education, Institute of Educational Sciences, National Center for Education Statistics [U.S. DOE], 2013).

The NAEP math proficiency rate for eighth graders from lower-income families was 25 percent compared to 58 percent for students from higher-income families, a gap of 33 percentage points. While overall Minnesota eighth graders performed better on NAEP math on average than their peers nationwide (Minnesota ranked fifth highest among the states), the achievement gap by students' income was slightly wider than the national average. The gap in eighth-grade math proficiency by income has widened in Minnesota during the past 17 years (U.S. DOE, 2013).

Potential contributing factors

Math teacher preparation and instructional resources differ just slightly by student income

Teachers' content knowledge and instructional resources in a subject area can affect student learning. Information available on these areas in Minnesota indicates a very small advantage for higher-income students. Turning first to teachers' preparation, NAEP data from 2011 for Minnesota showed that 42 percent of eighth-grade math teachers of lower-income students had an undergraduate major in math compared to 45 percent for higher-income students, a slight difference in favor of higher-income students. Next, eighth-grade math teachers were asked in 2011 how many of the resources needed for math instruction were provided by their school system (none, some, most, or all). Seventy-three percent of teachers of lower-income students said most or all the resources needed were provided by their school system (59% most and 14% all) compared to 80 percent of teachers of higher-income students (65% most and 15% all). Again, this is a small difference in favor of higher income students (Change the Equation, n.d.).
These slight differences in teacher preparation and instructional resources by students' family income may account for a small part of the eighth grade math achievement gap in Minnesota, but most of the gap is likely due to other factors. Other data on per pupil expenditures in the highest- and lowest-poverty districts in Minnesota suggest that this factor is unlikely to be a major explanation for the gap. The average per pupil expenditure in the highest- poverty districts is considerably higher

than the average expenditure in the lowest-poverty districts (Change the Equation, n.d.).

Actions to reduce gaps

Increase lower-income children's participation in high-quality preschools with a strong math component

To reduce gaps in math skills, intervening early before students begin school seems critical since the gaps emerge very early. Research has indicated that high-quality, center-based preschool programs can increase school readiness and narrow early learning gaps for children from poor or low-income families, including in math and science (Mueller, 2006; MacFarland & Krupicka, 2013). Math should be a significant focus of the preschool program. An example of an evidence-based supplemental math curriculum for three to five year olds is *Pre-K Mathematics* combined with *DLM Early Childhood Express* software. It is designed to develop informal math knowledge and skills through the following seven units: 1) counting and numbers, 2) understanding arithmetic operations (fall activities), 3) spatial sense and geometry, 4) patterns, 5) understanding arithmetic operations (spring activities), 6) measurement and data, and 7) logical reasoning (What Works Clearinghouse, 2007).

Provide timely math interventions in early elementary grades to avoid later difficulties

Once students are in school, it is important for teachers to monitor their math performance closely and intervene early with extra help if students are having difficulties such as with story problems or arithmetic combinations. Kindergarten or early first grade is not too early to intervene with children having such problems (Jordan, Kaplan, Olah, & Locuniak, 2006).While there is currently a focus on getting students one-on-one tutoring help in reading if they need it in early grades, it seems an equal emphasis on math tutoring for students who need it in the early grades is warranted. It is important for students to have successes and gain confidence in their math abilities early, especially at-risk students. Students can develop negative beliefs about their math capabilities early (e.g., "I'm not good at math.") or even a fear of math that becomes a psychological barrier to their achieving in math later (Goldberger & Bayerl, 2008).

Increase the number of top-performing math teachers in classrooms that need them the most

The small inequities in math teacher preparation and instructional resources between lower-income and higher-income students in Minnesota described above should be eliminated. Better yet, greater efforts should be made to get top-performing math teachers into the classrooms where students are behind or struggling academically (Committee on STEM Education, National Science and Technology Council, 2013; National Academy of Sciences, National Academy of Engineering & Institute of Medicine, 2011). Perhaps, an incentive system for teachers could help accomplish this goal. Also, more mentoring by outstanding math teachers of teachers working in classrooms with at-risk/ struggling students could be helpful.

Provide guidance to parents in how they can work with their children to improve their math skills

Greater efforts by teachers and school staff to work with parents, especially lower-income parents, to assist them in supporting their children's math learning, using evidenced-based practices, could also help close achievement gaps.

Seek to replicate the success of high poverty, high performing schools more widely

Finally, there are many examples of "high poverty, high performing schools" across the country, including Minnesota, that have "beat the odds" and demonstrated that students from poor and low-income families can be high performers in math and other subjects, equal to students from higher-income families. There is research literature that has identified characteristics that such schools have in common that may be helpful to schools trying to boost the academic performance of lower-income students. Characteristics of high poverty, high performing schools include: effective leadership; alignment of curriculum, instruction, and assessment; high levels of collaboration and communication among teachers; effective engagement of the school staff with parents; a school culture of high achievement and success that revolves around the success of each individual student; effective use of data in decision-making; and use of strategies to support and cultivate highly qualified teachers (Mohr, Petersen, & Mueller, 2013; Barr & Parrett, 2007; Shannon & Bylsma, 2007). One study of high poverty, high performing schools that focused especially on math found that the following three characteristics were shared by these schools: high expectations accompanied by strong support for academic excellence; challenging math content with math instruction that focused on "problem-solving and sense making," rather than rote instruction; and teachers building relationships with students and their families (Flores, 2007; Kitchen, DePree, Celedon-Pattichis, & Brinkerhoff, 2007).

Science proficiency

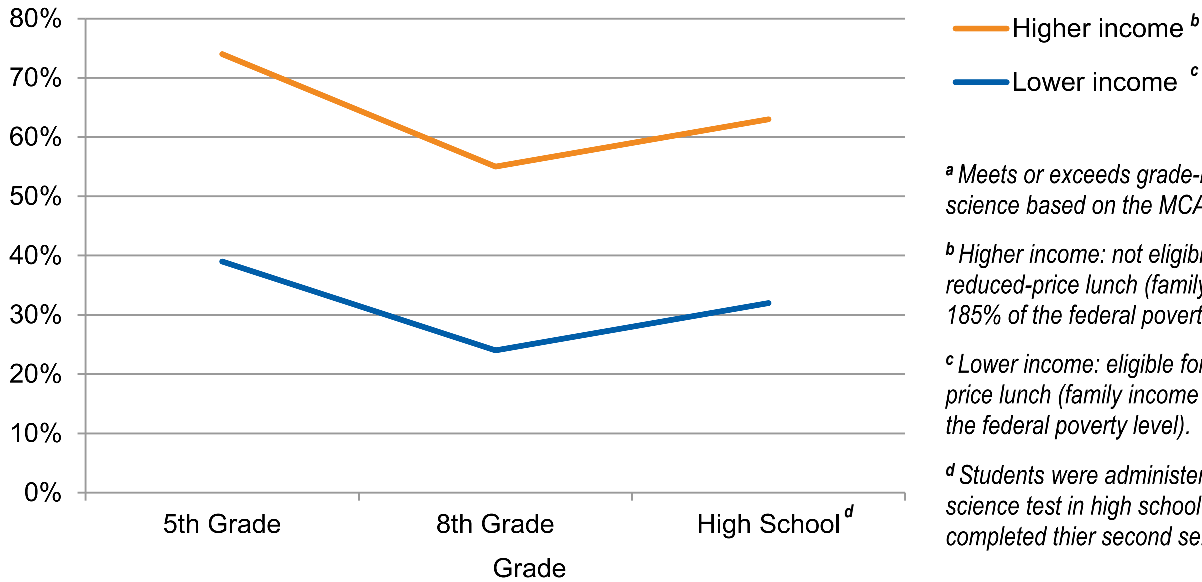
Key findings

Large gaps in science proficiency by income level occur from elementary through high school

A key indicator of student science skills in Minnesota is fifth-grade science proficiency based on the Minnesota Comprehensive Assessments, Series III (MCA-III). Statewide results from spring 2013 show that 60 percent of fifth graders were proficient in science with large differences in proficiency by students' family income. Thirty-nine percent of lower-income fifth graders were proficient in science compared to 74 percent of higher-income fifth graders, for a gap of 35 percentage points (Minnesota Department of Education, 2013). The gap in proficiency rates the previous year (2012) was similar at 34 percentage points (Minnesota Department of Education, 2013b).

Large gaps between students from lower- and higher-income families in Minnesota also occurred in later grades. Students were administered MCA-III science tests in eighth grade and in high school after they completed their second semester of biology. Overall student proficiency rates decreased in eighth grade compared to fifth grade (declined from 60% proficient in fifth grade to 44% proficient in eighth grade), and rose in high school to 53 percent proficient. The gap between lower-income and higher-income students in science proficiency in both eighth grade and high school was 31 percentage points (Figure 2) (Minnesota Department of Education, 2013b).

2. Science proficiency by grade: Minnesota students, 2013, percent proficient [a]



[a] Meets or exceeds grade-level standa science based on the MCA-III science t

[b] Higher income: not eligible for free or reduced-price lunch (family income abc 185% of the federal poverty level).

[c] Lower income: eligible for free or redu price lunch (family income at or below the federal poverty level).

[d] Students were administered the MCA science test in high school after they completed thier second semester of bic

Source: *Minnesota Department of Education, 2013b*

Note: *The decrease in science proficiency from fifth to eighth grade and the increase from eighth grade to high school may be due, at least in part, to how recently the material included in the test was covered. The fifth grade test included material covered in fifth grade while the eighth grade test included material covered in grades 6-8. The high school test included material covered the year the test was taken.*

Minnesota ranks among the top 10 states in science with average gaps by income level

NAEP science results for Minnesota fourth and eighth graders also showed large gaps in proficiency by students' family income. In the most recent year NAEP fourth-grade science data are available (2009), the proficiency rate for fourth graders from lower-income families was 21 percent compared to 53 percent for students from higher-income families, a gap of 32 percentage points. Overall Minnesota fourth graders performed better on NAEP science on average than their peers nationwide (Minnesota ranked ninth highest among the states). The achievement gap by students' family income compared to other states was near the middle (U.S. DOE, 2013).

NAEP eighth-grade science results for Minnesota in 2011 showed that students from lower-income families had a 24 percent proficiency rate compared to 50 percent for students from higher-income families. The resulting gap was 26 percentage points, somewhat smaller than the gap for NAEP fourth-grade science. Overall, Minnesota students ranked eighth among the states in eighth-grade science performance. Minnesota's achievement gap by income was slightly smaller than the national average (U.S. DOE, 2013).

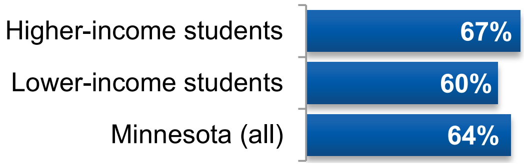
Potential contributing factors

Science teacher preparation, classroom time spent on science, and resources for instruction differ just slightly by student income level

Inequities in time and resources devoted to science instruction and differences in teacher preparation by students' family income levels could potentially help explain gaps observed in science proficiency.

As part of the 2009 NAEP science assessment, teachers of fourth graders were asked about how much time they spent on science instruction in a typical week (less than 1 hour, 1 to 1.9 hours, 2 to 2.9 hours, 3 to 3.9 hours, or 4 hours or more). Minnesota results indicated a small advantage in the percentage of higher-income students who received two or more hours of science instruction per week compared to lower-income students (Figure 3). Sixty-seven percent of higher-income students received two or more hours of science instruction compared to 60 percent of lower-income students (U.S. DOE, 2013). Minnesota lagged behind the nation in time spent on science in grades 1 through 4 based on the most recently available data (2008) (Change the Equation, n.d.).

3. 4th graders with 2 or more hours per week spent on science by income, Minnesota, 2009



Source: *U.S. Department of Education, 2013*

Note: *Income categories are based on eligibility for free or reduced-price lunch. The category "Lower-income" includes those eligible for free or reduced-price lunch. The category "Higher-income" includes those not eligible for free or reduced-price lunch.*

Minnesota eighth-grade math teachers were asked in 2011 how many of the resources needed for math instruction were provided by their school system (none, some, most, or all). Teachers of higher-income students were just slightly more likely to report that their school systems provided most or all the instructional resources they needed compared to teachers of lower-income students – 65 percent vs. 62 percent. In addition, Minnesota eighth-grade students were asked in 2011 if their school had laboratory facilities for eighth-grade science. Almost all of both lower-income and higher-income students reported that their schools had such lab facilities – 92 percent and 94 percent, respectively (Change the Equation, n.d.).

Turning to Minnesota science teachers' preparation, data from 2011 showed a slight advantage for higher-income eighth graders compared to lower-income eighth graders. That is, 79 percent of eighth-grade science teachers of higher-income students had an undergraduate major in science compared to 74 percent for lower-income students (Change the Equation, n.d.).

In sum, higher-income students in Minnesota tend to have a very slight advantage over lower-income students in the preparation of their science teachers, the time spent on science instruction, and the resources provided for such instruction. These slight advantages are likely to account for only a small part of the science achievement gap between students from lower- and higher-income families.

Actions to reduce gaps

Hold schools accountable for students' science achievement

Holding schools accountable for students' science performance could be helpful in focusing more attention on science education (Change the Equation, n.d.). Currently, Minnesota schools are held accountable for MCA reading and math results but not MCA science results. Minnesota lags behind the nation in the time spent on science by classroom teachers in elementary grades (Change the Equation, n.d.; U.S. DOE, 2013). Greater accountability for science results could increase classroom time and resources dedicated to science and strengthen efforts to improve the performance of all student groups (e.g., income, race/ethnicity, and gender groups) in the subject.

While inequities by students' family income were small in science instructional time and resources, and science teacher preparation, efforts should be made to eliminate them.

Improve K-12 science teaching including integrating science teaching with other STEM subjects

Improving the teaching of science is likely an important component in increasing the interest and performance of all students in science, perhaps especially students from poor or low-income families. Key to accomplishing this is providing professional development opportunities for teachers to learn how to teach science more effectively to diverse student classrooms. Effective science teaching includes connecting it to the context of students' lives using real-world examples or problems, and providing frequent opportunities for students to engage in scientific inquiry and the processes of developing scientific knowledge (National Research Council, 2007 & 2011; MN P-20 Education Partnership, 2011; Schroeder, Scott, Tolson, Huang, & Lee, 2007).

Integrated approaches to teaching STEM can enhance students' science learning. Efforts have increased in recent years to integrate the teaching of STEM subjects—that is, to combine the teaching of two or more STEM subjects. Although research on the effects of integrated STEM education on student outcomes is at an early stage, there is evidence that this approach has beneficial effects on student learning. Two meta-analysis studies that synthesized existing research on the effects of integrated STEM education found beneficial effects of integrated instruction on science learning (Becker & Park, 2011; Hurley, 2001). Integrated instruction tends to benefit science learning more than math learning (Hurley, 2001). Benefits to science learning tend to be greater when science is taught together with technology or with both technology and engineering (Becker & Park, 2011).

Increase opportunities for all children to participate in informal STEM education programs

Informal science or STEM education programs can also be important in stimulating interest in science/STEM and providing opportunities for children to engage in "hands-on" scientific investigation. Participation in these programs and activities may help to counter messages students in underrepresented groups may have received that they may not belong or excel in STEM fields (President's Council of Advisors on Science and Technology, 2010). Attention should be given to eliminating any barriers to the participation of lower-income families and their children such as admission costs or program fees, transportation, and program hours.

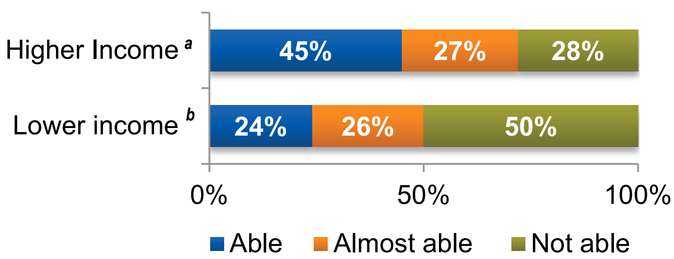
College readiness in STEM

Key findings

About one-quarter of college-bound lower-income students were ready for college coursework in STEM compared to 45 percent of their higher-income counterparts

In Minnesota, most of the high school graduates who are college bound take the ACT exam, usually in their junior or senior year in high school. Seventy-four percent of Minnesota high school graduates in 2012 took the ACT. Students' results on the ACT are a measure of their preparation for college-level coursework. Overall, the percentage of Minnesota high school graduates in 2012 who met ACT college-readiness benchmarks in both the ACT math and science subject area tests ("able") was 39 percent, and 26 percent passed one of the two tests ("almost able"). College-readiness benchmarks reflect scores on ACT math and science tests that represent the level of achievement required for students to have an approximately 50 percent chance of obtaining a B or higher or a 75 percent chance of attaining a C or higher in corresponding credit-bearing first-year college courses in algebra and biology. For this analysis, lower income was defined as a family income at or below $50,000 and higher income was defined as a family income above $50,000. Again, results indicate substantial gaps by students' family income level: 24 percent of lower-income students were "able" and 45 percent of higher-income students were "able," a gap of 21 percentage points (Figure 4). If students in the "able" and "almost able" categories are combined, 72 percent of higher-income students were able or almost able compared to 50 percent of lower-income students (ACT, Inc.). Lack of preparation in math is often the biggest barrier to students' academic success in college (Mueller & Gozali-Lee, 2013).

4. Minnesota 2012 high school graduates' ability in STEM



Source: *ACT, Inc.*

[a] Higher income refers to students who reported an annual family income greater than $50,000.

[b] Lower income refers to students who reported an annual family income of $50,000 or lower.

Note: *"Able" students are those meeting both science and math benchmarks on the ACT assessment. "Almost able" are those meeting one of the two benchmarks. "Not able" are those meeting neither benchmark.*

To help put these results in context, it is important to realize that fewer lower-income students are likely to take the ACT than higher-income students. This is because lower-income students are less likely to graduate from high school than higher-income students, and if they do, they are somewhat less likely to enroll in college (Mueller & Gozali-Lee, 2013). The ACT is mostly taken by college-bound high school students.

Actions to reduce gaps

Offer more opportunities for lower-income students to take advanced courses in high school

One way to potentially address the gap in ACT math and science exam results by students' family income is for more Minnesota high schools to provide students with the opportunity to take rigorous, advanced courses in math and science. Greater access to these courses could be accomplished by more high schools offering Advanced Placement (AP) courses in math and science (and International Baccalaureate, or IB, courses too). AP courses are offered in about 270 Minnesota high schools with AP offerings being the most limited in rural school districts. While students' participation in AP courses in Minnesota has increased in recent years, lower-income students are likely to still be underrepresented in these courses (Minnesota Office of Higher Education, 2013).

Besides AP or IB courses, another way for students to take advanced courses in high school is through dual-enrollment programs. Dual enrollment provides students with the opportunity to take college courses while still in high school and gain both college and high school credit for them. Dual enrollment has become an increasingly popular model of instruction for Career and Technical Education (CTE) programs. Minnesota offers a dual enrollment program called Post-

Secondary Enrollment Options (PSEO) that is not confined to CTE programs but also includes enrollment in many four-year colleges and universities. Lower-income students tend to be underrepresented in PSEO (Mueller & Gozali-Lee, 2013). Increasing the participation of such students in this program is another potential way of improving their college readiness. Building stronger partnerships between community and technical colleges and high schools could be one way to do this. Although rare in Minnesota, Early College High School is one promising program model for such partnerships (Mueller & Gozali-Lee, 2013; Hooker & Brand, 2009).

Improve the preparation of lower-income students for advanced courses in high school

Students, of course, need to be prepared to succeed in AP, IB, PSEO, or other advanced high school courses when offered the opportunity to take them. As we have seen from the earlier achievement data, lower-income students are more likely to be unprepared for such courses when they reach high school. There are many possible reasons for this lack of preparation but one might be a lack of opportunity to take the courses needed in earlier grades to be ready for advanced coursework in high school. A National Research Council (2002) report recommends that advanced study programs in high school should be integrated with the rest of the school district's or school's program through a coherent plan from middle school through high school. This plan should include the elimination of course options in grades 6 through 10 that have reduced expectations such that they leave students unprepared for further study in a discipline. The report notes that an exception to this recommendation might be made for courses designed to meet the needs of special education students.

An example of a tool that could be helpful in getting students ready for college and reducing achievement gaps is the Educational Planning and Assessment System (EPAS) from ACT, Inc. The EPAS is a set of assessments designed to provide a longitudinal, systematic approach to educational and career planning, assessment, instructional support, and evaluation. These assessments were developed to benchmark college readiness for students nationally. Students are given the EXPLORE assessment in eighth grade, the PLAN assessment in tenth grade, and the ACT in eleventh or twelfth grade. The EXPLORE and PLAN, especially, could be used by schools to measure student progress toward college readiness, develop course plans, and intervene with students as appropriate.

Offer other evidence-based programs to help lower-income students prepare for college

There are other programs with evidence of success in preparing high school students for college-level STEM courses that work with lower-income students. One such program is Upward Bound Math-Science (Hooker & Brand, 2009). A couple of initiatives in high school CTE that have evidence of improving students' readiness for postsecondary education are *Project Lead the Way* (Bottoms & Uhn, 2007) and the Math-in-CTE model (Stone, Alfeld, & Pearson, 2008). These programs and projects are described in "Best Practices" in the "Excite, Challenge, and Prepare" part of the STEM section of Minnesota Compass.

STEM interest

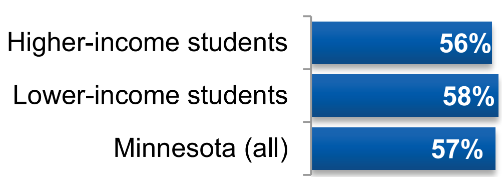
Key findings

The pattern we see in math and science proficiency of large gaps between students from lower- and higher-income families is generally not seen in the data available on interest in science or STEM. Lower-income students tend to have at least as much interest in STEM as higher-income students, and sometimes even slightly more.

Fourth graders' interest in science is very similar across income levels

As part of fourth-grade science assessments, the National Assessment of Educational Progress (NAEP) includes a question about interest in science. Fourth graders are asked how much they like studying science: very little, some, quite a bit, or very much. The most recent results available (2009) indicated that 57 percent of Minnesota fourth graders have high interest in science (combines the "quite a bit" and "very much" responses). Results by students' family income showed similar levels of interest for lower-income and higher-income students (Figure 5). The percentage of lower-income students having high interest in science was 58 percent compared to 56 percent for higher-income students, a slight edge for lower-income students but within the margin of error for the study sample (U.S. DOE, 2013).

5. Percent of 4th graders with high interest in science by income, Minnesota, 2009



Source: *U.S. Department of Education, 2013*

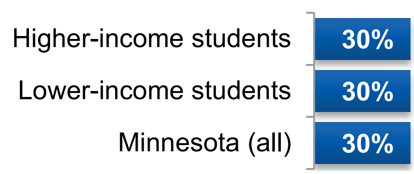
Notes: *Fourth-graders were asked how much they like studying science: very little, some, quite a bit, or very much. Combines response categories of "very much" and "quite a bit" of interest.*

Income categories are based on eligibility for free or reduced-price lunch. The category "Lower-income" includes those eligible for free or reduced-price lunch. The category "Higher-income" includes those not eligible for free or reduced-price lunch.

Eighth graders' participation in non-school science activities doesn't differ by income level

As part of eighth-grade NAEP science assessments, students are asked how much they disagree or agree that they do science-related activities that are not for schoolwork: strongly disagree, disagree, agree, or strongly agree. This question probably measures both interest in science and opportunity to participate in out-of-school science programs or activities. Combining those who responded "strongly agree" or "agree," the percentage of lower- and higher-income Minnesota eighth graders who said they did non-school science activities was identical – 30 percent for both income groups (Figure 6) (U.S. DOE, 2013).

6. Percent of 8th graders doing science activities not for school by income, Minnesota, 2011



Source: *U.S. Department of Education, 2013*

Notes: *Eighth-graders were asked how much they disagree or agree that they do science-related activities that are not for schoolwork: strongly disagree, disagree, agree, or strongly agree. Combines response categories of "agree" and "strongly agree."*

Income categories are based on eligibility for free or reduced-price lunch. The category "Lower-income" includes those eligible for free or reduced-price lunch. The category "Higher-income" includes those not eligible for free or reduced-price lunch.

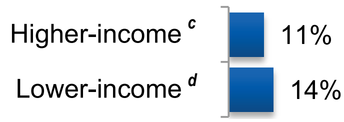
Lower-income college-bound students express more interest in STEM majors than their higher-income counterparts

High school graduates in 2012 who took the ACT exams while in high school were asked their choice of a major in college. Those students who indicated that they were "very sure" of their choice of a

STEM college major were classified as "interested" in STEM by ACT, Inc. Results indicated that 10 percent of Minnesota high school graduates were interested in STEM based on this definition. More lower-income students than higher-income students were interested in STEM – 13 percent and 10 percent, respectively. For this analysis, lower income was defined as a family income at or below $50,000 and higher income was defined as a family income above $50,000. Although more lower-income high school graduates taking the ACT exams indicated an interest in pursuing a STEM major, it is important to remember that a lower proportion of lower-income students are likely to take the ACT compared to higher-income students. This is because lower-income students are less likely to graduate from high school and attend college, and the ACT is mostly taken by college-bound students (Mueller & Gozali-Lee, 2013).

We examined the proportion of Minnesota high school graduates in 2012 who were "able" (met the college-readiness benchmarks on both the ACT math and science exams) that were also "interested" in STEM (very sure about pursuing a STEM major in college). Lower-income students who were able in STEM were somewhat more likely to be interested in STEM compared to higher-income students. That is, 14 percent of able lower-income students were interested in majoring in a STEM field in college compared to 11 percent of able higher-income students (Figure 7). Among all higher-income students assessed, 5.0 percent were both able and interested in STEM, and among all lower-income students assessed, 3.4 percent were both able and interested in STEM (ACT, Inc., 2013). The ACT results along with occupational projections in STEM areas suggest that it is desirable to increase both Minnesota students' interest and ability in STEM from a workforce needs perspective.

7. Percent of 2012 Minnesota high school graduates able[a] in STEM who are interested in STEM[b]



[a] Able students are those meeting both science and math benchmarks on the ACT.

[s] Students' interest in STEM is based on students' reporting of their choice of a college major.

[c] Higher income refers to students who reported an annual family income greater than $50,000.

[d] Lower income refers to students who reported an annual family income of $50,000 or lower.

Actions to increase interest in STEM

Improve the teaching of science

As discussed earlier, improving how science and other STEM subjects are taught is potentially important to increasing interest in these areas for both lower- and higher-income students. Effective teacher professional development programs as well as improvements in teacher preparation programs could be very helpful in this regard.

Provide more coordinated and aligned informal STEM education to build on students' initial interest

Reaching more students with high-quality informal STEM education opportunities could also boost interest in STEM. Another challenge is sustaining the interest of students after an initial, stimulating STEM experience through an informal STEM education program, school classroom lessons, or both. One approach to this challenge is creating greater coordination among informal education providers such that students have the opportunity to participate in a series of informal STEM education activities over a number of years, offered by several providers that build on each other's program activities and strongly align with and complement what the students are learning in the school classroom. Such a model, focused especially on students currently underrepresented in STEM, is being developed and evaluated over the next two years through a partnership of the Minneapolis Public Schools with seven informal STEM education organizations and the Minnesota Department of Education. Wilder Research is serving as the evaluator for the project.

Increase students' awareness of STEM careers

Programs that enable high school students to explore or gain exposure to STEM occupations and careers can also stimulate interest in STEM. Opportunities for this could include, for example, career centers, summer job opportunities, or STEM programs for high school students offered by local colleges and universities. Programs offered by colleges and universities often focus on students underrepresented in STEM, including lower-income students (Mueller & Gozali-Lee, 2013; Schneider, Judy, & Marzuca, 2012; Yelamarthi & Mawasha, 2008; Lam, Srivatsan, Doverspike, Vesalo, & Mawasha, 2005).

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